Aug. 13, 1946. B. S. T. BISHOP ET AL 2,405,550

PROFILE MILLING MACHINE

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Fig. 1.

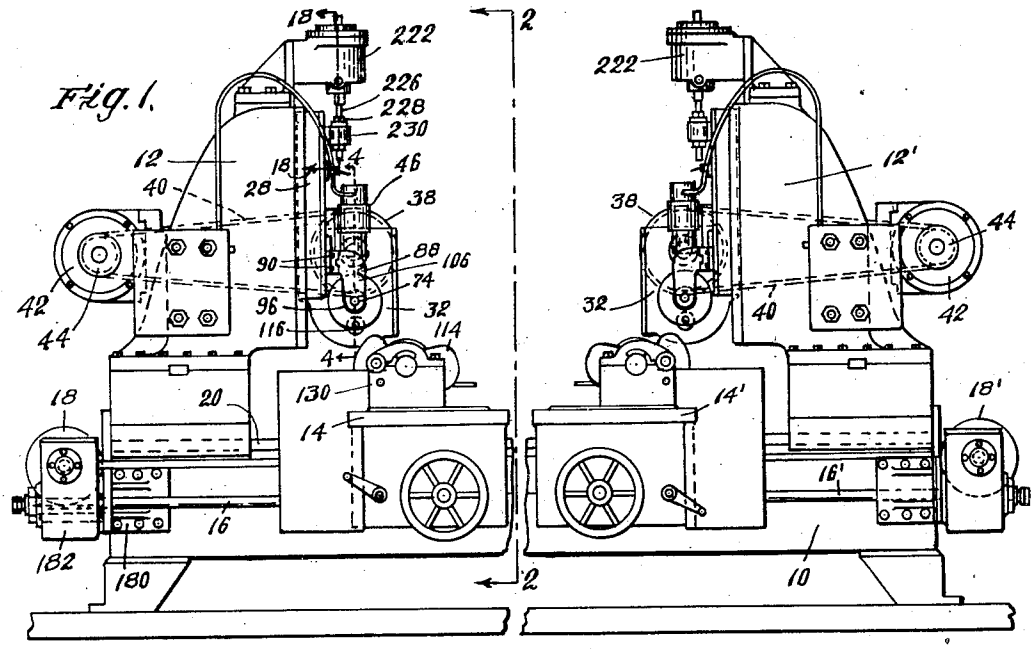


Fig. 4.

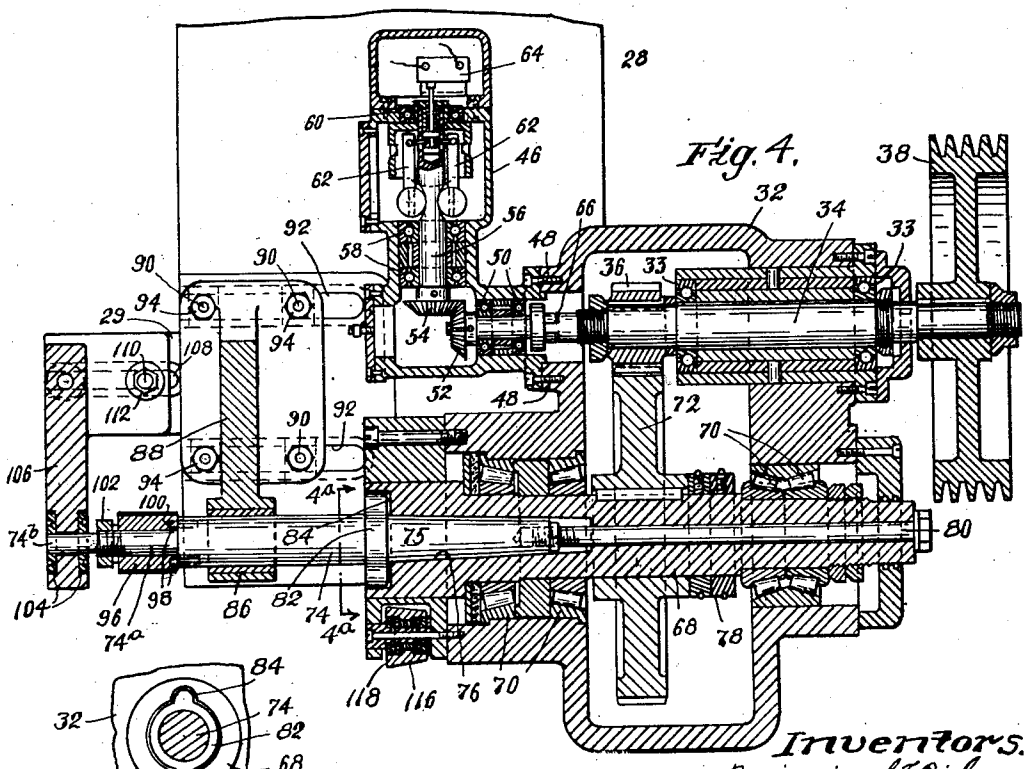


Fig. 4a.

