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Dalton, deceased et al.

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[54] **KNIFE SHARPENER, PARTICULARLY FOR A MICROTOME**

[75] Inventors: **Robert J. Dalton, deceased,** late of Haddonfield, N.J., by Ruth C. Dalton, executrix; **Frederick W. Pfleger,** Cherry Hill, N.J.; **John Y. Steel,** Jenkintown, Pa.

[73] Assignee: **Arthur H. Thomas, Company,** Philadelphia, Pa.

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[52] **U.S. Cl.** ..... **51/59 R,** 51/153, 51/159

[51] **Int. Cl.** **B24b 3/48**

[58] **Field of Search** ..... 51/59 R, 62, 67, 153, 159, 51/63

[56] **References Cited**

UNITED STATES PATENTS

941,529	11/1909	Myers	51/159 UX
1,512,058	10/1924	Salerni	51/153
1,878,791	9/1932	Magnano	51/159
1,953,559	4/1934	Hughes	51/159 X
2,287,317	6/1942	McDonnell	51/153
2,391,260	12/1945	Miller	51/59 R
2,431,624	11/1947	Smith	51/159

Primary Examiner—Harold D. Whitehead
Attorney, Agent, or Firm—Seidel, Gonda & Goldhammer

[57] **ABSTRACT**

A knife sharpener, particularly for a microtome knife, holds the knife against a reciprocating surface at a first angular position relative to the direction of displacement of the surface, shifts the knife to another angular position relative to the displacement of the surface after a predetermined amount of relative knife and surface displacement, lifts and turns the knife over to sharpen the opposite side of the edge in response to a further measured amount of displacement of the surface, again shifts the angular position of the knife relative to the surface in response to yet a further relative displacement of the surface, then lifts and turns the knife over, and the entire cycle is repeated.

18 Claims, 13 Drawing Figures

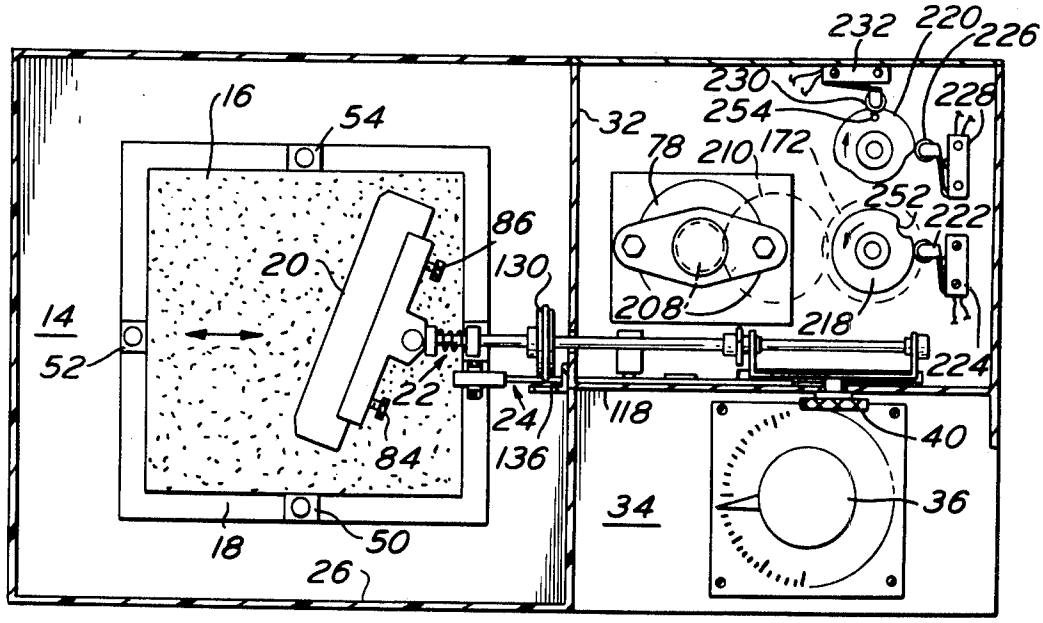
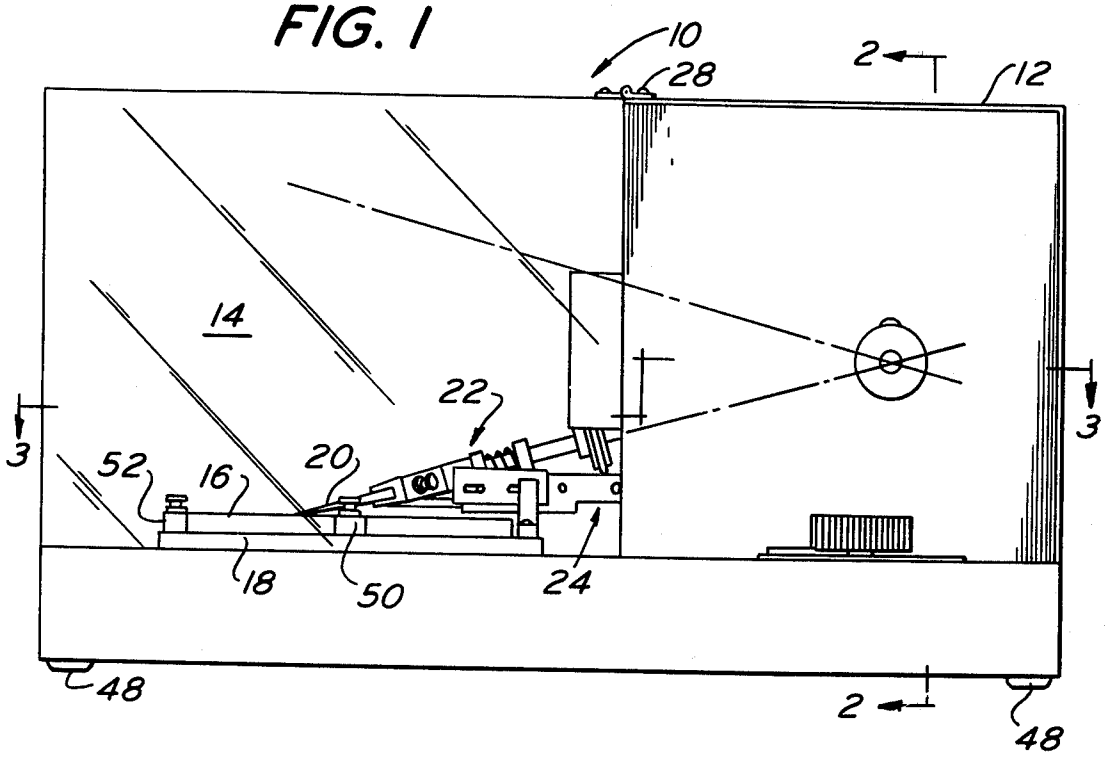


