Nov. 8, 1955 O. THIEL 2,722,788

ABRADING OR POLISHING MACHINE

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FIG.1.

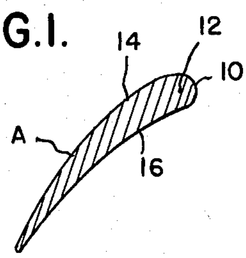
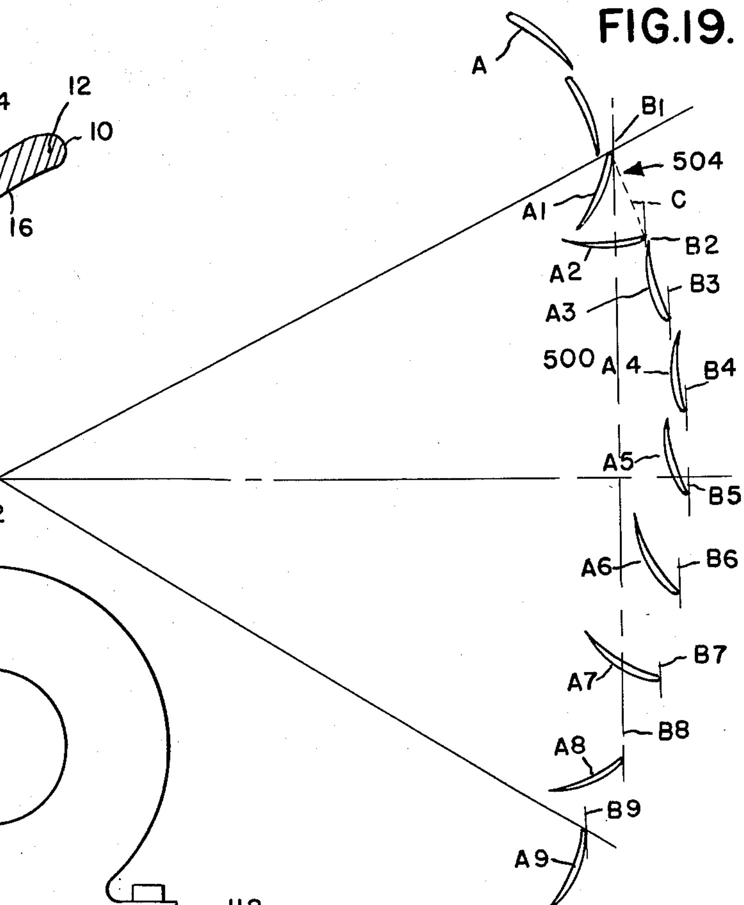


FIG.19.



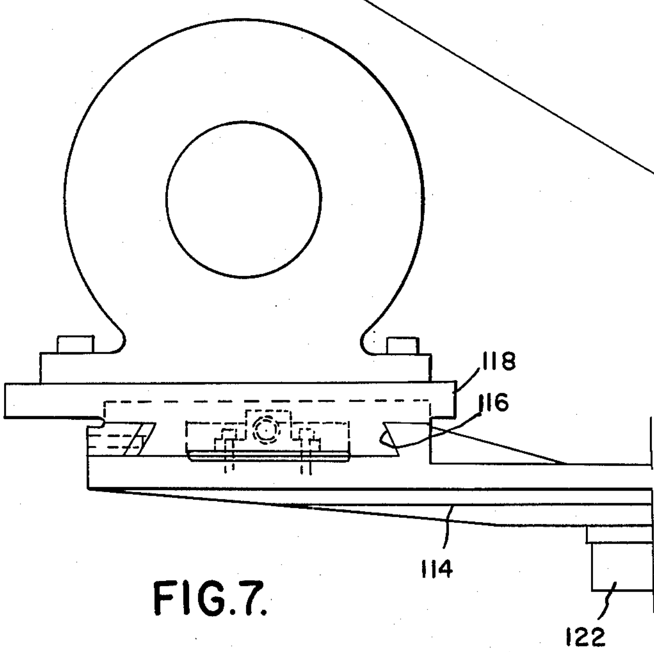


FIG.7.

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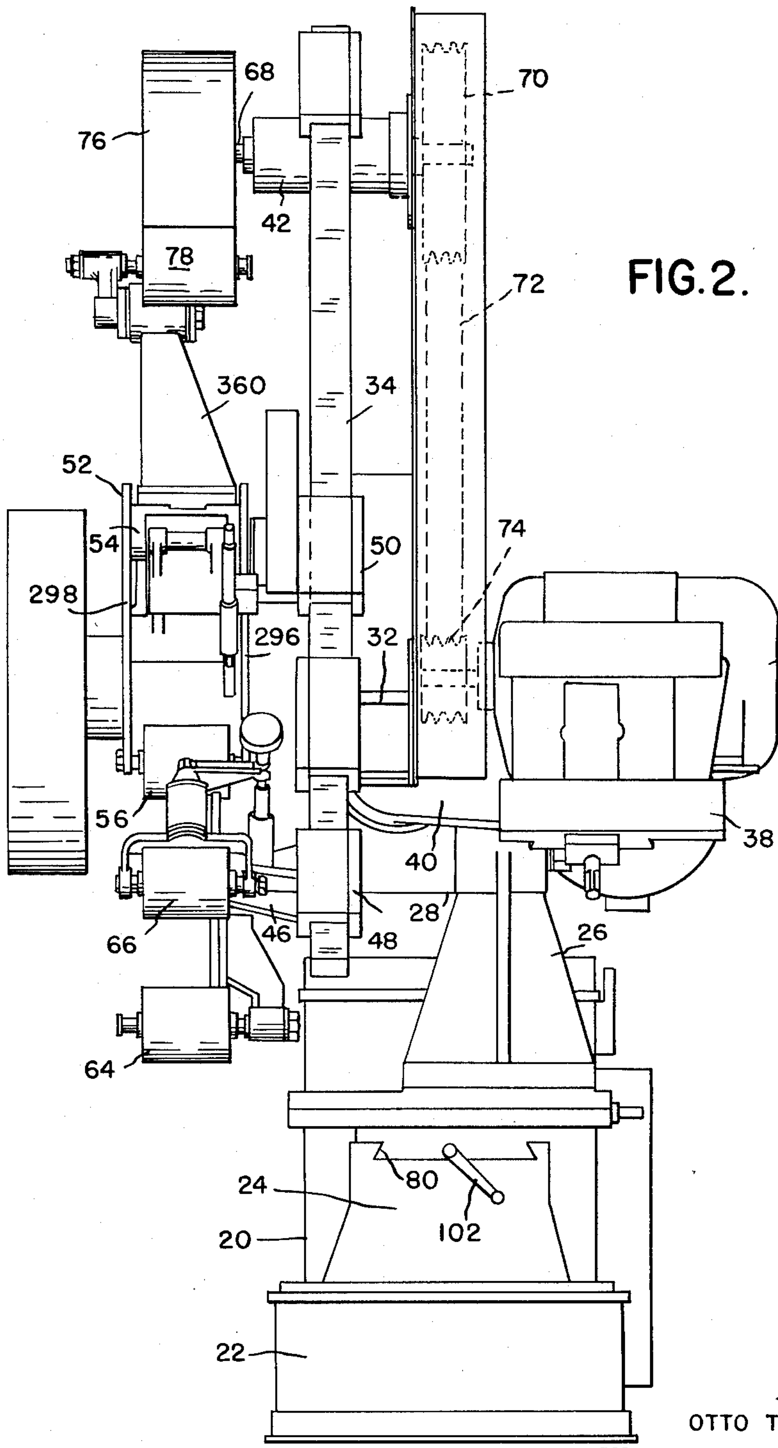

FIG. 2.