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PROFILE MILLING MACHINE

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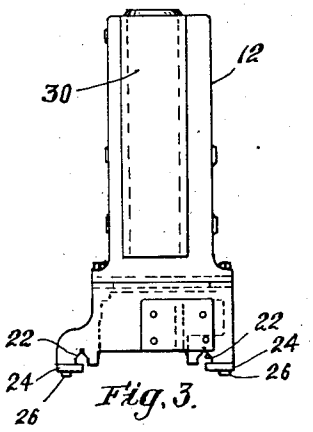


Fig. 3.

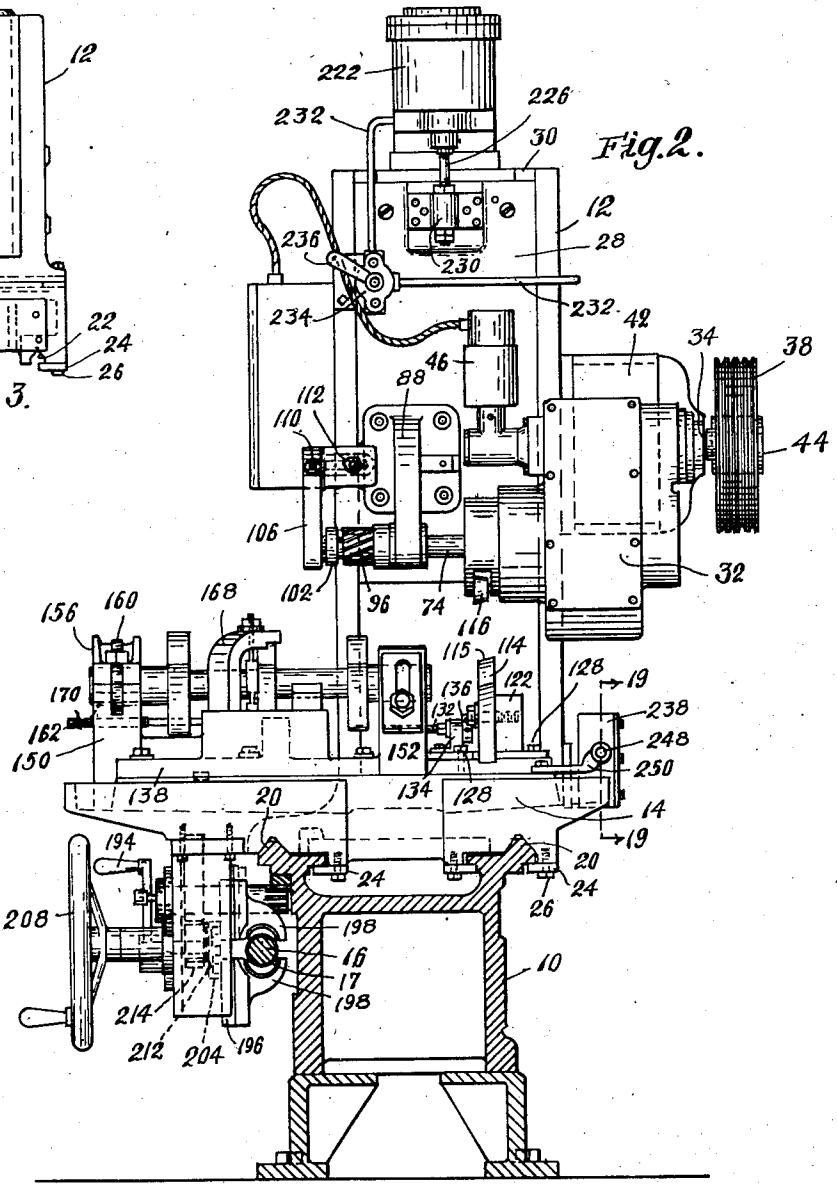


Fig. 2.

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PROFILE MILLING MACHINE

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Fig. 5.