FIG. 1


10
28
2
12
14
22
3
3
52
16
20
18
50
24
48
2
48

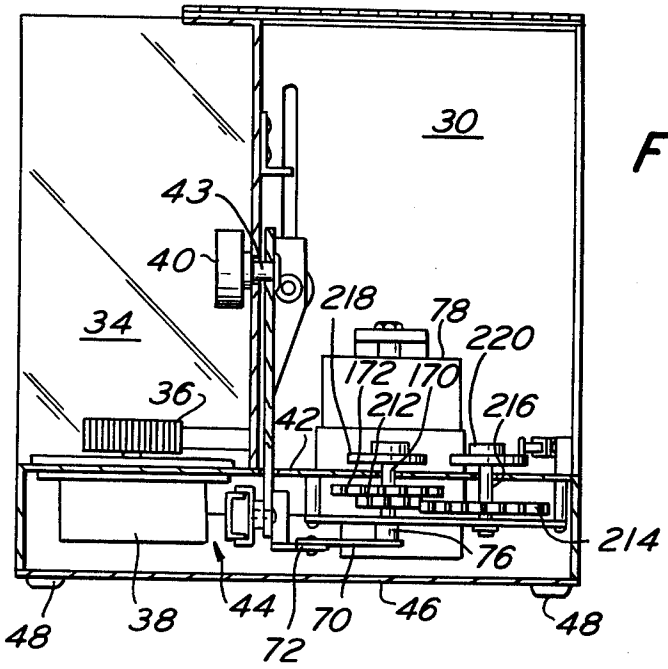
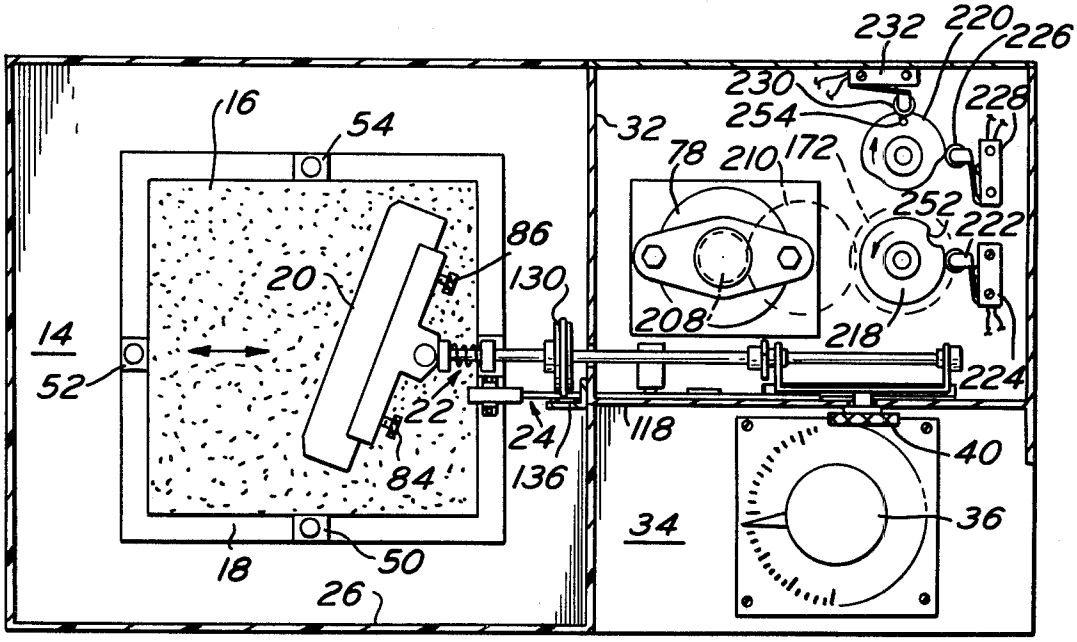

30
43
40
218
78
220
34
172
170
212
216
36
42
214
76
48
38
44
70
46
48
72

FIG. 2

FIG. 3


232
220
226
230
254
228
16
54
32
78
210
172
252
222
86
130
20
208
218
14
52
22
24
118
224
84
136
40
34
36
18
50
26