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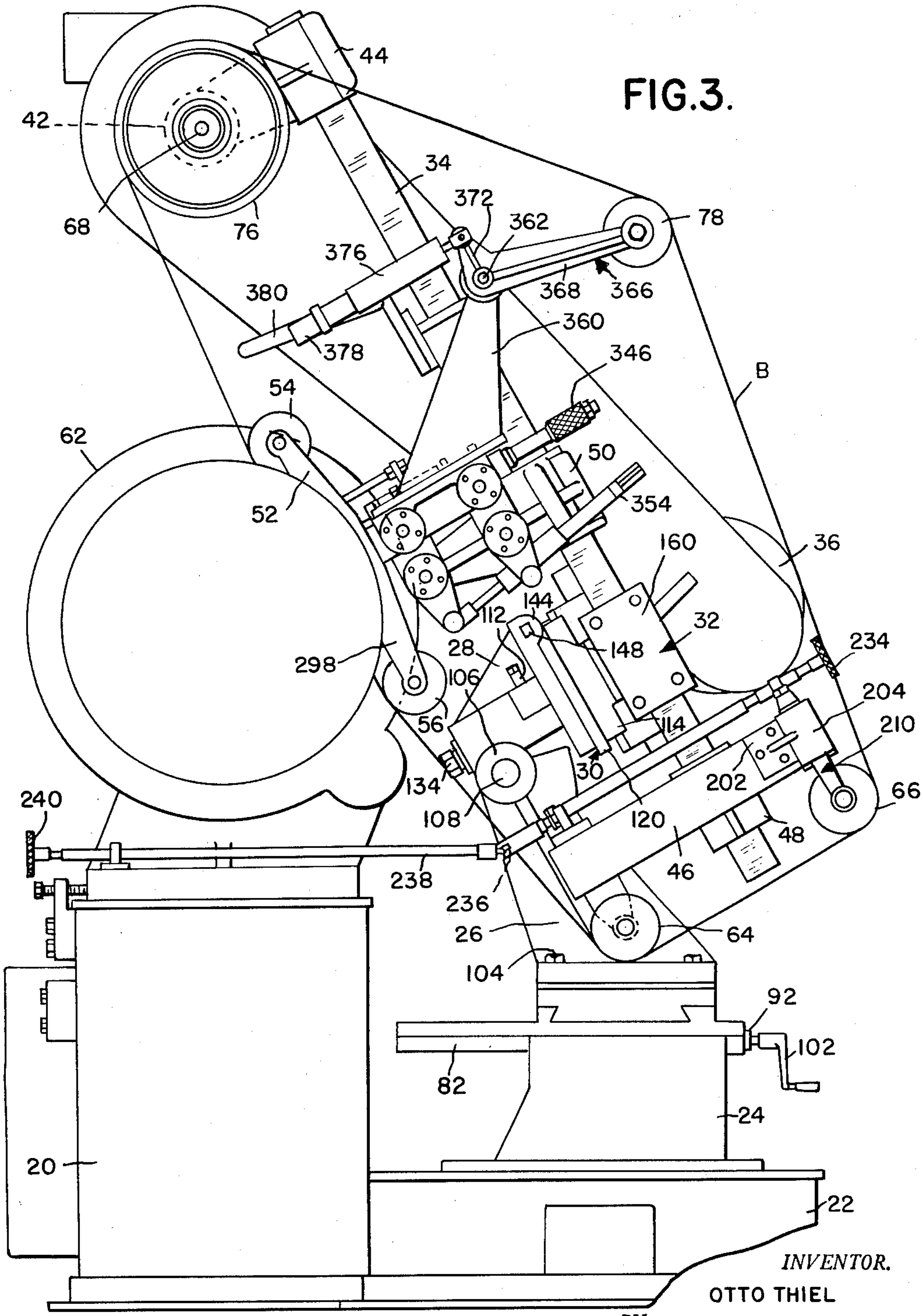
FIG.3.



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ABRADING OR POLISHING MACHINE

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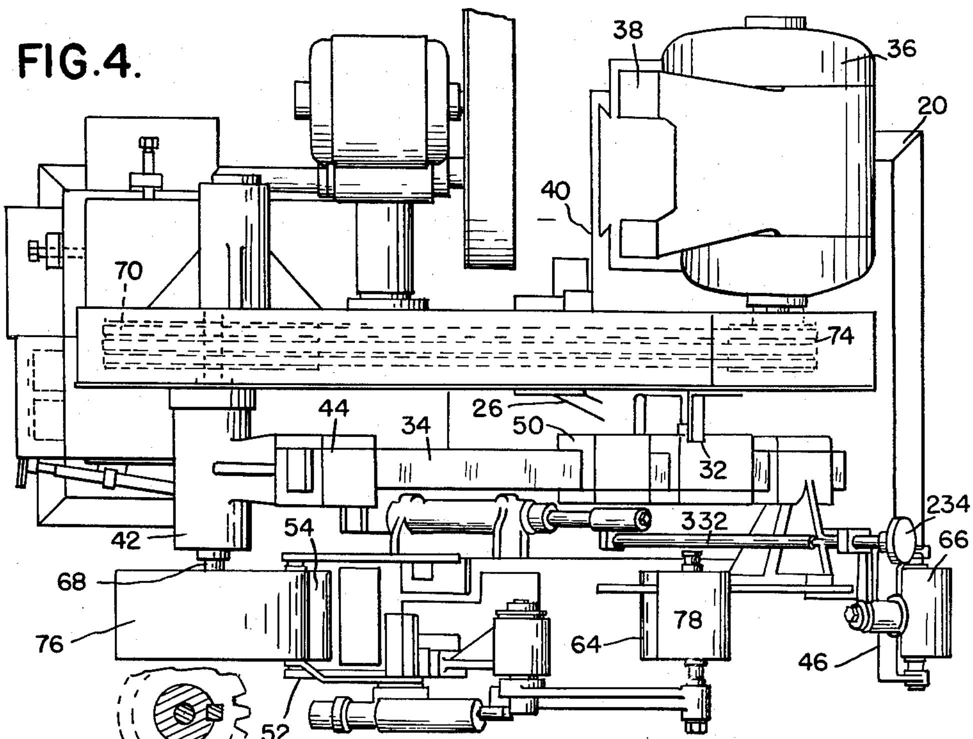
FIG.4.



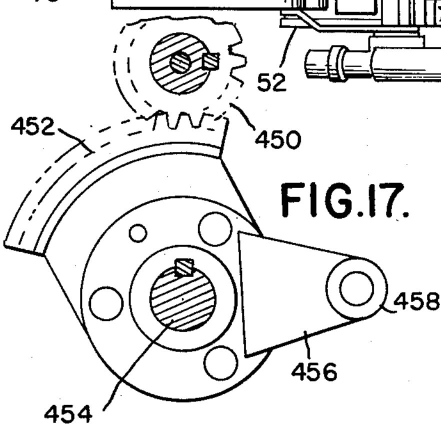
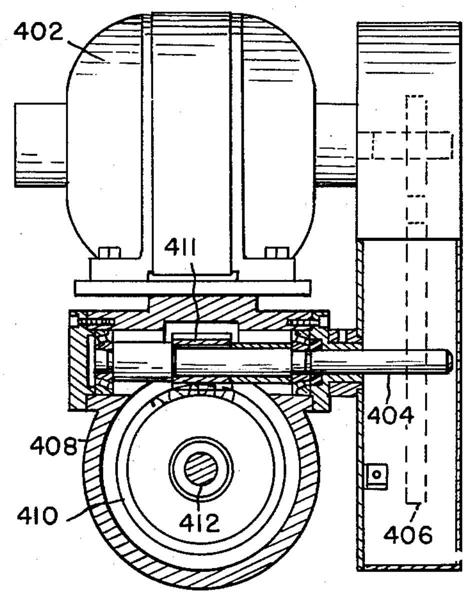


FIG.17.



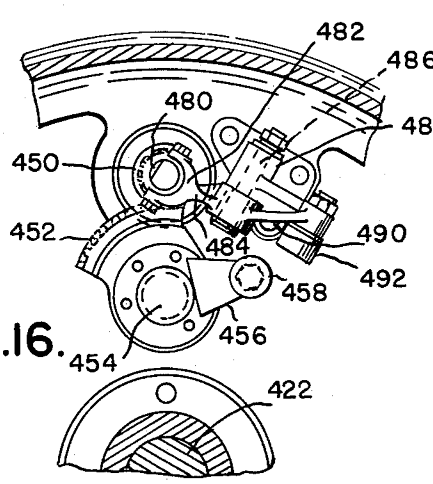


FIG.16.

FIG.18.

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ABRADING OR POLISHING MACHINE

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FIG.5.