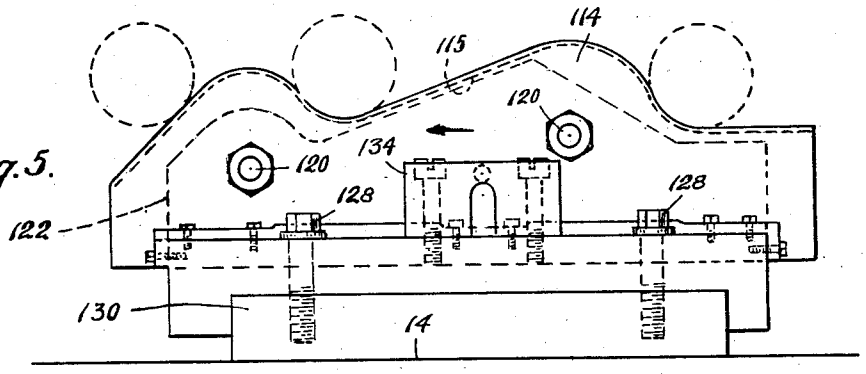


Fig. 6.

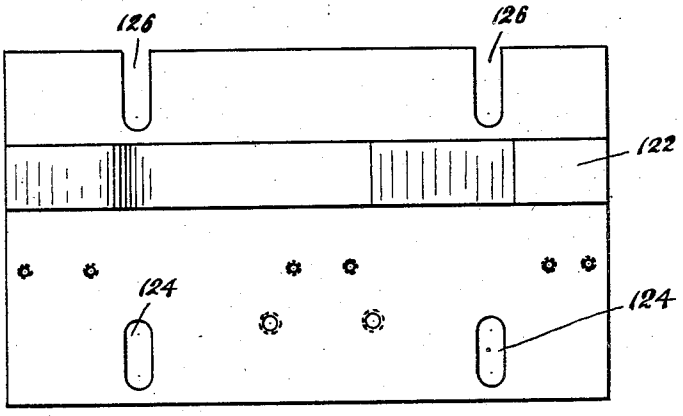
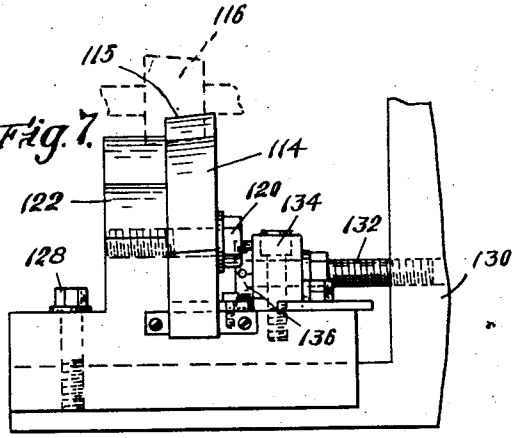


Fig. 7.



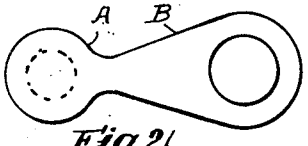


Fig. 21.

Fig. 8.

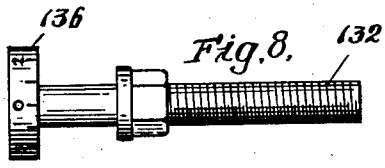
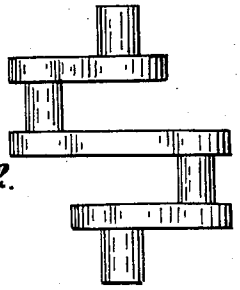


Fig. 12.



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PROFILE MILLING MACHINE

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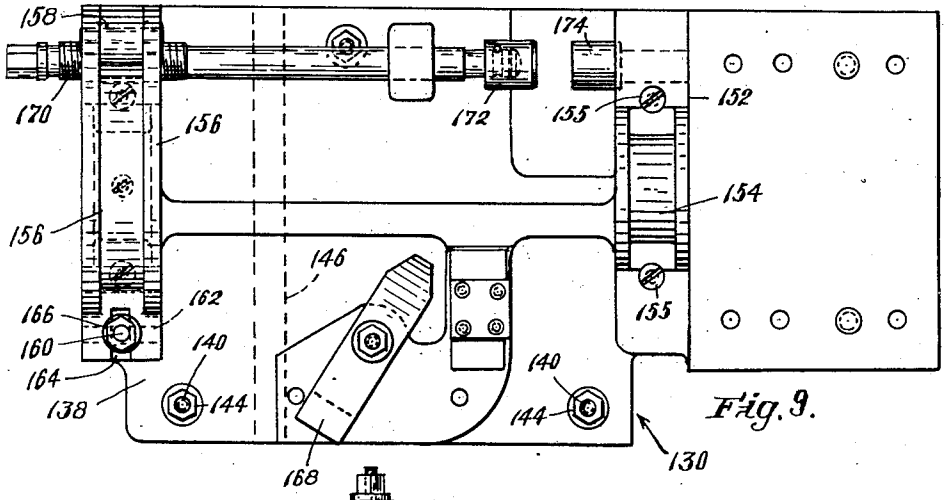


Fig. 9.