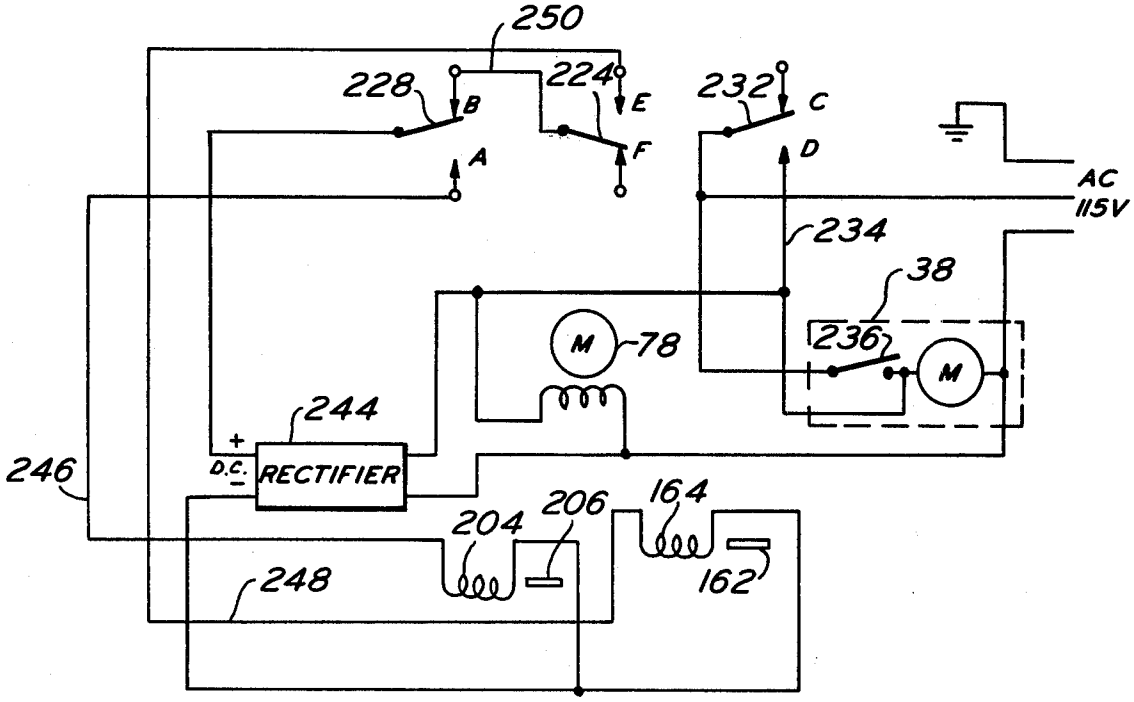

250
228
B
224
E
232
C
A
F
D
AC
115V
234
38
M
78
236
M
244
+
D.C.
−
RECTIFIER
246
204
206
164
248
162

FIG. 10

FIG. 4

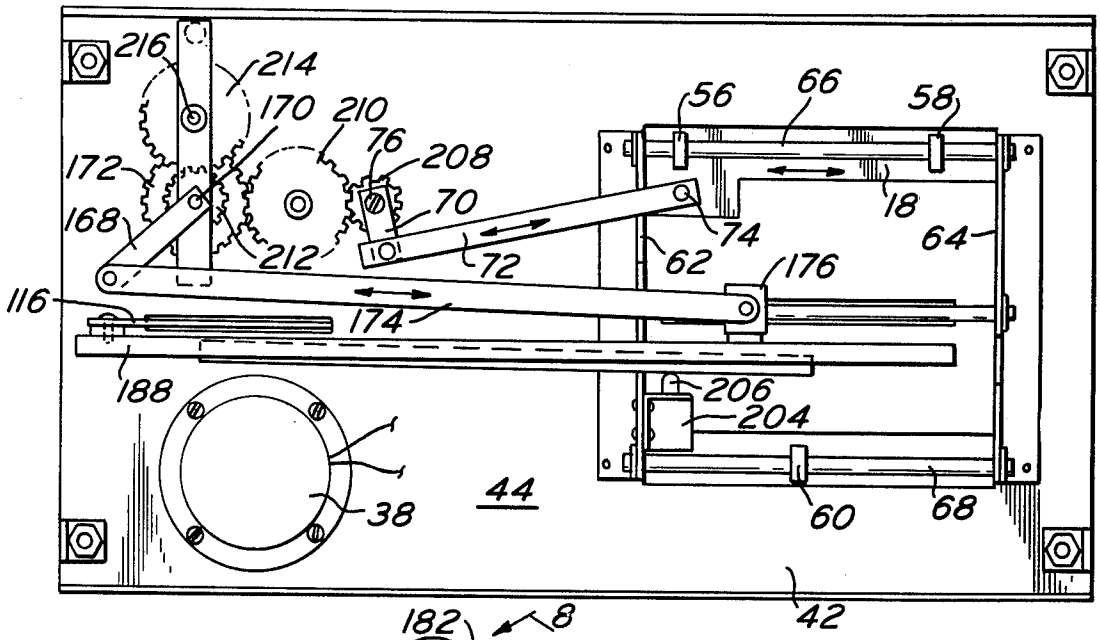


FIG. 7

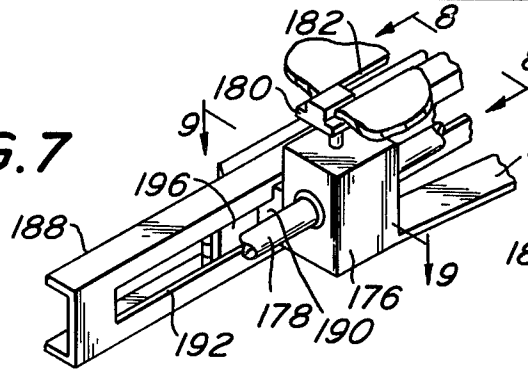


FIG. 8

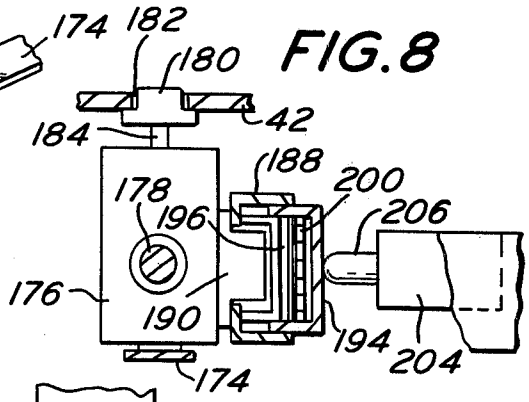
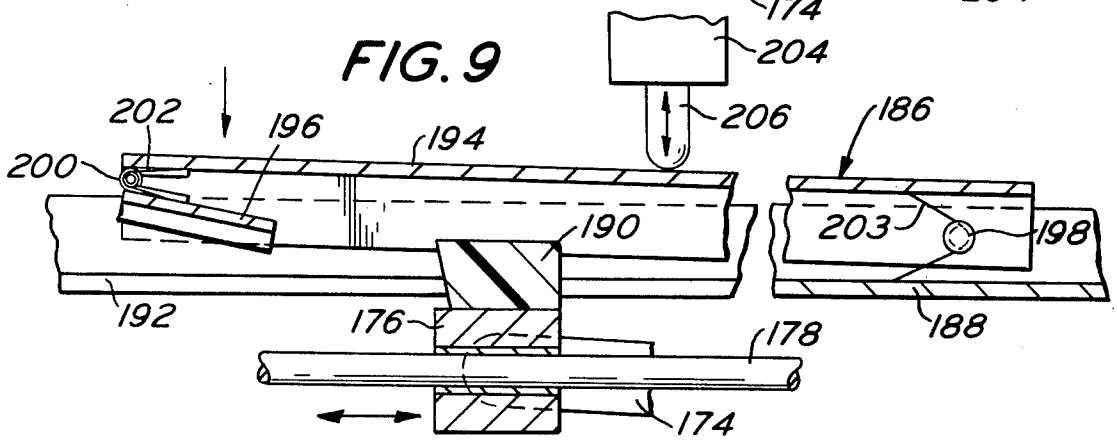


FIG. 9



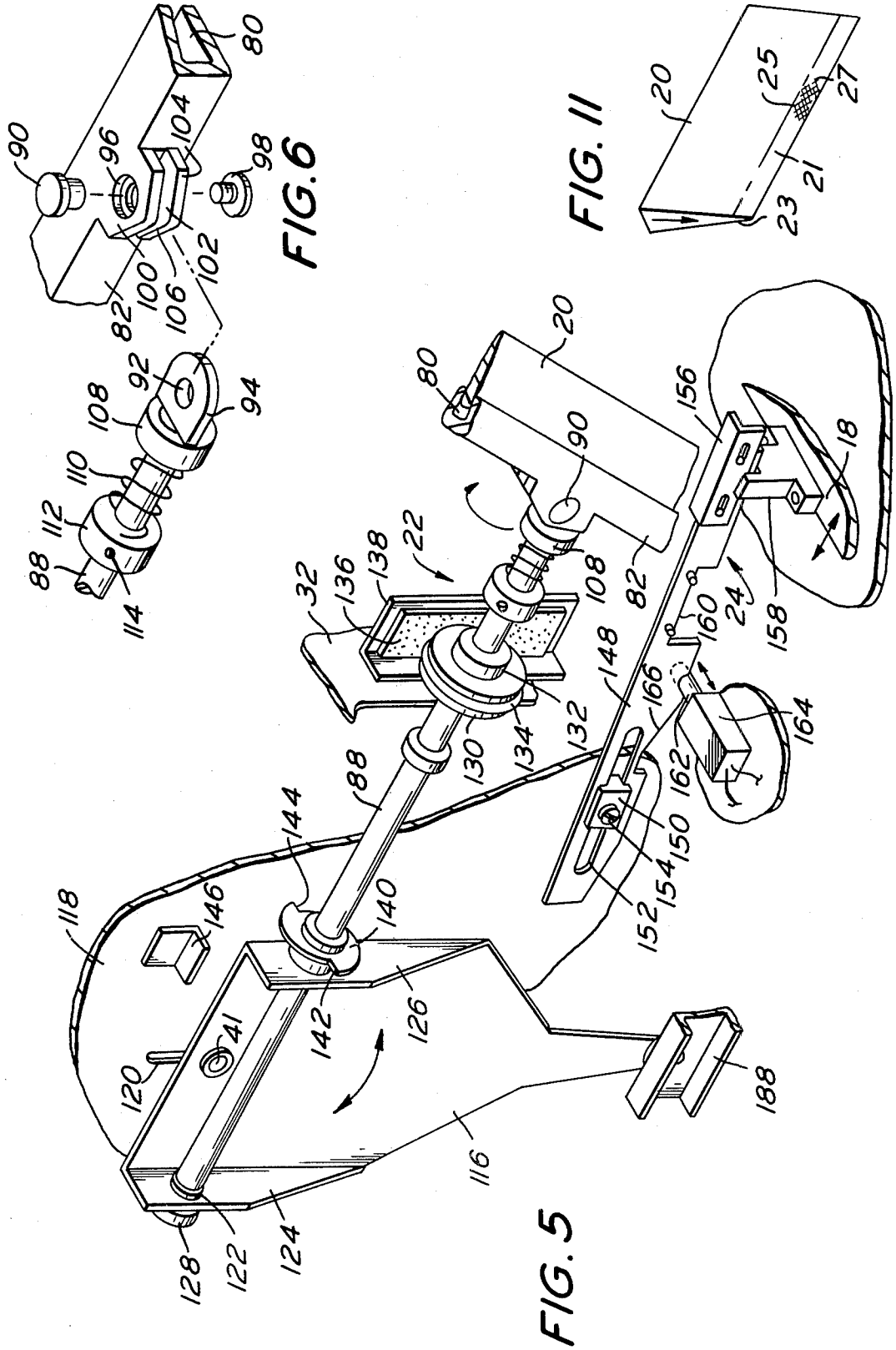
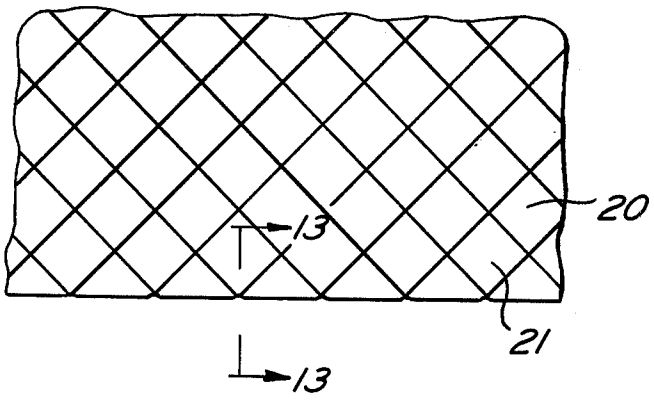