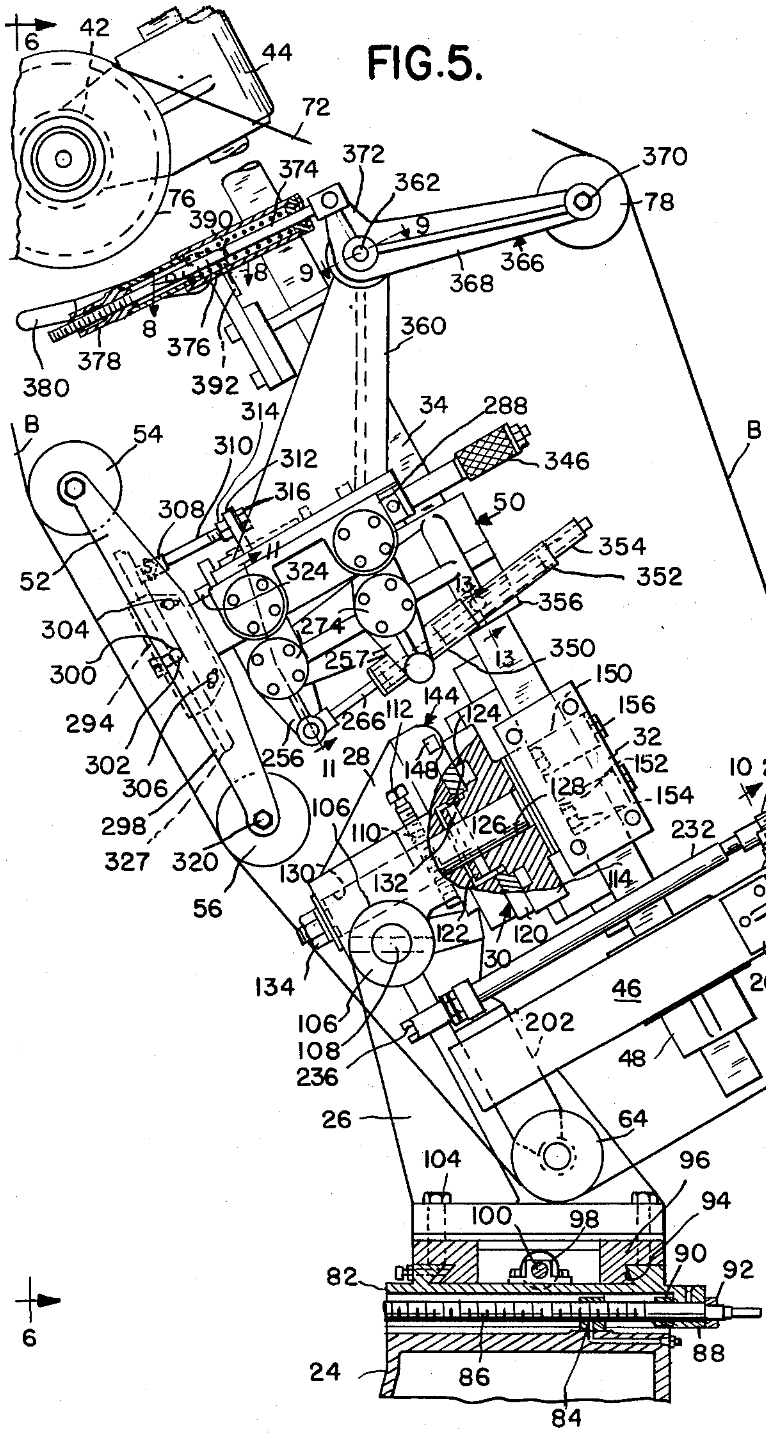
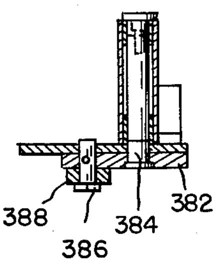


FIG.8.



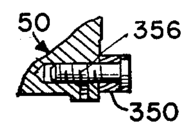


FIG.13.

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ABRADING OR POLISHING MACHINE

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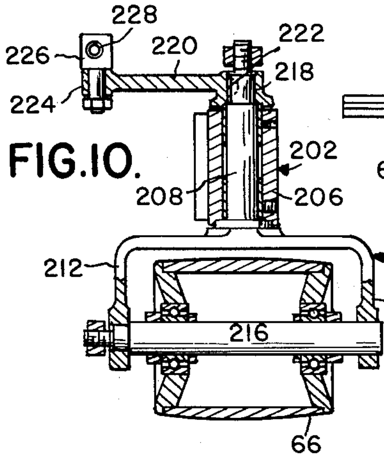

FIG.10.

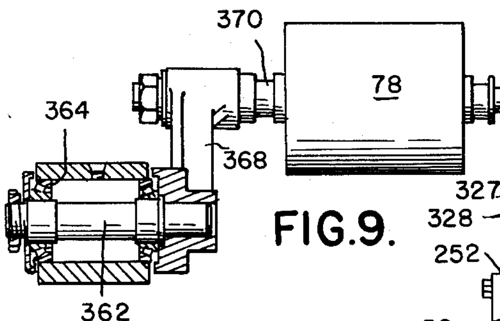

FIG.9.

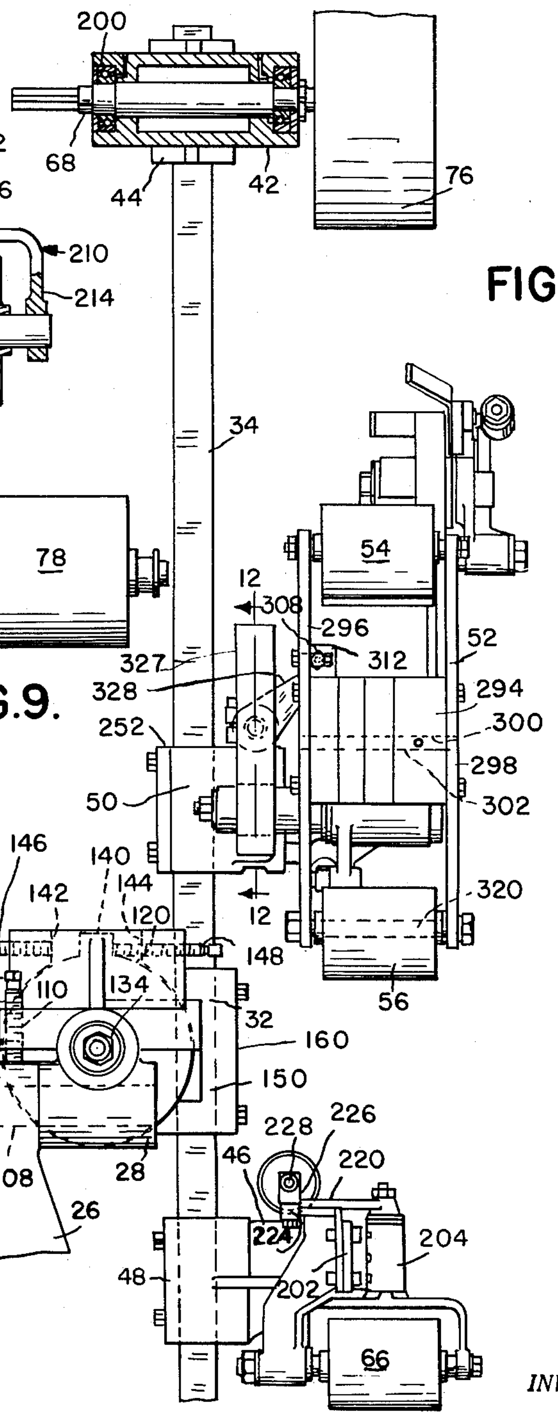

FIG.6.

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ABRADING OR POLISHING MACHINE

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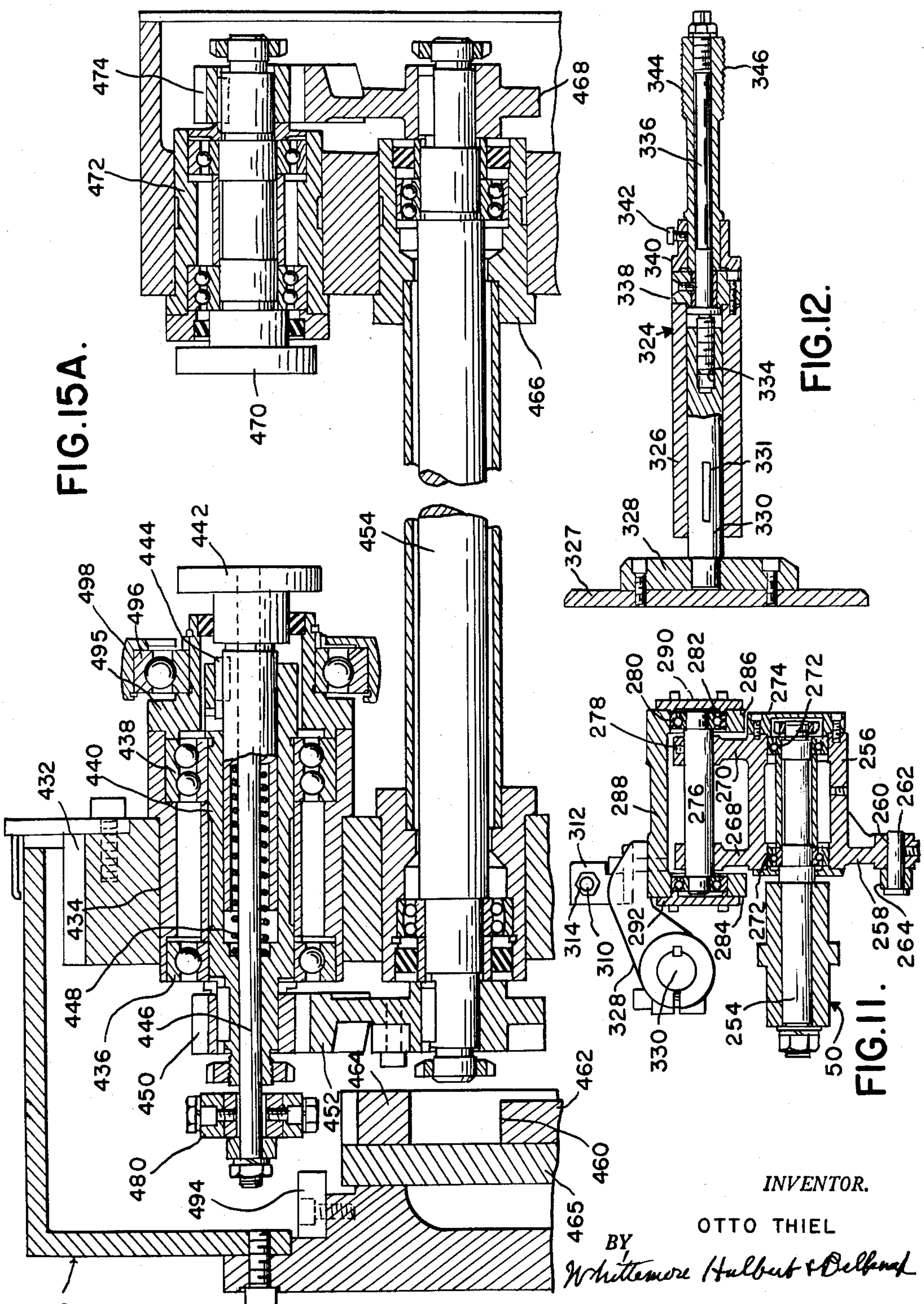