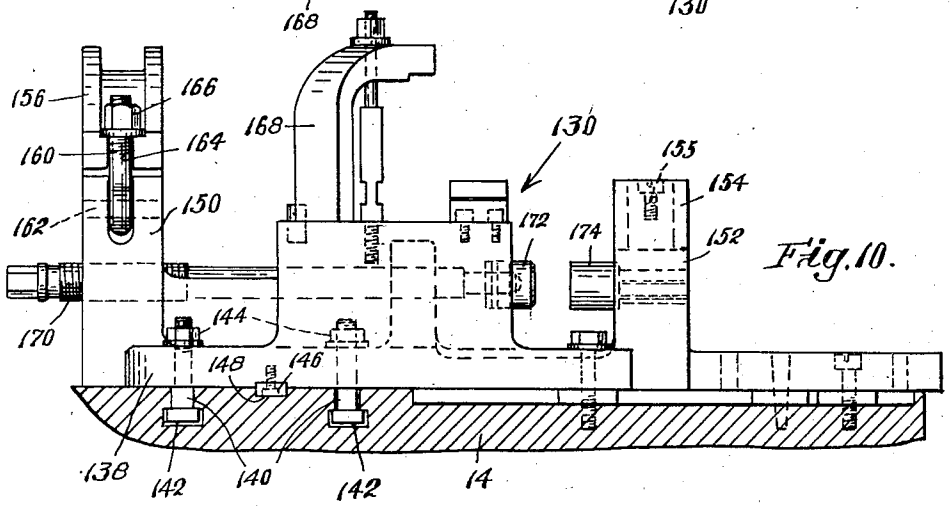


Fig. 10.

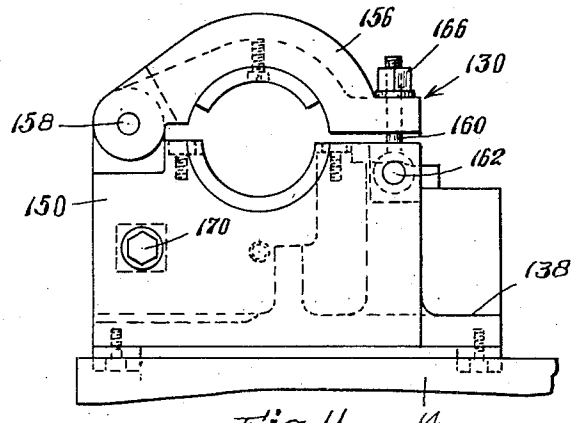


Fig. 11.

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PROFILE MILLING MACHINE

Filed Dec. 9, 1943 7 Sheets-Sheet 5

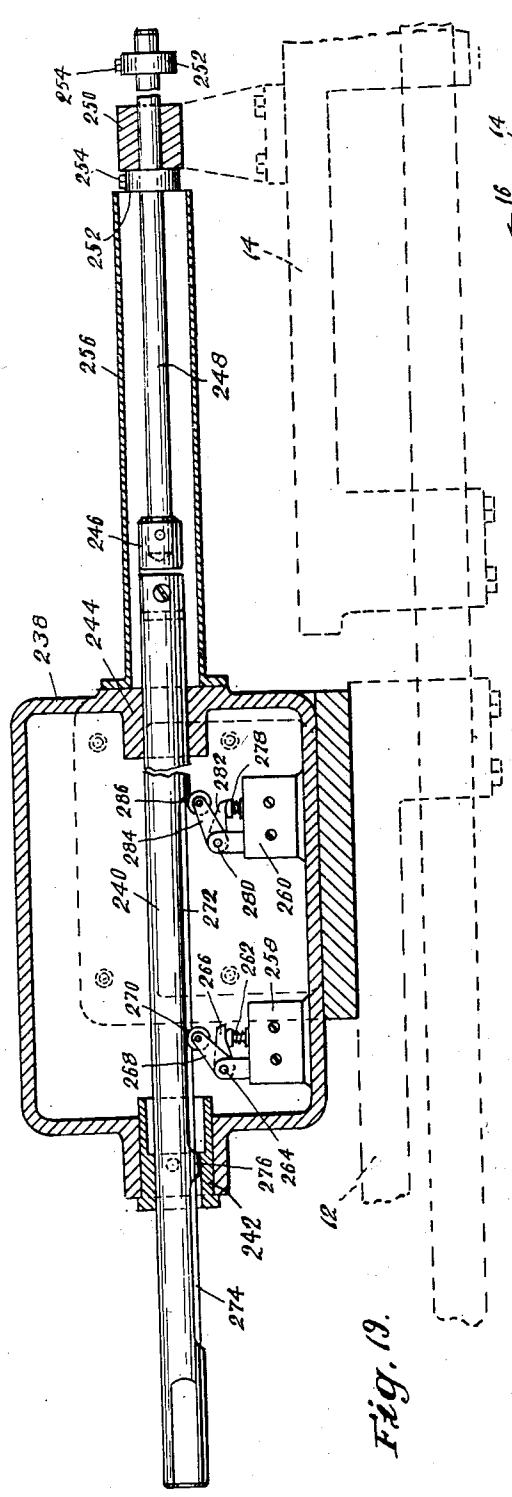


Fig. 19.