FIG. 6

FIG. 11

FIG. 5

FIG. 12



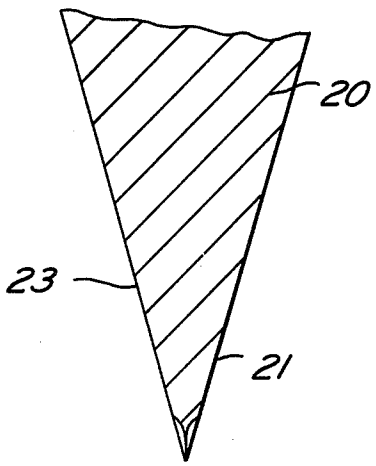


FIG. 13

KNIFE SHARPENER, PARTICULARLY FOR A MICROTOME

This invention relates to a knife sharpener, particularly for a microtome.

It is desirable to put an extremely fine edge on certain types of cutting devices, such as the microtome knife. Originally, knives were sharpened by hand. Hand sharpening involves holding the knife against the abrasive surface at a predetermined angle and appying sufficient pressure to hold the edge evenly against the surface. The amount of pressure must be gauged in accordance with the hardness of the knife and the fineness of the grinding surface. At best, hand sharpening of a microtome knife is an empirical process and the more experienced the operator, the better the edge.

Not unexpectedly, machines have been developed to assist in producing a quality edge on a knife such as a microtome. One such machine is the Model 7203 "Thomas – Fanz Microtome Knife Sharpener" sold by Arthur H. Thomas Company, Philadelphia Pa. Such a machine is shown at page 769 of the Arthur H. Thomas Company catalog entitled Scientific Apparatus and Reagents, published in 1968. The Thomas — Fanz Microtome Knife Sharpener includes a reversible glass disc that is turned mechanically at a constant speed. A knife holder is mounted on a counterbalanced rod that is adjustable for inclination. A motor drive sweeps the knife across the diameter of the plate and an attachment automatically lifts and reverses the knife by means of a cam shaft, gears, lever and connecting cable.

Although hand sharpening has many drawbacks as explained above, the basic approach is still the best for providing a good edge on a microtome knife. In particular, the best technique is an angular, but straight line relative motion between the knife edge and the abrasive surface as shown in FIG. **3**. The straight line motion between the knife edge and the abrasive surface produces straight microscopic scratches on the surface which define the edge of the knife. By holding the knife such that its edge is at an angle other than normal (90°) to the direction of motion, the microscopic scratches are also at an angle other than normal. By shifting the knife so that the scratches are first at one angle and then at a substantially equal but opposite angle with respect to the normal, the microscopic scratches essentially form a cross hatching on the surface of the knife as illustrated hereinafter. The microscopic scratches are necessary to a good cutting action for a microtome and are normally generated by the hand action. The scratches on opposite sides of the surfaces that define the edge meet at the edge. As such they form desirable microscopic nicks in the edge; that is they form a saw or serrated edge which is required for good cutting.

The best edge is acquired if the knife is not permitted to shift, roll or change position during each stroke. Moreover, a sufficient and constant pressure should be applied. This is extremely difficult, if not impossible to accomplish by hand techniques. The present invention seeks to improve upon existing knife sharpening machines by fully duplicating the hand sharpening technique without incurring the difficulties normally attributed to such technique. In particular, the present machine seeks to fully duplicate the hand sharpening technique while eliminating the inherent deficiencies incurred when actually sharpening a knife by hand.

In particular, the present invention provides a machine wherein there is straight line reciprocating relative motion between the knife edge and the abrasive surface. Either the knife can move relative to a fixed abrasive surface, or the surface can move relative to a fixed knife. In operation, the machine makes a predetermined number of strokes on a first side of the knife with the knife being in a first angular position. Thereafter, the machine shifts the knife to a second angular position and an equal number of strokes on the same side of the knife are made. Next, the machine raises and turns the knife over. Thereafter, the same number of predetermined strokes in both the first and second angular position of the knife are made so that the knife is equally stroked on both sides. Finally, the knife is again turned over to the first side and the process is repeated.

For the purpose of illustrating the invention, there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIG. **1** is a side elevational view of a knife sharpener in accordance with the present invention.

FIG. **2** is a sectional view of the knife sharpener taken along the line **2—2** of FIG. **1.**

FIG. **3** is a sectional view of the knife sharpener taken along the line **3—3** in FIG. **1.**

FIG. **4** is a bottom plan view of the knife sharpener.

FIG. **5** is an enlarged partial perspective view of the knife sharpener illustrating the knife turnover mechanism and knife angle shift mechanism.

FIG. **6** is an exploded view of a portion of the knife holder.

FIG. **7** is a partial perspective view of a latch mechanism for the knife turnover mechanism.

FIG. **8** is a sectional view of the latch mechanism illustrated in FIG. **7** taken along the line **8—8.**

FIG. **9** is an enlarged sectional view of the latch mechanism in FIG. **7** taken along the line **9—9.**

FIG. **10** is a schematic circuit diagram of the drive, timing and solenoid control.

FIG. **11** is a perspective view of a microtome knife.

FIG. **12** is an enlarged plan view of the cutting edge of a microtome knive.

FIG. **13** is an enlarged partial sectional view of a microtome knife.

The machine described below provides a knife edge having a requisite sharpness on a repeatable basis. This is accomplished by duplicating the preferred knife stroking method using a machine that eliminates variations through human intervention. The preferred stroking method has been described above.

It has also been pointed out that the preferred knife stroking method generates microscopic parallel scratches in the facets or sides of the knife that define the cutting edge of the knife. Depending upon the quality of the cutting edge, these scratches can be reduced, but not eliminated. Indeed, it is not desirable to eliminate the scratches.

Referring to FIG. **11,** there is shown a microtome knife **20** having facets **21** and **23** which define the cutting edge. Shown on the facets are a series of scratches **25** and **27** at equal but opposite angles with respect to a line drawn normal to the edge of the knife **20.** These scratches would not ordinarily be observable by the naked eye. They are shown merely for the purpose of illustrating the desired result. The arrow shown at the side of the knife **20** shows its direction of motion when sectioning a sample. As best shown in FIGS. **12** and **13,**

it is most desirable that the scratches intersect at the knife edge. Of course, such scratches are shown greatly exaggerated in size for purposes of illustration. Note that not only do opposte scratches meet or intersect to define serrations, but also the angled scratches on eact facet **21** or **23** also meet.