FIG.15A.

FIG.12.

FIG.11.

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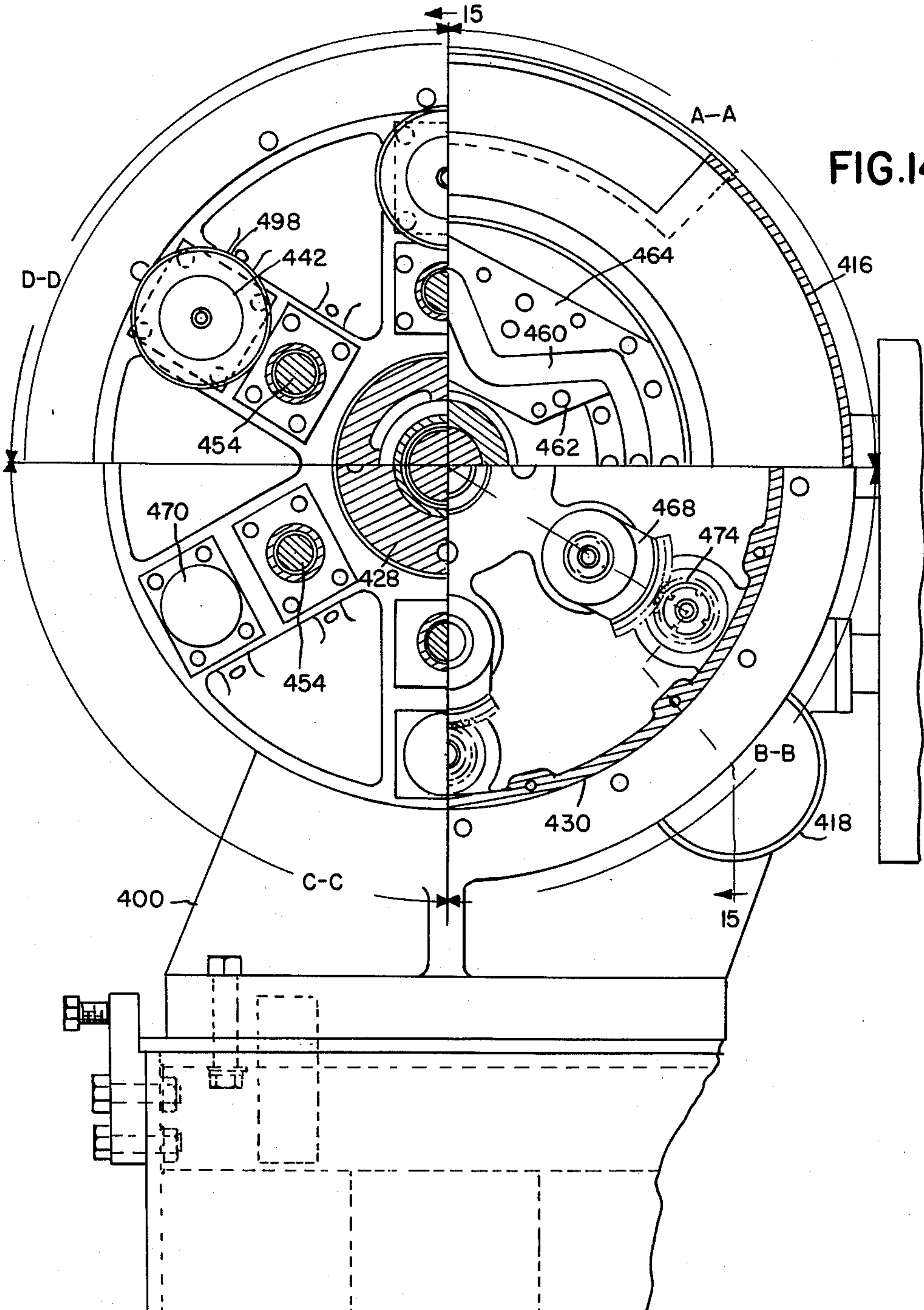

FIG. 14.

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ABRADING OR POLISHING MACHINE

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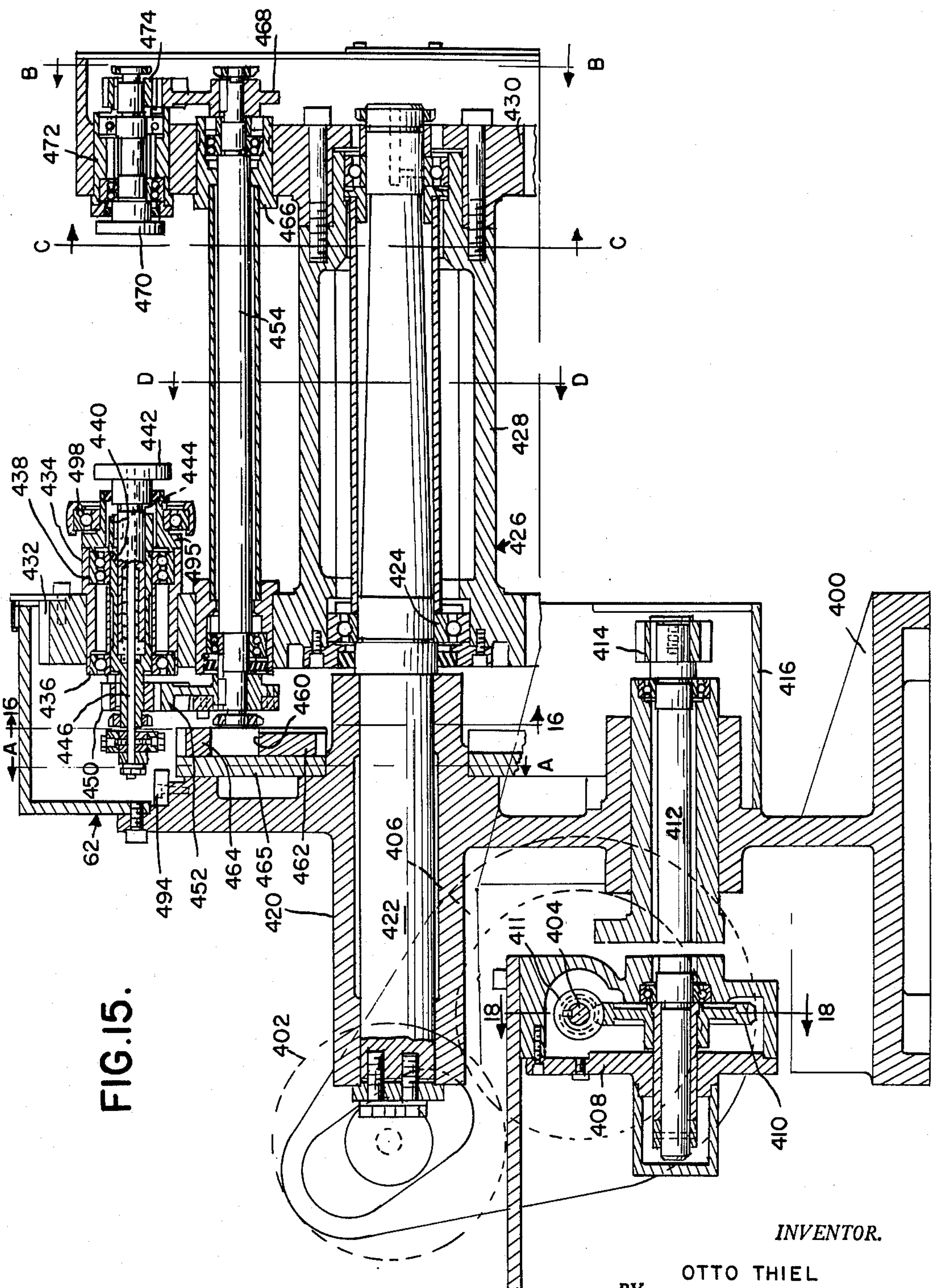

FIG. 15.