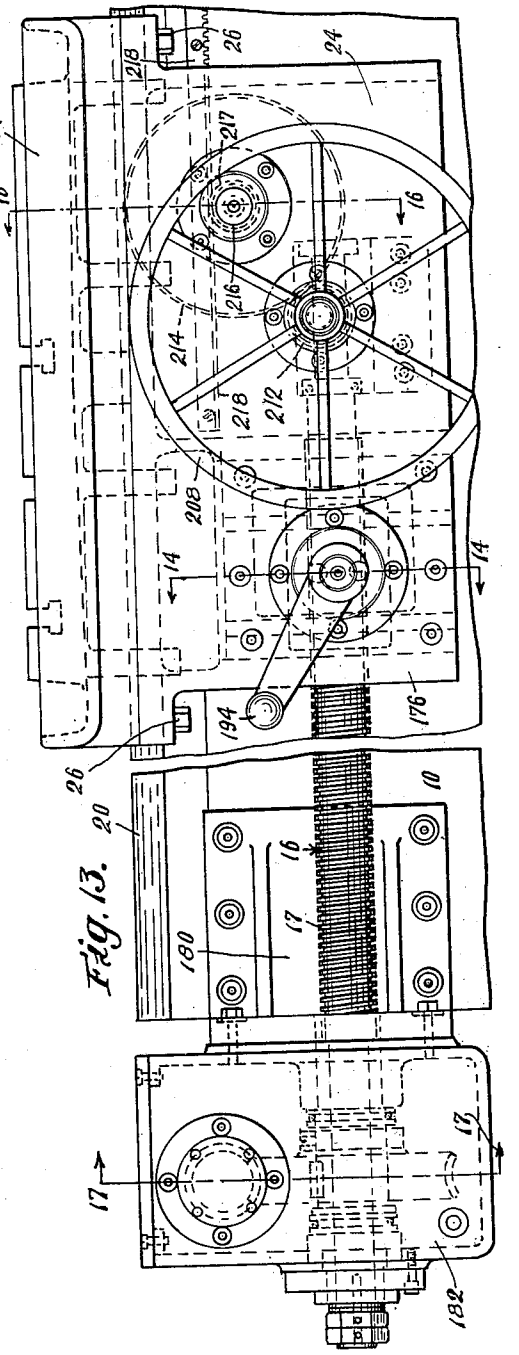


Fig. 13.

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PROFILE MILLING MACHINE

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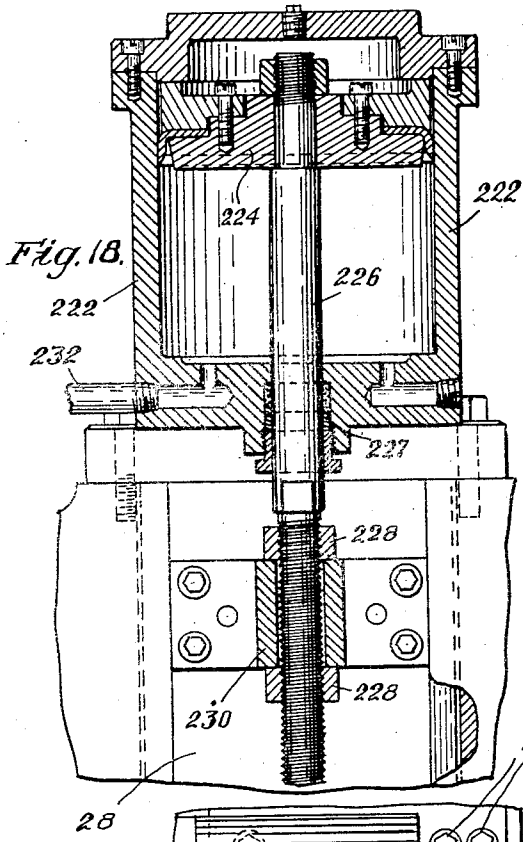


Fig. 18.