Referring now to the drawings in detail, wherein like numerals like elements, there is shown in FIG. **1** a knife sharpener, particularly for a microtome, designated generally as **10.**

The knife sharpener **10** is contained within a housing **12** that is divided into three compartments. The knife compartment **14** contains the sharpening plate **16** mounted on a reciprocable table **18.** The compartment also contains knife **20** to be sharpened. The knife **20** illustrated in the drawings is a microtome blade. However, it should be understood that the microtome is illustrated herein as exemplary since other knives can equally well be sharpened using the knife sharpener **10.** The compartment **14** also contains a portion of the knife support mechanism **22** and the knife angle shift mechaism **24,** both of which are described in more detail hereinafter. The entire compartment **14** is enclosed by a hood **26,** preferably made of a clear plastic so that the sharpening procedure can be readily observed. The hood **26** is hingedly fixed to the housing **12** by means of the hinge **28** as shown in FIG. **1.** This permits access to the compartment **14.**

Immediately behind compartment **14** is the motor compartment **30** (FIGS. **2** and **3**) separated from the compartment **14** by the wall **32.** Motor compartment **30** also contains portions of the knife support mechanism **22** and portions of the knife angle shift mechanism **24** which extend through the wall **32.** Also located within motor compartment **30** are control microswitches and timing cams described hereinafter.

Immediately adjacent the motor compartment **30** is the control section which includes adjustment knob **36** for the timer **38** as well as the adjustment knob **40** for controlling the angle of attach for the blade **20** by adjusting the height of the knife support mechanism.

Bottom wall **42** (FIG. **2**) separates the compartments **14** and **30** from the bottom compartment **44** which houses the driving mechanisms as hereinafter described. The bottom compartment **44** is closed by a lower bottom wall **46** to which appropriate resilient glides **48** are affixed.

The sharpening plate **16** may be a glass plate fixed on the reciprocable table **18** by conventional means, such as the abuting blocks **50, 52** and **54.** The glass plate **16** is used for supporting a dry grinding paper. However, the plate can be modified to support a wet grinding compound if desired.

As shown in FIG. **4,** slide blocks **56, 58** and **60** are affixed to the bottom of reciprocable table **18** and extend through slotted openings in bottom wall **42.** Flanges **62** and **64** are riveted or otherwise affixed to bottom wall **42** so as to depend therefrom and provide support for retaining the slide rods **66** and **68.** Slide rods **66** and **68** extend through holes in slide blocks **56, 58** and **60** and thereby provide means for supporting and guiding the table **18** as it is reciprocated. The reciprocal motion of the table **18** is in a straight line as defined by the guide rods **66** and **68.**

The table **18** is driven in its reciprocable motion by crank **70** which is pivotally connected to the connecting rod **72.** Rod **72** is also pivotally connected to the table **18** by the pin **74.** Crank **70** is directly fixed to the gear reduced output **76** of the drive motor **78** mounted within motor compartment **30.**

As shown in FIG. **5,** the knife **20** is wedge shaped. It therefore can be retained within a similar wedge shaped slot **80** formed in the knife holder **82.** The knife **20** is wedged into position within the slot **80** by the thumbscrews **84** and **86** which extend through threaded holes in the holder **82** and bear against the back surface of the knife **20.** Of course, other knife holders, as required, may be used.

The knife holder **82** is connected to the knife turnover rod **88** by the pin **90** extending through the aligned holes **96** and **92.** Holes **96** are formed in the cam flanges **100** and **102** which extend from the back of the knife holder **82.** Hole **92** is formed in the flattened terminus portion **94** of the turnover rod **88.** Terminus portion **94** fits snugly between the cam flanges **100** and **102.** Pin **90** is held in position within the holes **92** and **96** by the screw **98.**

The cam flanges **100** and **102** each define cam surfaces **104** and **106** at a predetermined angle with respect to the axis of turnover rod **88.** Sleeve **108** is slidably mounted on turnover rod **88** and normally biased toward the cam surfaces **104** and **106** by spring **110.** Spring **110** is held in position by collar **112** which is fixed to the turnover rod **88** by the set screw **114.**

The force of sleeve **108** against either surfaces **104** or surfaces **106** of the cam flanges **100** and **102** holds the knife holder **82** and hence the knife **20** in position at an angle with respect to the axis of turnover rod **88.** As used herein, the "angle" may be defined as the angle between an imaginary line normal to the edge of the knife **20** and the axis of the turnover rod **88.** It should be understood, however, that the foregoing is for the purpose of defining the angle and therefore should not be considered as limiting since other methods of defining the position of the knife **20** may be appropriate. Since the turnover rod **88** is mounted to extend parallel to the direction of displacement of the table **18,** it therefore follows that an imaginary line normal to the edge of the knife **20** is at the same angle with respect to the direction of the displacement of the table **18.** In view of the foregoing, it follows that the cutting edge of the knife **20** is at a complementary angle with respect to the axis of the rod **88.** In the embodiment illustrated herein, the angle is chosen to be 30°. Such angle is defined by the angle of the cam surfaces **104** and **106** (FIG. **6**). It therefore follows that the cutting edge of the knife **20** is at a complement of the angle, hence 60°, with respect to the direction of displacement of table **18.** It is in nowise intended that the angle be limited to what is specified herein. Such angles are exemplary only, and other angles may be chosen as desired.

The surfaces **106** and **104** are at equal angles with respect to the axis of turnover rod **88.** Moreover, such surfaces combined with the force applied by the sliding sleeve **108** define an over center mechanism. The over center mechanism thus holds the knife holder **82** and hence the knife **20** in one of two angular positions with respect to the axis of turnover rod **88.** Either position defines the same angle with respect to that axis, which angle may be 30° as defined above.

The turnover rod **88** is supported on a lever **116,** FIG. **5,** which in turn is pivotally connected to the wall **118** by means of a shaft and appropriate bushing **41** which extends through a slot **120.** Shaft-bushing **41** permits

lever **116** to freely rotate. The knob **40** and shaft-bushing **41** provide a means for raising and lowering the level **116** with respect to the bottom wall **42** and lock the same in position. This changes the vertical angle of the axis of rod **88** with respect to the horizontal and hence provides a means to change the angle at which the knife **20** rests against the plate **16.** The particular angle selected depends upon the use to which the knife is to be put. By way of example, but not limitation, the length of slot **120** is such that the angle between the axis of rod **88** and the horizontal can be changed from 14° to 20°. Of course, other ranges of angles can be used. This range of angles is sufficient for sharpening microtome knives. Other angular selections would be built into the machine for other types of knives.

The turnover rod **88** is supported on the lever **116** by appropriate bushings **122** (FIG. **5**) extending through holes in the flanges **124** and **126** which depend from the lever **116.** Turnover rod **88** terminates in a friction bearing **128** which prevents the rod from freely rotating except upon the application of a turning torque as hereinafter described.

As previously indicated, the lever **116** pivots on the shaft-bushing **41.** In doing so, it lifts the rod and hence knife **20** upward from the sharpening plate **16.** This upward movement of the turnover rod **88** is used to cause the knife **20** to rotate 180°. Such rotation turns over the knife **20** so that the opposite side can be brought to rest against the plate **16** when the rod **88** is returned to its lowered position.

Wheel **130** is connected to rod **88** through one-way clutch **132.** As is conventional, one-way clutch **132** permits the wheel **130** to rotate freely in one direction with respect to rod **88** but blocks rotation in the opposite direction. In the embodiment shown herein, wheel **130** is free to move only in the counterclockwise direction.