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United States Patent Office

2,722,788

Patented Nov. 8, 1955

2,722,788

ABRADING OR POLISHING MACHINE

Otto Thiel, Detroit, Mich., assignor to Midwest Supply and Manufacturing Company, Ferndale, Mich., a corporation of Michigan

Application February 25, 1952, Serial No. 273,188

23 Claims. (Cl. 51—145)

The present invention relates to a machine for finishing the leading edge radius on jet turbine blades. The machine is designed to effect relative movement between a part such as a jet turbine blade and a moving abrasive belt so as to blend the generally cylindrical surface of the leading edge of the blade into the side surfaces thereof.

It is an object of the present invention to provide a machine designed to control the pressure between the belt and the work piece during relative movement therebetween and to permit adjustment of such pressure as required.

It is a further object of the present invention to provide a machine designed to provide for the continuous finishing of a sequence of work pieces which includes a work supporting head including a plurality of work supporting devices, means for rotating the head, means responsive to rotation of the head to effect clamping and unclamping of the work piece, and means responsive to rotation of the head to effect predetermined movement of the work pieces so as to provide for a selected relative motion between the work pieces and a moving abrasive belt.

It is a further object of the present invention to provide in a machine of the character described a moving abrasive belt in combination with a head including means for mounting supporting rollers and means for effecting movement of the supporting rollers toward and away from the path of the work pieces.

More specifically, it is an object of the present invention to provide rotary work supporting means for moving a series of work pieces in a circular path, means for supporting an abrasive belt in position to be intercepted by the path of the work pieces, means for supporting the abrasive belt throughout its zone of contact with the work pieces, and means for effecting movement of the belt supporting means in accordance with movement of the work pieces.

It is a further object of the present invention to provide a machine of the character described comprising means for moving a series of work pieces in a circular path, means for supporting an abrasive belt in position to intercept the path of the work pieces, means for supporting the abrasive belt in its zone of contact with the work pieces, a support for the abrasive belt in such zone, and means automatically operated by movement of the work pieces to effect movement of the support generally away from and toward the path of the work pieces as the work pieces move into and out of contact with the abrasive belt.

It is a further object of the present invention to provide a machine of the character described comprising a support for a plurality of work pieces, means for effecting continuous rotation of the support, means for supporting and driving an abrasive belt, said last means including means for adjusting the position and path of the abrasive belt with reference to the path of movement of the work pieces.

It is a further object of the present invention to provide

a polishing machine characterized by the provision of mechanism for effecting substantially uniform adjustment between the path of the abrasive belt and the path of movement of the work pieces so as to effect control of the pressure between the work pieces and the abrasive belt and the action of the abrasive belt on the work pieces.

Other objects and features of the invention will become apparent as the description proceeds, especially when taken in conjunction with the accompanying drawings, wherein:

Figure 1 is a sectional view through a typical work piece for which the machine is designed.

Figure 2 is a rear elevation of the machine.

Figure 3 is a side elevation of the machine.

Figure 4 is a plan view of the machine.

Figure 5 is a fragmentary side elevation with parts omitted and parts in section, showing the mechanism for supporting and driving the abrasive belt.

Figure 6 is a fragmentary front elevation with parts in section looking in the direction of the arrows **6—6**, Figure 5.

Figure 7 is a fragmentary elevational view of the motor supporting mechanism shown in Figure 6.

Figure 8 is a sectional view on the line **8—8**, Figure 5.

Figure 9 is a sectional view on the line **9—9**, Figure 5.

Figure 10 is a sectional view on the line **10—10**, Figure 5.

Figure 11 is a sectional view on the line **11—11**, Figure 5.

Figure 12 is a sectional view on the line **12—12**, Figure 6.

Figure 13 is a fragmentary sectional view on the line **13—13**, Figure 5.

Figure 14 is an elevational view with parts in section of the work supporting head.

Figure 15 is a transverse sectional view of the mechanism shown in Figure 14, taken on the line **15—15** therein.

In Figure 14 the quadrant A—A represents a section taken on the line A—A, Figure 15; the quadrant B—B represents a section taken on the line B—B, Figure 15; the quadrant C—C represents a section taken on the line C—C, Figure 15; and the quadrant D—D represents a section taken on the line D—D, Figure 15.

Figure 15A is an enlargement of a portion of Figure 15.

Figure 16 is a fragmentary section taken on the line **16—16**, Figure 15.

Figure 17 is an enlarged elevational view with parts in section, of mechanism shown in Figure 16.

Figure 18 is a sectional view on the line **18—18**, Figure 15.

Figure 19 is a diagrammatic view illustrating successive positions of the belt and work piece during a polishing cycle.

Referring now to the drawings, Figure 1 is a transverse sectional view through an elongated jet turbine blade A. This blade has a generally cylindrical end surface **10** the center of curvature of which is indicated at **12**. It is desired to finish the surface **10** and to blend this surface into the side surfaces **14** and **16**. For this purpose the machine illustrated and described herein has been designed.

Referring now to Figures 2, 3, and 4, the major components of the machine are illustrated in the assembled relation.

The machine comprises a work base **20** adapted to support the mechanism for mounting and rotating the work pieces, and a belt base **22** on which is adjustably supported mechanism for mounting and driving the abrasive belt.

Mounted on the belt base **22** is a short pedestal **24** on which is mounted a base bracket **26** for universal adjustment in a horizontal plane as will subsequently be described. A tilt bracket **28** is pivoted to the upper end of the base bracket **26** and has a tilt plate **30** secured thereto for angular adjustment as will subsequently be described in detail.

The tilt plate **30** includes a column bracket **32** which has associated therewith mechanism later to be described, for clamping and supporting an elongated column member **34**.

From the foregoing described mechanism it will be observed that the column **34** is adjustable in any direction in a horizontal plane as a result of the adjustment provided between the base bracket **26** and the short pedestal **24**, and is further mounted for limited but universal angular adjustment as a result of the pivot mounting of the tilt bracket **28** and the swivel mounting of the tilt plate **30** relative to the tilt bracket **28**.

A motor **36** is carried by a motor plate **38** which in turn is carried by a motor support **40** also adjustable with the column bracket **32** to partake of the same adjustments as the column **34**. Mechanism for supporting the abrasive belt B is supported from the column **34**. In general, this mechanism comprises a drive shaft housing **42** carried by a clamp bracket **44** secured to the upper end of the column **34**. At the lower end of the column **34** is a swivel bracket base **46** secured to the column **34** by a clamping sleeve **48**. Intermediate the ends of the column **34** is a clamping bracket **50** which supports a special belt head indicated generally by the numeral **52** which will subsequently be described in detail. In general however, the belt head **52** includes a means for supporting a pair of rollers or pulleys **54** and **56** which provide localized support for the abrasive belt B. The pulleys **54** and **56** are carried by pulley brackets which are mounted for arcuate movement generally toward and away from a work supporting head indicated generally at **62**, as will subsequently be described in detail.

The abrasive belt B is trained over a pair of angularly adjustable pulleys **64** and **66** suitably mounted on the swivel bracket **46**, as will subsequently be described in detail. The drive shaft housing **42** carries a drive shaft **68** which at one end is provided with a sheave **70** adapted to be connected by belting **72** to the drive pulley **74** of the motor **36**. At its opposite end the shaft **68** carries a drive pulley **76** over which the abrasive belt B is trained. A tensioning pulley **78** is provided which is movable with the means supporting the pulleys **54** and **56** so as to maintain tension of the abrasive belt B approximately constant.

Referring now particularly to Figure 5, the pedestal **24** is provided at its upper surface with rectilinearly extending ways **80** (Figure 2). In these ways a bottom slide **82** is received for longitudinal adjustment. Extending upwardly from the upper surface of the pedestal **24** is a stationary nut **84** in which is received an adjusting screw **86**, the screw being journaled in a depending lug **88** at one side of the bottom slide **82** and retained against longitudinal movement by collars **90** and **92**. Obviously, rotation of the screw **86** by a suitable hand tool will effect movement of the bottom slide from front to back of the machine. The bottom slide **82** is provided with rectilinear ways **94** in its top surface and in the ways is received a top slide **96**. The ways **94** extend at right angles to the ways **80** so that by virtue of these angularly disposed ways, movement of the top slide **96** in any direction in a horizontal plane can be obtained. The top slide carries a stationary feed nut **98** in which is received an adjusting screw **100** suitably journaled in the top slide **96** and retained against longitudinal movement therein. The screws **86** and **100**, as seen in Figure 2, may be manipulated by a hand tool **102** to effect movement of the top slide in the ways **80** and **94** laterally of the machine.