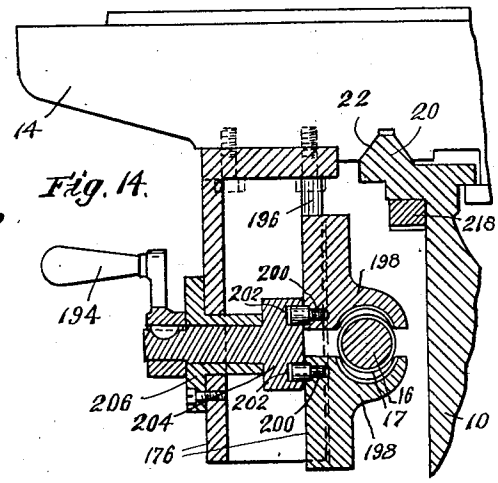


Fig. 14.

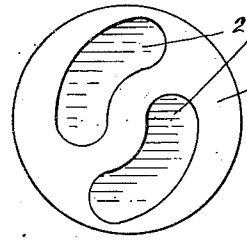


Fig. 15.

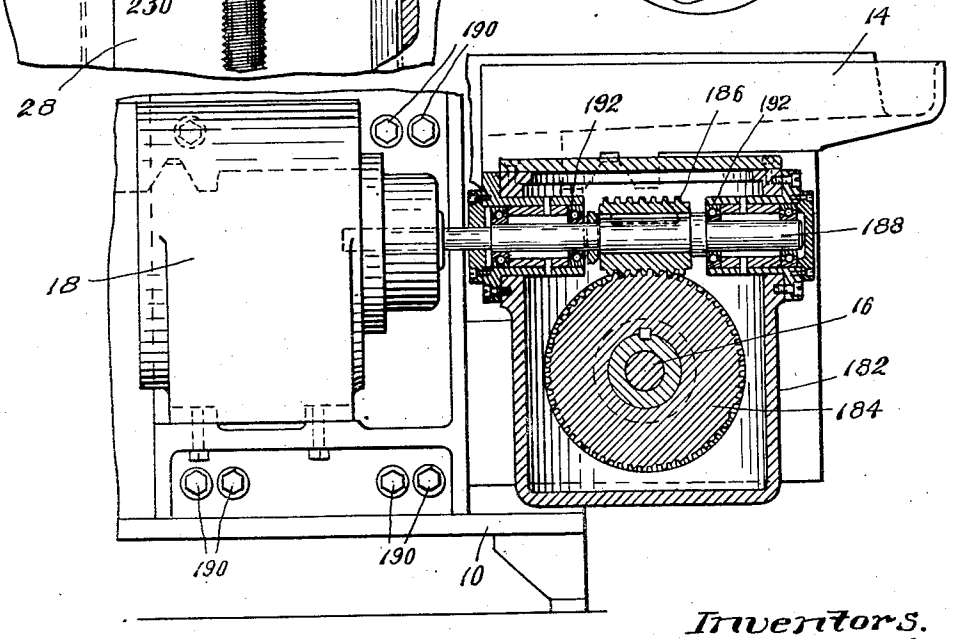


Fig. 17.

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PROFILE MILLING MACHINE

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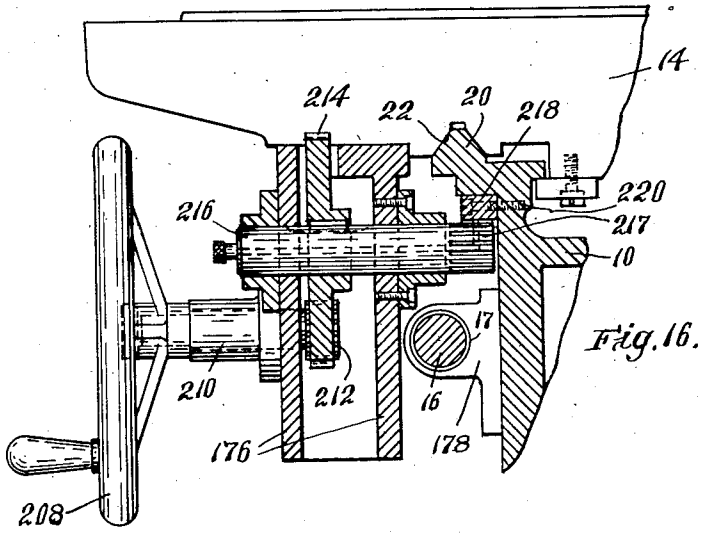


Fig. 16.