The outer surface of wheel **130** is provided with a friction tire **134** preferably made of rubber or a resilient plastic. Friction tire **134** bears against pad **136** mounted on plate **138** which is affixed to wall **32.** Pad **136** is made of rubber or a plastic material which has a sufficiently high friction to cause wheel **130** to rotate when friction tire **134** bears against it as turnover rod **88** is raised and lowered. Upon raising rod **88,** the wheel **130** tends to rotate in a clockwise direction and hence drives the rod in the same direction through clutch **132.** As the rod **88** is lowered, the wheel **130** turns freely and hence does not rotate the rod. The friction bearing **128** holds the rod in position as it lowers knife **20** toward sharpening plate **16.**

The length of pad **136** is sufficient to rotate wheel **130** and hence the rod **88** 180°. Therefore, the knife **20** is turned over by the upward movement of the rod **88.**

To be certain that the rod **88** rotates only 180°, a stop **140** is affixed thereto. Stop **140** is provided with diametrically spaced shoulders **142** and **144.** Shoulders **142** and **144** are positioned to engage the lip **146** fixed to wall **118** when the rod has turned a full 180°. Once shoulder **142** or **144** engages lip **146,** the wheel **130** merely slips along pad **136.** This prevents any over rotation of the rod **88** and hence possible damage to the corners of the knife **20** when it is lowered to the plate. Thus, the rod **88** rotates exactly 180° each time it is lifted away from the plate **16** by turning the lever **116.**

As best shown in FIG. **5,** the mechanism for shifting the knife holder **82** from one angular position to another angular position as determined by the over center mechanism includes the pusher **148.** Pusher **148** is slidably held adjacent wall **118** by a T-shaped block **150** that extends through slot **152.** Block **150** is pivotally held to wall **118** by means of pivot pin **154.** Thus, the pusher **148** is free to slide relative to block **150** and also is free to pivot upwardly and downwardly with block **150** on pin **154.**

Pusher head **156** is fixed to the forward end of pusher **148** by resilient means such as a spring (not shown). The function of pusher **148** is to move forwardly to engage the knife holder **82** and cause it to shift from one angle to the other angle as determined by the over center mechanism. Pusher head **156** is resiliently mounted on pusher **148** so as to absorb any excess toward travel of the pusher **148.** Such excess travel is designed in to accommodate the angular position of the mechanisms.

Pusher **148** is selectively caused to move forward to engage knife holder **82** by means of the bifurcated pusher block **158** fixed to reciprocable table **18.** Pusher **148** engages the pusher block **158** by means of slot **160.** The pusher **148** is normally held out of engagement with pusher block **158** by the actuator **162** of solenoid **164.** However, upon retraction of the actuator **162,** the pusher **148** pivots downwardly by its own weight until it rests upon the bigth of the bifurcated block **158.** When the table **18** reciprocates toward the wall **32,** it will reach a position wherein the slot **160** overlies the bight of block **158** and the pusher **148** will fall into engagement therewith. As the table **18** reciprocates away from the wall **32,** it will pull the pusher **148** with it. The length of pusher **148** is more than sufficient for the pusher head **156** to engage the knife holder **82** and cause it to rotate about pin **90** until the over center mechanism causes it to assume the other angle. When the table **18** reciprocates toward the wall **32,** the actuator **162** is again extended. The block **158** carries the pusher **148** with it. As a result, the pusher **148** engages the actuator **162** along inclined cam **166** and thereby raises the pusher **148** sufficiently to disengage the front of slot **160** from the block **158.** Thus, pusher **148** remains out of engagement with the block **158** until the actuator **162** is again withdrawin by the solenoid **164.** Note the difference in length between the front wall and the back wall of slot **160.** The back wall is longer. The length of the back wall is sufficient to be engaged by block **158** on all movements toward wall **32,** if the push has first been moved forward.

As previously indicated, the knife **20** is turned over by pivoting lever **116.** The lever **116** is intermittently pivoted by means of the apparatus described below.

As shown in FIG. **4,** crank **168** is connected to the shaft **170** which is driven by gear **172.** Connecting rod **174** is pivotally connected to the crank **168** at one end and to the slide block **176** at the other end. As best shown in FIGS. **7** and **8,** slide block **176** is slidingly mounted on slide rod **178** and is maintained in position by means of guide **180** which moves in guide slot **182** formed in bottom wall **42.** Guide **180** is fixed to slide block **176** by pin **184.** It should be apparent from the foregoing that slide block **176** therefore reciprocates along guide rod **178** at a rate determined by the angular velocity of crank **168.**

As shown in FIGS. **4** and **5,** the lever **116** includes a tab which extends through an opening in bottom wall

44 and it is connected to channel bar 188 of the knife turnover latch mechanism 186. Channel bar 188 extends from the pivotal connection with lever 116 under the table 18 where it is slidingly connected to slide block 176. Slide block 176 includes a laterally protruding extension 190, as best shown in FIGS. 7 and 8. Extension 190 includes a portion that protrudes through an elongated slot 192 formed in the side of channel bar 188. Thus, reciprocating slide block 176 and its extension 190 provide support for channel bar 188 and can reciprocate relative to the channel bar.

From the foregoing, it should be apparent that by latching or otherwise connecting channel bar 188 to the reciprocating slide block 176, the channel bar 188 will be caused to move with the slide block and hence will pivot the lever 116 about shaft 41. As an end result, the blade 20 is turned over.

Channel bar 188 is latched to slide block 176 by means of primary pivot arm 194 and spring biased secondary pivot arm 196. As shown in FIG. 9, primary pivot arm 194 is pivotably connected to channel bar 188 by pivot arm 198. Secondary pivot arm 196 is pivotally connected to primary pivot arm 194 by means of hinge 200. Spring 202 normally biases secondary pivot arm 196 away from primary arm 194. Spring 203, normally biases the primary arm 194 outward from the channel bar 188. A limit stop is provided in hinge 200 so that secondary pivot arm 196 always maintains an acute angle with respect to primary pivot arm 194 even when fully biased outwardly.

Solenoid 204 is located to the side of primary pivot arm 194 and includes actuator 206. Solenoid 204 is mounted on plate 62. Upon energization, actuator 206 extends outwardly from solenoid 204 and pivots primary pivot arm 194 toward channel bar 188 against the bias of springs 202 and 203. This action latches channel bar 188 to slide block extension 190 in the following manner. The slide block extension 190 normally misses secondary pivot arm 196 as it reciprocates within slot 192. However, upon movement toward channel bar 188 under the force applied by actuator 206, the extension 190 now engages the end of secondary pivot arm 196 and pushes it forward. The movement of pivot arm 196 carries with it the channel 188 and hence pivots lever 116. The weight of the knife 20 and the knife support mechanism 22 is sufficient to maintain secondary pivot arm 196 in contact with extension 190 throughout the cycle. Thus, the knife is not dropped back onto sharpening plate 16. Rather, it is lowered. Thereafter, actuator 206 is retracted and the turnover mechanism is not operated until it is again extended.

It should be obvious from the foregoing that there has been described a mechanism for sharpening the knife 20 at two different angles on one side, turning over the knife and then sharpening it on the other side at the same two angles. It should also be apparent that the sequence of the foregoing is determined by the actuation of solenoids 164 and 204. The timing sequence for the actuation of solenoids 164 and 204 is as follows.

All motive power for the knife sharpener 10 is derived from motor 78 (FIG. 3) mounted within motor compartment 30. The output of motor 78 drives shaft 76 (FIG. 4) to which is affixed gear 208. Gear 208 meshes with idler gear 210 which is in turn meshed with gear 172. Gear 212 is mounted in common with gear 172 on shaft 170. Gear 212 meshes with gear 214 mounted on shaft 216.