Carried by the top slide **96** is the base bracket **26** which as seen in Figure 5, is bolted to the upper surface of the top slide by means of bolts **104**. At its upper end the base bracket **26** has a head portion **106** apertured to receive a shaft **108** (Figure 6) which extends through the head **106** and projects laterally therebeyond. Mounted for angular adjustment on the shaft **108** is the tilt bracket **28** previously referred to. The tilt bracket **28** is provided with a threaded opening **110** through which extends an adjusting screw **112**, the lower end of the adjusting screw, as indicated in Figure 5, being rounded and bearing against the upper surface of the base bracket **26** at a point laterally displaced from the axis of the shaft **108**. Obviously, adjustment of the screw **112** effects rocking movement of the tilt bracket **28** about the axis of the shaft **108**.

Carried by the tilt bracket **28** is the motor support **40** including a bracket **114** having ways indicated at **116** in which is slidably secured a motor mounting plate **118**. The motor bracket **114** is bolted and doweled to a generally flat tilt plate **120** (Figure 5). The motor bracket **114** has projecting therefrom a cylindrical portion **122** which extends through a corresponding opening in the tilt plate **120** into a cylindrical recess **124** provided in the tilt bracket. A stud **126** extends into an opening **128** in the motor bracket and through a corresponding opening **130** in the tilt bracket. The stud **126** has a transverse opening therethrough for the reception of a dowel pin **132** which also extends through the cylindrical portion **122** of the motor bracket so as to retain the motor bracket and tilt plate assembled on the stud. The stud **126** extends through the opening **130** in the tilt bracket and is retained in place by the nut **134**.

The tilt plate **120**, as best seen in Figure 6, includes a radially projecting ear **140** which is received between and spaced from ears **142** and **144** on the tilt bracket **28**. The ears **142** and **144** are tapped to receive adjusting screws **146** and **148**. As will be evident, the tilt plate together with the motor bracket may be angularly adjusted about the axis of the stud **126** by appropriate adjustment of the adjusting screws **146** and **148**.

Secured to one side of the motor bracket **114** is a column bracket **150** which is thereby rigidly secured to the motor bracket and is adjustable therewith. The column bracket **150** includes a mounting base flange **152** bolted to the motor bracket by bolts **154**. The motor bracket also includes a portion surrounding three sides of the column **34**, appropriately drilled to receive additional assembly bolts **156** securing the column bracket to the motor bracket. A column clamp **160** is provided to close the open side of the portion of the column bracket so as to grip the column rigidly in the column bracket.

From the structure just described it will be observed that the column and motor bracket are adjustable as a unit as indicated below. Due to the angularly disposed horizontally extending ways **80** and **94** the column and the structure carried thereby may be adjusted in any direction in a horizontal plane. By adjustment of the adjusting screw **112** the column and structure carried thereby may be angularly adjusted about the axis of the shaft **108**. In like manner by appropriate adjustment of the screws **146** and **148** the column **34** and structure carried thereby may be angularly adjusted about the axis of the stud **126**.

As best seen in Figure 6, the drive shaft housing **42** is journaled and contains bearings **200** for mounting the drive pulley shaft **68**.

At the opposite end of the column **34** the swivel bracket base **46** is provided at its opposite ends with a fixed bracket **202** and a swivel bracket **204**. As best seen in Figure 10, the swivel bracket **204** includes a sleeve portion **206** in which is journaled a cylindrical portion **208** of a pulley swivel bracket **210**. The pulley swivel bracket **210** includes a pair of spaced arms **212** and **214** between which is journaled a belt pulley spindle **216** carrying the pulley **66**. At its opposite end the cylindrical portion **208** of the bracket **210** is reduced and received within the apertured end **218** of the tracking lever **220**, the lever being secured to the reduced portion by means of a key

222. At its outer end the tracking lever 220 includes an eye 224 in which is swiveled an alignment screw pivot member 226 having a threaded opening 228 therethrough.

Belt alignment adjusting means are provided cooperating with the alignment screw pivot member 226 which is associated with the swivel bracket 204. Threaded within the openings in the screw pivot member 226 is a threaded element slidably associated with a pulley alignment shaft 232 having a hand wheel 234 at one end and a universal connection indicated generally at 236 at the opposite end. As best seen in Figure 3, the universal connection 236 provides connection to a remote adjusting rod 238 extending to the front of the machine where it is provided with a hand wheel 240. Thus, the angularity of the pulley 66 may be adjusted from either the front or the back of the machine. This adjustment is provided for the purpose of controlling belt alignment with the several pulleys over which the abrasive belt is trained.

Referring now particularly to Figures 5, 6, 11 and 12, there is shown the mechanism for supporting and controlling the action of the portion of the abrasive belt in contact with the work. A shoe clamp sleeve 50 is secured to the column 34 by a column clamp piece 252. The shoe clamp sleeve 50 extends generally downwardly from the column 34 and is provided with a pair of clamp sleeve spindles 254, one of which is shown in detail in Figure 11. Referring to this figure, it will be observed that the clamp sleeve spindles 254 extend laterally from the shoe clamp sleeve 50 and receive lever devices 256 and 257. In detail, the lever devices 256 and 257 include arms 258 having apertured heads 260, one of which is adapted to receive a pivot pin 262 for connection to a tension rod pivot block 264 connected to a spring tension rod 266, the latter being shown in Figure 5. The lever devices 256 and 257 include spaced webs 268 and 270 apertured to receive bearings 272 engaging the clamp sleeve spindles 254. The outer ends of the apertures are closed by removable bearing covers 274 and these two bearing covers are shown in Figure 5.

Adjacent the upper ends of the lever devices 256 and 257 are openings receiving shoe base spindles 276, the ends of these spindles extending laterally beyond the webs 268 and 270. The spindles are locked in position by set screws 278 and at their outer ends carry bearings 280, portions of which are journaled in openings 282 formed in depending webs 284 and 286 of a shoe base 288. The shoe hase 288 is of generally U-shaped cross-section, as best seen in Figure 11, and is provided with a pair of bearing covers 290 and 292 at each side thereof. The bearing covers 290 and 292 also appear in Figure 5, thus indicating the location of the two shoe base spindles in this view.

The shoe base 288 includes a head 294 to the sides of which are secured a pair of shoe pulley bracket plates 296 and 298. The plates 296 and 298 are provided with openings 300 for the reception of a pin by means of which the plates 296 and 298 may be angularly adjusted with respect to the head 294 of the shoe base 288. To permit this adjustment plates 296 and 298 are provided with elongated slots 304 through which clamping screws 306 are extended so that when the clamping screws are loosened the plates may be adjusted about the axis of the pin 302. To effect this adjustment one of the plates, as for example the plate 296 in Figure 6, is provided with a bracket 308 to which is swiveled an adjusting rod 310 passing through an opening in a bracket 312 carried by the shoe base 288. The rod 310 carries adjusting nuts 314 and 316 so that by loosening one nut and tightening the other upper ends of the plates 296 and 298 may be moved forwardly or rearwardly. At their opposite ends the plates 296 and 298 are apertured to receive shoe pulley spindles 320 carrying the pulleys 54 and 56 previously described. The abrasive belt B engages the pulleys 54 and 56 which provide local support for the belt in the abrading zone.

Inasmuch as the work pieces move in a circular arc a segment of which is intercepted by the normal position of the abrasive belt, it will be appreciated that variable pressure between the work piece and the abrasive belt would result unless special means are provided to avoid it. The mechanism for supporting the shoe base 288 permits movement of the abrasive belt in a particular manner to produce the desired results.

As will subsequently be described, each of the individual work supports includes a rigid guide roller which is located beyond one end of the work piece. To cooperate with this guide roller the shoe base 288 has rigidly secured thereto a bracket 324 including a cylindrical sleeve portion 326. As best seen in Figure 12, a shoe guide bar 327 is bolted or otherwise rigidly secured to a shoe guide bracket 328, the latter being fixed to one end of a shoe guide shaft 330 slidably received within the sleeve portion 326 of the shoe adjustment bracket 324. Key means indicated at 331 are provided to prevent rotation between the shoe guide shaft 330 and the sleeve portion 326. In order to effect adjustment of the shoe guide bar 327 relative to the shoe base 288, the inner end of the shaft 330 is tapped as indicated at 334 and receives the threaded end of an adjusting screw 336. A screw bearing block 338 is bolted to the end of the sleeve portion 326 and a clamping collar 340 is provided which surrounds the screw 336, the collar being provided with a lock screw 342. The screw 336 has connected thereto an adjustment sleeve 344 the outer end of which is knurled as indicated at 346 (Figure 5). Obviously, rotation of the sleeve 344 results in rotation of the screw 336 and accordingly results in movement of the shaft 330 and the shoe guide bar 327.