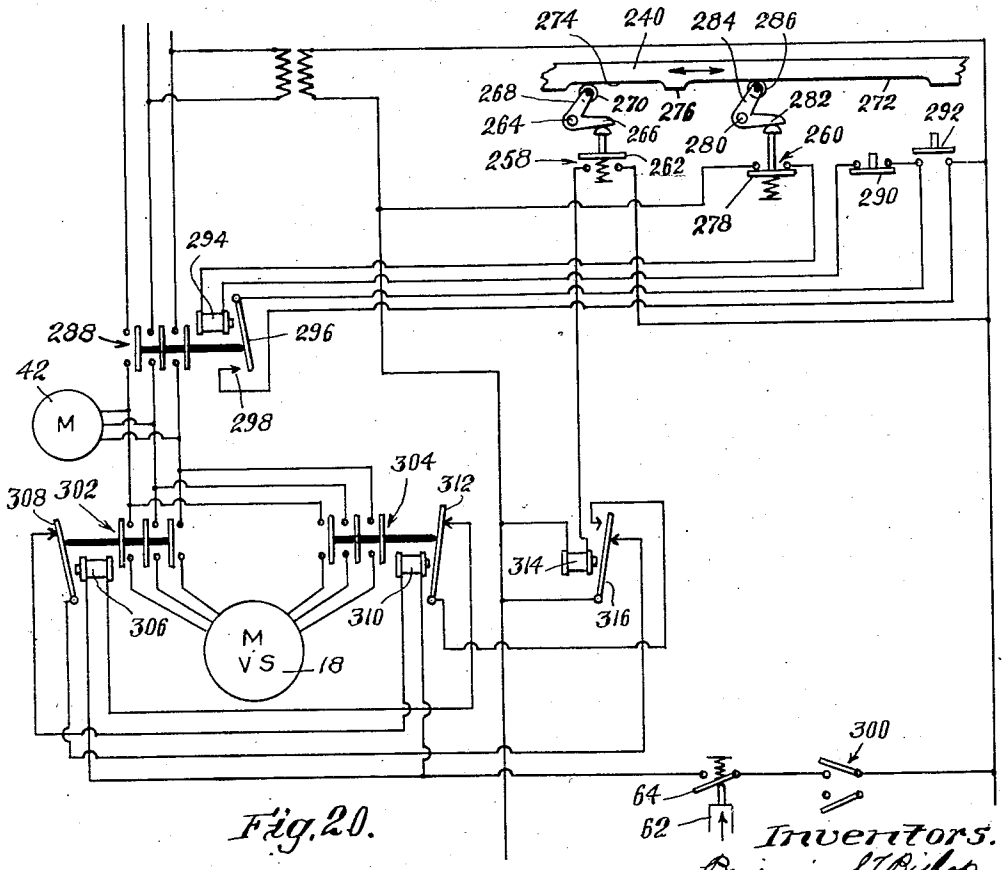


Fig. 20.

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Patented Aug. 13, 1946 2,405,550

UNITED STATES PATENT OFFICE

2,405,550

PROFILE MILLING MACHINE

Benjamin S. T. Bishop, Shrewsbury, and Frank A. Bicknell, Worcester, Mass., assignors to Leland-Gifford Company, Worcester, Mass., a corporation of Massachusetts

Application December 9, 1943, Serial No. 513,552

18 Claims. (Cl. 90—13.5)

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This invention relates to improvements in milling machines. More particularly it provides a milling machine which can mill irregularly shaped profile surfaces of work pieces, such as the profile edges of balancing webs of crank shafts, for example.

It is among the objects of the present invention to greatly increase the speed and efficiency of machining the profile edges of crank shaft webs and comparable surfaces as compared with prior procedures. Heretofore, the balancing webs of crank shafts have been machined on shapers or planers involving a multiplicity of cutting strokes in direction parallel to the axis of the crank shaft which makes the machining of an entire web profile relatively slow. The machine of the present invention steps up production several times what has been customary and feasible according to shaper and planer methods of profiling. A rotating milling cutter is carried on a vertically movable carriage and does the profiling as the work is moved toward and in contact therewith, the cutter carriage being guided in its vertical movements by a cam whose cam surface corresponds to the desired profile of the web that is undergoing machining. A feature is that the cutting is done by the periphery of the milling cutter held in cutting relation to the work by the action of gravity acting on the cutter carriage and maintaining a cam roller thereon in contact with the cam surface.

Approximately one-half of the edge contour of a crank shaft web may be profiled by a single travel of the work carriage past the cutter. Then the crank shaft is turned over and the other half of the same web is similarly profiled, either in the same machine with suitable interchange of work holding jig and cam or, preferably, in a substantially duplicate machine having the proper work jig and cam thereon which conveniently may be associated with the first machine, on a common bed. For crank shafts having two balancing webs requiring profiling, an efficient set up is to have four of the duplex machines, two for rough profiling of the two balancing webs and the other two for finish profiling of the same two webs. Provision of a milling machine having the features and capabilities as described is a further object of this invention.