Gears 172 and 210 have the same diameter and the same number of teeth about their periphery. Hence, they rotate at the same but opposite angular velocities. Since gears 172 and 210 are larger in diameter than gear 208, they rotate at a slower angular velocity than gear 208. Accordingly, crank 168 turns at a slower angular velocity than crank 70. As a result, slide block 176 has a slower rate of reciprocation than table 18.

Gear 212 has a smaller diameter than gear 172. Gear 214 has a larger diameter than gear 212. Accordingly, gear 214, which is driven by gear 212, rotates at a slower angular velocity than gear 172.

Timing cam 218 is mounted on shaft 170 together with gears 172 and 212, as shown in FIG. 2. Hence, timing cam 218 rotates at the same angular velocity as shaft 170 and gears 172 and 212.

Timing cam 220 is mounted on shaft 216 in common with gear 214 and hence rotates at the same angular velocity as gear 214.

As best shown in FIG. 3, timing cam 218 controls the actuator 222 for knife shift microswitch 224. Timing cam 220 controls the actuator 226 for turnover microswitch 228 as well as the actuator 230 for power microswitch 232.

The function of the foregoing is best understood by reference to the schematic diagram shown in FIG. 10.

As shown in FIG. 10, power is drived from a conventional source of AC voltage and applied to the motor of timer 38 by closing timer switch 236. Timer 38 is conventional and therefore need not be described in detail. It is sufficient to state that upon rotation of knob 36, switch 236 is held closed until the timer 38 times out.

Power microswitch 232 functions as a supplemental power switch to bypass timer switch 236 through conductor 234. The function of this bypass is to maintain the operation of motor 78 until knife 20 has been lowered to sharpening plate 16. If timer 38 were allowed to merely time out, the possibility exists that this may occur while knife 20 is in a raised position. This is an extremely dangerous condition. To prevent this, power microswitch 232 is maintained in a closed (D) condition except at one position of the timing cam 220 when it moves to the open (C) condition by the engagement of actuator 230 (FIG. 3) with timing pin 254. Power microswitch 232 is illustrated in the open (C) condition in FIG. 10. Pin 254 is positioned on cam 220 so that microswitch 232 can be in the (C) condition only when knife 20 is on plate 16.

As illustrated in FIG. 10, motor 78 is connected to one side of the alternating current voltage source. The other terminal of motor 78 is connected to switch 232 and to recitifier 244. Rectifier 244 is connected across the source of AC voltage through switch 232. The negative side of rectifier 244 is connected to solenoid 204. The opposite terminal of solenoid 204 is connected through conductor 246 to terminal (A) of microswitch 228. Hence, microswitch 228 controls the actuation of solenoid 204, and hence the latch mechanism 186. As illustrated in FIG. 10, the circuit for energizing solenoid 204 is open.

The negative side of rectifier 244 is also connected to one terminal of solenoid 164. The opposite terminal of solenoid 164 is connected through conductor 248 to terminal (E) of microswitch 224. Microswitch 224, as shown, is connected through terminal (E) and conductor 250 to terminal (B) of microswitch 228. Thus, sole-

noid **164** is actuated upon movement of microswitch **228** from the position (A) to its opposite connective position (B) when microswitch **224** is in position (E).

As previously indicated, the timing sequence of the knife sharpener **10** is such that the knife is to be sharpened on one side at a first angle, sharpened on the same side at a second angle, turned over, and sharpened on the second side at the second angle, and then sharpened on the second side at the first angle. The knife **20** is then turned over again and the process repeated. This process continues for a preset period of time as determined by the timer **38.** The sequence of the foregoing is determined by the timing cams **218** and **220.** The movement of the timing cams is in turn determined by the angular velocity of the various gears within the gear train shown in FIG. **4.**

By way of example, but not limitation, it may be desirable to reciprocate the table forward and back three times before shifting the angle of the knife **20.** Accordingly, the gear ratio between gears **208** and **172** is selected at 3-to-1 with idler gear **210** being at a ratio of 1-1 with gear **172.** Thus, timing cam **218** is turning at an angular velocity which is one-third as fast as the angular velocity of gear **208** and crank **70.** Stated otherwise, timing cam **218** will make one revolution for each three revolutions of gear **208.**

At the same time, the ratio between gears **212** and **214** is also 3-to-1. Accordingly, gear **214** will make one revolution for each three revolutions of the gear **212** and one revolution for each nine revolutions of gear **208.**

From the foregoing, it can be seen that the knife sharpener **10** operates as follows:

Gear **208** makes three revolutions, thereby reciprocating plate **18** against knife **20** three times. (A complete cycle of reciprocation includes a forward and back stroke of plate **18** relative to wall **32**).

Timing cam **218** turns one complete revolution, thereby bringing actuator **222** into notch **252.** Switch **224** thereby shifts from the (F) position in which it has been held by cam **218** to the (E) position.

At the same time, timing cam **220** will have made one-third of a revolution. Actuator **226** follows the high portion of the cam **220** and holds switch **229** in the B position. Thus, a circuit is completed through switch **228** to the positive side of the rectifier **244,** thereby energizing solenoid **164** and solenoid actuator **162.** This causes pusher **148** to move forward in the manner described above and shift knife holder **82** to the angular position illustrated in FIG. **3.**

Gear **208** continues to rotate and makes three additional revolutions which result in three additional reciprocations of table **18,** this time with the knife **20** in its second angular position.

As the completion of the second three revolutions, switch **224** again moves from the (F) position to the (E) position, but it operates without effect since actuator **226** now follows the low or short radius portion of cam **220.** Therefore, switch **228** is in the (A) position inhibiting switch **224.**

Cam **220** having now made an additional one-third revolution and actuator **226** is now moved onto the low or short radius portion of the periphery of cam **220.** The short radius portion extends over 120° of the periphery of cam **220.** This moves switch **228** to the (A) position. This in turn completes a circuit through solenoid **204** and hence actuates the lift and turnover mechanism.

During the lift and turnover operation, gear **208** makes an additional three revolutions resulting in additional three reciprocations of the table **18.** At the same time, cam **220** rotates an additional one-third revolution bringing it back to the position illustrated in FIG. **3;** that is, with the actuator **226** on the high or large radius portion of the cam. During this sequence, actuator **222** falls into notch **252** on cam **218.** But this does not operate the pusher **148** because switch **224** cannot complete the circuit through switch **228.** This can only be done when switch **228** is in the (B) position.

As previously indicated, switch **232** prevents the knife sharpener **10** from timing out via timer **28** with knife **20** in the raised position. This is prevented by positioning switch **232** such that its actuator **230** is in position (D) except when lifted by timing pin **254** to position (C). This allows switch **232** to bypass timer switch **236,** thereby maintaining power to motor **78** to complete the turnover operation. Upon completion of the turnover operation, actuator **230** will be moved to its (C) position by timing pin **254,** thereby turning off the motor.

From the foregoing example, it can be seen that the knife **20** is sharpened by three complete reciprocating strokes on a first side at a first angle, by three additional complete reciprocating strokes at a second angle, and then the knife is turned over. The knife is turned over while the table **18** completes three additional reciprocating strokes. Thereafter, the knife is sharpened by three complete reciprocating strokes at the first angle, and then shifted back to the second angle and sharpened by three additional reciprocating strokes. Thereafter, the knife is again turned over to the first side and the process repeated.

It should be noted that when the knife is turned over from the position illustrated in FIG. **3,** the side of the knife holder **82** on which thumbscrew **86** is located is now adjacent to the pusher **148.** Thus, the pusher **148** need be only on one side of the turnover rod **88.**

Although the operation of the knife sharpener **10** has been described in terms of a 3-to-1 ratio between the various cycles, it should be understood that other ratios and timing cycles can be incorporated into the machine.