Secured to the lower end of the forward lever 256 as previously described, is the spring tension rod 266 which extends within a spring housing comprising the spring cover tubes 350 and 352. The tension rod 266 includes a tension adjusting nut 354 to adjust the effectiveness of spring means located within the spring housing. The spring housing as a unit is mounted for rocking movement about a pin 356 (Figure 13) so that as the lever 256 moves in an arc about the axis of the clamp sleeve spindle 254 the spring housing rocks about the axis of the pivot pin 356. It will be observed that the spring mechanism is connected only to the lever 256, but since the lever 257 is interconnected to the lever 256 through the shoe base 288, it will be appreciated that the spring mechanism serves to provide a predetermined selected force tending to rock the levers 256 and 257 in a counterclockwise direction as seen in Figure 5.

As the work pieces revolve the guide rollers contact the shoe guide bar 327 and thus effect positive rearward movement of the shoe base 288 and hence of the pulleys 54 and 56. Thus the supporting rollers are moved toward and from the work piece in accordance with the arcuate path of movement of the work piece past the abrasive belt.

The angular position of the bracket plates 296 and 298 moreover permits the relative movement between the supporting rollers and the work piece to be variable so as to effect a desired pressure and hence a desired finishing action of the abrasive belt on particular portions of the work piece. As will subsequently be described, the work piece is turned on its axis or oscillated while it is in contact with the abrasive belt and by proper setting of the angularity of the plates 296 and 298 the pressure between the abrasive belt and the work piece may be substantially uniform or increasing or decreasing throughout the time the belt is in contact with each particular work piece.

Inasmuch as movement of the shoe base 288 in response to the camming action of the guide rollers on the shoe guide bar 327 tends to vary the overall tension of the abrasive belt B it is necessary to provide means for controlling this tension. This mechanism comprises a belt tightener bracket 360 rigidly secured to the shoe base 288 and carrying at its upper end a pivot pin 362 provided with bearings 364. The pivot pin 362 carries a bell crank lever 366 including a relatively long arm 368 carrying a pin 370 on which is mounted the tension roller 78. The lever 366 includes a shorter arm 372 connected to a spring tension rod 374 extending into a housing 376. The spring tension rod includes a tension adjusting nut 378. Means are provided for relieving the abrasive belt B of tension and this means comprises a release lever 380 pivoted to a stop plate 382 as indicated at 384 and pivoted by a pin 386 to a pivot 388 carried by the housing 376. The lever 380 includes a nose 390 adapted to engage an abutment 392 in over-center relation when the spring housing has been moved to the left as seen in Figure 5, by clockwise movement of the lever 380 to the position illustrated. At this time the tension exerted by the roller 78 is determined by the adjustment of the nut 378. However, when the lever 380 is swung in a counterclockwise direction all of the tension of the spring means located within the housing 376 is relieved.

Referring now more particularly to Figures 14–18, the work supporting means comprises a rotor base 400 bolted or otherwise suitably secured to the top of the work base 20. Mounted on the rotor base 400 is a motor 402 adapted to drive a worm shaft 404 through a belt connection driven from a pulley on the motor and connected to a pulley 406 connected to the worm shaft 404. The rotor base 400 is shaped to provide housing structure indicated generally at 408 including the worm wheel 410 in mesh with a worm 411 carried by the worm shaft 404 whereby a substantial speed reduction occurs between the motor and a shaft 412, keyed or otherwise secured to the worm wheel 410. At the opposite end of the shaft 412 there is provided a driving pinion 414. Secured to the rotor base 400 is a cover member 416 which is of generally circular outline but as seen in Figure 14, has an offset portion 418 which houses the pinion 414. The rotor base 400 includes a sleeve 420 in which is mounted a rotor stud 422. Mounted on the rotor stud 422 are suitable bearings indicated at 424 carrying a rotor base head 426. The rotor base head 426 is of generally circular construction and includes a laterally extending sleeve 428 to the outer end of which is rigidly secured a rotor base tail 430. The rotor base head is provided with an external gear 432, the teeth of which mesh with the teeth of the pinion 414. Accordingly, the rotor base head and tail are rotated as a unit by the pinion 414.

The rotor base head in general is provided with a plurality, and as illustrated herein six, of driving and work supporting assemblies. In general a plurality of driving head chuck spindles are carried by the rotor base head and a corresponding number of rotatable tail spindles are provided in the rotor base tail. Work pieces are supported between the head and tail spindles, suitable work supporting fixtures (not shown) being provided in accordance with the exact shape of the work piece.

Since the several work supporting and driving assemblies are identical only one will be described in detail. The head supporting structure comprises a head bearing block 434 containing bearings 436 and 438 in which is journaled a head shaft 440. The inner end of the head shaft 440 is recessed and slidably receives the inner end of the head chuck spindle 442, rotation between these parts being prevented by a key 444. Secured to the head chuck spindle is a pull rod 446, the inner end of the head chuck spindle being enlarged to define with the pull rod an annular space for the reception of a compression spring 448. At its outer end the head shaft 440 has keyed or otherwise secured thereto a pinion 450. As best seen in Figures 16 and 17 the pinion 450 meshes with a gear segment 452 keyed to the inner end of a jack shaft 454 which extends between the rotor base head 428 and the rotor base tail 430. Secured to the gear segment 452 is an arm 456 carrying a cam follower roller 458. The cam follower roller is adapted to enter into a cam track 460 defined between inner cam blocks 462 and outer cam blocks 464 carried by a cam base plate 465 which in turn is mounted on the rotor base 400. In general, the cam track 460 throughout the major portion of its circumference is at a constant radius. However, at the appropriate zone when the work piece carried by the associated head chuck spindle is in engagement with the abrasive belt, the cam track departs from its constant radius and imparts a predetermined back and forth oscillation to the work piece.

The opposite end of the jack shaft 454 extends through a bearing block 466 in the rotor base tail 430 and carries a gear segment 468 of similar shape to the gear segment 452. The tail spindle 470 is journaled in a tail bearing block 472 and carries a pinion 474 keyed or otherwise secured thereto which is identical with the pinion 450. Accordingly, oscillation of the arm 456 by the cam follower 458 results in oscillation of the gear segments 452 and 468 which in turn results in corresponding oscillation of the head chuck spindle 442 and the tail spindle 470.

In addition to the foregoing, automatic means are provided for effecting movement of the head chuck spindle toward and away from the tail spindle at the appropriate time so as to permit ease in loading and unloading the machine. Specifically, as a particular work supporting assembly approaches the front of the machine where the operator stands, the head chuck spindle retracts, thus permitting a finished work piece to be removed directly from the machine. After a predetermined further rotation the head chuck spindle again moves toward the tail spindle so that suitable work supporting fixtures carried by the tail spindle and the head chuck spindle may engage a work piece. Accordingly, it is only necessary for the operator to grasp a work piece as it is released by movement of the head chuck spindle and to replace it with an unfinished work piece which will be automatically gripped by movement of the head chuck spindle toward the tail spindle. The pressure on the work piece between the tail spindle and the head chuck spindle is determined by the effectiveness of the compression spring 448.

At its outer end the pull rod 446 is provided with a thrust collar 480 to which is pivoted a yoke 482 of a lever 484, best seen in Figure 16. The lever 484 is supported for rotation intermediate its ends by means of a pin 486 supported in a chuck lever bracket 488. The lever 484 includes a second arm 490 carrying a roller 492 adapted to engage a circular cam track 494. As each work supporting mechanism approaches the loading zone the roller 492 rides up on an elevated portion of the cam track 494 which swings the lever 484 in the appropriate direction to move the thrust collar 480 to the left as seen in Figure 15, thus moving the work supporting fixture carried by the head chuck spindle 442 to the left and permitting ready withdrawal of a finished work piece. Further rotation of the rotor base mechanism causes the roller 492 eventually to ride off the elevated portion of the cam at which time the head chuck spindle 442 moves to the right under the influence of the spring 448, thereby clamping a work piece in proper position for the subsequent abrading operation.

Secured to the outer end of the head bearing block 434 is a member 495 carrying a bearing 496 on which is mounted a guide roller or bearing tire 498. The guide roller 498 is thereby rigidly supported coaxially with the associated work piece. It is this guide roller which engages the shoe guide bar 327 previously described, so as to effect swinging movement of the supporting rollers 54, 56 as previously described.