The present invention has been exemplified by describing the table **18** as moving with respect to the knife **20.** It should be understood, however, that the invention is not limited to reciprocation of the table **18.** It is within the scope of the present invention to reciprocate the knife **20** relative to a fixed table or to otherwise create the necessary relative motion. For example, the table could be moved in a crosswise fashion with respect to the knife.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

I claim:

1. In a knife sharpener, means for holding a knife against an abrasive surface for sharpening the knife edge, drive means for displacing said knife and said surface relative to each other, the direction of relative displacement between said knife and surface being at an

oblique angle with respect to the cutting edge of said knife, means for automatically changing said angle from a first predetermined angular position to a second predetermined angular position in response to a measured amount of relative displacement of said knife and surface, and means to turn the knife over to sharpen an opposite side of the edge in response to a further measured amount of relative displacement of said knife and said surface.

2. In a knife sharpener, means for holding a knife against an abrasive surface for sharpening the knife edge, drive means for displacing said surface and said knife relative to each other, means for automatically shifting the angular position of the knife relative to the direction of displacement from a first predetermined angular position to another predetermined angular position in response to a measured amount of displacement of the surface, and means to turn the knife over to sharpen an opposite side of the edge in response to a further measured amount of displacement of said surface.

3. In a knife sharpener in accordance with claim **2** wherein said means for shifting the angular position of the knife relative to the direction of displacement of the surface comprises means to push the knife from one angular position to another angular position.

4. In a knife sharpener in accordance with claim **3** wherein said means for shifting the angular position of the knife includes means to bring said means to push the knife into operative engagement with the knife in response to a measured amount of displacement of the surface.

5. In a knife sharpener in accordance with claim **1** wherein said means to turn the knife over to sharpen an opposite side of the edge of a knife includes means for lifting and rotating the means for holding the knife.

6. In a knife sharpener, means for holding a knife against an abrasive surface for sharpening the knife edge, drive means for displacing said surface and said knife in straight line linear motion relative to each other, means for automatically shifting the angular position of the knife relative to the direction of linear displacement from a first predetermined angular position to a second predetermined angular position in response to a predetermined amount of displacement of the surface and knife relative to each other, and means to turn the knife over to sharpen the opposite side of the edge in response to a further predetermined amount of displacement of the knife and surface relative to each other.

7. In a knife sharpener, means for holding a knife against an abrasive surface for sharpening the knife edge, drive means for displacing said surface in straight line linear reciprocable motion relative to said knife, means for automatically shifting the angular position of the knife relative to the direction of linear displacement of said surface from a first predetermined angular position to a second predetermined angular position in response to a predetermined number of reciprocations of said surface, and means to turn the knife over to sharpen an opposite side of the edge in response to a further predetermined number of reciprocations of said surface.

8. In a knife sharpener in accordance with claim **7** wherein said means for shifting the angular position of the knife relative to the direction of displacement of the surface comprises means to push the means for holding the knife from one angular position to a second angular position.

9. In a knife sharpener in accordance with claim **8** wherein said means for pushing the means for holding the knife includes a pusher and means for selectively engaging said pusher to the reciprocating abrasive surface to bring said pusher into engagement with said means for holding said knife.

10. In a knife sharpener in accordance with claim **7** wherein said means to turn the knife over includes means for lifting and rotating the means for holding the knife through 180°.

11. In a knife sharpener in accordance with claim **10** wherein said means for lifting and rotating the knife holder includes means for selectively latching the means for lifting and rotating the knife holder to the reciprocable abrasive surface.

12. In a knife sharpener, means for holding a knife against an abrasive surface for sharpening the knife edge, support means for the abrasive surface, drive means for displacing said support means in straight line linear reciprocable motion to thereby displace said abrasive surface in straight line linear motion relative to the knife, means for shifting the angular position of the knife relative to the direction of linear reciprocation of said abrasive surface from a first angular position to a second angular position, said means for shifting the angular position of the knife including a pusher for pushing the means for holding the knife from a first angular position to a second angular position and means for selectively engaging said pusher with said reciprocating support means, and means to turn the knife over to sharpen its opposite side, said means to turn the knife over including means to lift and rotate the knife through 180°, said means to lift and rotate the knife through 180° including means to selectively latch the means to lift and rotate the knife through 180° to the reciprocable support means.

13. In a knife sharpener, means for holding a knife against an abrasive surface for sharpening the knife edge, support means for the abrasive surface, drive means for displacing said support means in reciprocable straight line linear motion relative to said knife edge, means to hold one side of said knife edge against said abrasive surface at a first predetermined angular position for at least one reciprocation of said surface, means to shift said knife edge to a second predetermined angular position, means to hold said knife edge at said second predetermined angular position for at least one reciprocation of said surface, means to lift and turn the knife over, means to hold the opposite side of the edge of said knife against said abrasive surface at a first predetermined angular position for at least one reciprocation of said surface, means to shift said knife edge to a second predetermined angular position and means to hold said knife edge at said second predetermined angular position for at least one reciprocation of said surface.

14. In a knife sharpener, means for holding a knife against an abrasive surface for sharpening the knife edge, drive means for displacing said knife and said surface relative to each other, means for maintaining the cutting edge of said knife at an oblique angle with respect to the direction of relative displacement between said knife and said surface, means for changing said angle from a first angular position to a second angular position in response to a measured amount of relative

displacement of said knife and surface, means to turn the knife over to sharpen an opposite side of the edge in response to a further measured amount of relative displacement of said knife and said surface, means for again changing said angle from a first angular position to a second angular position in response to a measured amount of relative displacement of said knife and surface, and means to turn the knife over to again sharpen the first side of the knife edge in response to a further measured amount of relative displacement of said knife and said surface.

15. In a knife sharpener in accordance with claim **14** wherein said means for changing the angle of relative displacement between said knife and surface comprises means to push the knife from one angular position to another angular position.

16. In a knife sharpener, means for holding a knife against an abrasive surface for sharpening the knife edge, drive means for displacing said surface in straight line linear reciprocable motion relative to said knife, means for shifting the angular position of the knife relative to the direction of linear displacement of said surface from a first angular position to a second angular position in response to a predetermined number of reciprocations of said surface, said means for shifting including a pusher for pushing the means for holding the knife and means for selectively engaging said pusher to the reciprocating abrasive surface to bring said pusher into engagement with said means for holding said knife, and means to turn the knife over to sharpen an opposite side of the edge in response to a further predetermined number of reciprocations of said surface.

17. In a knife sharpener, means for holding a knife against an abrasive surface for sharpening the knife edge, drive means for displacing said surface in straight line linear reciprocable motion relative to said knife, means for shifting the angular position of the knife relative to the direction of linear displacement of said surface from a first angular position to a second angular position in response to a predetermined number of reciprocations of said surface, and means to turn the knife over to sharpen an opposite side of the edge in response to a further predetermined number of reciprocations of said surface, said means to turn the knife over including means for lifting the means for holding the knife and for rotating the same through 180° and means for selectively latching the means for lifting and rotating the knife holder to the reciprocable abrasive surface.

18. In a knife sharpener, means for holding a knife against an abrasive surface for sharpening the knife edge, drive means for displacing said surface and said knife edge in straight line linear motion relative to each other, means to hold one side of said knife edge against said abrasive surface at a first and then a second angular position, means to move said knife in a first direction away from said surface, means to rotate said knife relative to said surface in a direction from said first direction to thereby turn the knife over, and means to hold the opposite side of the edge of said knife against said abrasive surface at a first and then a second angular position.

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