Referring now to Figure 19 there is illustrated the position of a work piece relative to the abrasive belt as it moves through the active arc of its movement. In this figure, the work piece is designated as A and the line 500 represents the line of the abrasive belt in the position in which it is closest to the axis 502 about which the work pieces revolve. As previously described, the work pieces A includes generally cylindrical edges 10 which it is desired to finish with the abrasive belt and to blend these surfaces smoothly to the side surfaces 14 and 16. Accordingly, the work supporting fixtures are arranged such that the axis 12 of the several work pieces is coincident with the axis of rotation of the head chuck spindle and tail spindles.

At 504 a work piece is illustrated in the position A1 just contacting the abrasive belt, the operating portion of which is illustrated in position B1 as determined by location of the supporting rollers 54, 56. It will be observed from this portion of the figure that initial contact between the work piece A and the belt B is substantially at the junction between the side surfaces 14 and the adjacent cylindrical portion 10. As the work piece moves from the position A1 to the position A2 along an arcuate path designated generally at C, the work piece is oscillated about the axis 12 in a clockwise direction so that when it contacts the belt in the position B2 it is in contact with approximately the mid-portion of the cylindrical portion 10 of the work piece. When the work piece has moved to the position A3 and the abrasive belt has been moved to the position B3 the belt is approaching contact with the portion of the cylindrical surface 10 most closely adjacent to the side surface 16. This motion continues to the position A4 of the work piece and a corresponding position B4 of the belt. As the work piece starts upon its arc of recession it moves counterclockwise to the successive positions A5, A6, A7, A8, and A9 which again causes the contact between the belt as represented in the successive positions B5, B6, B7, B8 and B9 to move back over the cylindrical portion of the work piece substantially to the point of initial contact. In other words, the position of the work piece and belt at A1, B1 and A9, B9 are approximately the same and represent a back and forth oscillation of the work piece about the axis 12 of its cylindrical surface 10.

Inasmuch as the abrasive belt B has been moved by positive camming action to compensate for the arcuate path of the work piece, the pressure between the abrasive belt and the work piece may be substantially constant throughout, or, as previously described, may be caused to increase or decrease more or less uniformly throughout the abrading operation.

The drawings and the foregoing specification constitute a description of the improved abrading or polishing machine in such full, clear, concise and exact terms as to enable any person skilled in the art to practice the invention, the scope of which is indicated by the appended claims.

What I claim as my invention is:

1. Apparatus of the class described comprising means for supporting and driving a continuous abrasive belt, means for effecting continuous revolution of a work piece in an arcuate path impinging the belt, means for supporting the portion of the belt engaged by the work piece comprising a pair of rollers spaced from opposite ends of the zone of impingement, means mounting said pair of rollers for movement generally toward and away from the path of movement of the work piece, and camming means including a part movable with a work piece for moving said pair of rollers in accordance with movement of the work piece to control the pressure between the belt and work piece said camming means comprising a plate generally parallel to the line joining the axes of said pair of rollers, and a cam movable with the work piece in its arcuate travel.

2. Apparatus as defined in claim 1 comprising means for adjusting said plate relative to said pair of rollers in a direction toward and away from the axis about which the work piece revolves.

3. Apparatus as defined in claim 1 comprising means for relatively adjusting the angularity between said plate and the plane joining the axes of said pair of rollers.

4. An abrasive belt head comprising a movable support, a pair of rollers on said support, a belt passing over said rollers, means mounting said support for movement generally perpendicular to the plane containing the axes of said rollers, a plate rigidly carried by said support generally parallel to the plane containing the axes of said rollers, a work support movable in a circular path intersecting the plane of said belt intermediate said rollers, and means movable with said work support engageable with said plate to move said support in a direction generally perpendicular to the plane containing the axes of said rollers.

5. Structure as defined in claim 4 in which means are provided for relatively adjusting said plate and support in a direction generally perpendicular to the plane containing the axes of said rollers.

6. Structure as defined in claim 4 in which means are provided for effecting angular adjustment between said plate and said support about an axis parallel to the plane containing the axes of said rollers.

7. Apparatus of the class described comprising a base having horizontal ways thereon, a lower slide movable on said ways and having horizontal ways thereon extending at an angle to said first ways, an upper slide movable on said second named ways, a bracket on said upper slide, a second bracket swiveled to said first bracket for adjustment about a horizontal axis, a swivel plate carried by said second bracket for adjustment relative thereto about an axis perpendicular to said first axis, a column clamp carried by said plate, a column mounted in said column clamp, roll support brackets carried by said column adjacent opposite ends thereof, a work head carried by said base including a plurality of work supports, means for rotating said head, and means operable by rotation of said head to rotate said work supports on said head.

8. Apparatus of the class described comprising a base having horizontal ways thereon, a lower slide movable on said ways and having horizontal ways thereon extending at an angle to said first ways, an upper slide movable on said second named ways, a bracket on said upper slide, a second bracket swiveled to said first bracket for adjustment about a horizontal axis, a swivel plate carried by said second bracket for adjustment relative thereto about an axis perpendicular to said first axis, a column clamp carried by said plate, a column mounted in said column clamp, roll support brackets carried by said column adjacent opposite ends thereof, a work head carried by said base including a plurality of work supports, means for rotating said head, and means operable by rotation of said head to effect gripping and releasing of work pieces by said work supports.

9. In apparatus of the class described, a work supporting head, a plurality of work supporting devices arranged on said head in a circular array, means for revolving said devices continuously about a central axis, and means responsive to revolution of said devices about said axis to effect individual back and forth oscillation of said devices during continued revolution thereof about axes parallel to said central axis said last means comprising a fixed cam, and a cam follower operatively connected to each of said devices.

10. Structure as defined in claim 9 comprising gear members interconnecting said cam followers and said work supporting devices.

11. Apparatus for finishing a work piece which comprises an abrasive belt, a plurality of rollers for supporting and driving said belt including a pair of parallel support rollers movable as a unit in a direction substantially perpendicular to the plane containing the axes thereof, belt tensioning means operable to maintain the portion of said belt intermediate said pair of rollers substantially in a plane, work support means comprising means for

effecting continuous revolution of a work support in an arcuate path intersecting said plane and having an arc of approach toward and an arc of recession from said plane during which a work piece carried thereby is in contact with said belt, and cam means including a member movable with said work support for moving said pair of rolls away from said work support during its arc of approach relative to said plane and toward said work support during its arc of recession from said plane to control belt pressure on a work piece.

12. Apparatus as defined in claim 11 which comprises means for effecting both forward and backward rotation of said work support during engagement between a work piece carried thereby and said belt.

13. Apparatus of the class described comprising an abrasive belt, means for driving said belt, means for supporting said belt in a working zone comprising a pair of belt supporting rollers spaced apart to define said working zone therebetween, a work support, means for effecting continuous advance of said work support through said working zone with a work piece carried thereby in continuous contact with said belt, means for effecting angular movement of said work support about an axis perpendicular to its direction of advance while it remains in said zone, and means responsive to the continued movement of said work support through said zone to effect relative movement between said work support and said rollers in a direction generally perpendicular to the plane containing the axes of said rollers to control the pressure between a work piece and said belt.

14. Apparatus as defined in claim 13 in which said last means comprises cam means operatively connected to said work support and rollers.

15. Apparatus as defined in claim 13 which comprises a holder for said rollers, means mounting said holder for movement in a direction generally perpendicular to the plane containing the axes of said rollers, resilient means operatively connected to said holder to urge said holder toward said work support, and cam means carried by said holder and work support operable to move said holder against the force of said resilient means.

16. Apparatus as defined in claim 15 which comprises means for effecting relative angular adjustment between said cam means and said holder about an axis parallel to said plane to produce a varying pressure between a work piece and said belt as the work piece moves through said zone.

17. Apparatus of the class described comprising means for effecting continuous movement of a work support in an arcuate path, means for supporting and driving an abrasive belt including a pair of parallel rollers supporting a section of the belt in position to be engaged by a work piece on said work support and cam means including a camming member movable with said work support in its arcuate path of travel.

18. Structure as defined in claim 17 which comprises means for adjusting the pressure between the belt and work piece.

19. Structure as defined in claim 17 comprising an angularly adjustable member engageable by said camming member to provide selectively uniform, increasing and decreasing belt pressure on a work piece.

20. Structure as defined in claim 17 comprising a cam plate having a camming surface generally parallel to the plane joining the axes of said pair of rollers and engageable by said camming member, said plate and rollers being movable as a unit.

21. Structure as defined in claim 20 comprising means for effecting relative adjustment between the plane joining the axes of said supporting rollers and camming surface of said plate.

22. Structure as defined in claim 20 comprising spring means opposing movement of said supporting rollers away from the path of movement of said work support.

23. Structure as defined in claim 20 comprising parallel linkage means supporting said supporting rollers for movement generally toward and away from the path of movement of said work support.

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