Another object is to provide for approximately uniform cutting speed notwithstanding that the web profile may include one or more relatively sharp inclines and one or more relatively long gradual inclines. According to the invention the speed of feed of the work to the cutter automatically reduces substantially when the cutter is working on a steep incline as compared with the feed of the work when the cutter is working on a gradual incline. An electric motor having at least two speeds is employed for driving the work carriage and mechanism is effective for shifting automatically from one motor speed of say 1200 R. P. M. to another which may be 600 R. P. M., when the cutter is working on a steep incline, and for shifting automatically back to the first speed when a more gradual incline is reached. The provision of mechanism for accomplishing this automatic change of speed of work feed constitutes a further object of the invention.

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Still another object resides in a pneumatic control for the vertical cutter carriage. Provision is made for pneumatic lifting of the cutter carriage in response to operation of a hand valve, thereby to condition the machine for loading and unloading.

A further object of the invention is to provide an automatic safety control which is operative to stop the work feed if and when the speed of the cutter drops below a predetermined minimum, as when the cutting load may be too great. A centrifugal governor operated from the tool spindle is adapted to cause opening of the circuit to the work feed motor if and when the cutter speed drops below a predetermined minimum.

It is, moreover, our purpose and object generally to improve the structure and efficiency of milling machines.

In the accompanying drawings:

Figure 1 is a front elevation of a duplex milling machine embodying features of the present invention, a mid part of the bed being broken away;

Figure 2 is a cross-sectional view on line 2—2 of Figure 1;

Figure 3 is a detail elevation of one of the columns or heads on which the tool carriage is mounted for vertical movement;

Figure 4 is a cross-sectional view on line 4—4 of Figure 1;

Figure 4a is a detail cross-sectional view on line 4a—4a of Figure 4;

Figure 5 is a front elevation of the cam and its supporting means;

Figure 6 is a top plan view of the cam bracket;

Figure 7 is an end elevation of the cam and its bracket and showing the means for adjusting the cam relative to the cam roller on the tool carriage;

Figure 8 is an elevation of the cam-adjusting screw;

Figure 9 is a top plan view of the work holding jig;

Figure 10 is a side elevation of the work jig showing the manner of its mounting on the work carriage;

Figure 11 is a front end elevation of the work jig;

Figure 12 is an elevation of a crank shaft of the general type whose balancing webs may be profiled in the present machine;

Figure 13 is a front elevation of the work carriage and its driving means, a mid portion of the bed of the machine being broken away for conservation of space;

Figure 14 is a cross-sectional view on line 14—14 of Figure 13;

Figure 15 is a detail face view of the feed nut cam;

Figure 16 is a cross-sectional view on line 16—16 of Figure 13;

Figure 17 is a cross-sectional view on line 17—17 of Figure 13, the motor being shown in elevation;

Figure 18 is a cross-sectional view on line 18—18 of Figure 1;

Figure 19 is a cross-sectional view through the motor-speed-shifting mechanism, on line 19—19 of Figure 2;

Figure 20 is a diagrammatic view showing the electrical connections; and

Figure 21 is an elevation looking at the end of a crank shaft and showing the general profile of a balancing web thereof.

Referring to the drawings, the machine shown in front elevation in Fig. 1 is in reality two identical but reversed profiling machines mounted on a common bed 10. Each has a column or head 12, 12' adapted to be fixed at their respective ends of the bed, and each has a work carriage 14, 14' and separate feed screw shafts 16, 16' driven by separate motors 18, 18' mounted on opposite ends of the bed 10. Inasmuch as the structure and operation of both profiling machines is the same, only the left hand half of the complete machine of Fig. 1 is shown in detail in the drawings and only that half will be described, it being understood that the description applies equally to both profiling machines which are in opposed conveniently spaced apart relation on bed 10 so that one half of a balancing web of a crank shaft, for example, may be profiled by one profiling machine, after which the crank shaft will be transferred to the other machine for profiling of the other half of the web.

The bed 10 has the pair of spaced guide ways 20 extending horizontally from one end to the other of the bed, and the base of column 12 has complementary grooves 22 in its under face for slidably mounting the column or head on the ways 20. However, after the column has been positioned as desired along the bed 10, it is fixed to the bed by any suitable means (not shown). Retaining plates 24 on the under face of the column base and engaging under the ways 20 hold the column on the ways as by the screws 26 (Fig. 3).

A tool carriage 28 is slidably mounted on the vertical dove-tail guide 30 of column 12 and is operated thereon by means later to be described. Mounted on the carriage 28, or formed integral therewith, is the housing 32 within which is mounted in suitable bearings 33 an upper horizontal shaft 34 (Fig. 4) having the pinion gear 36 keyed thereon. The rear end of shaft 34 projects out of the housing and has a pulley 38 keyed thereon by which, through belt 40, shaft 34 is

driven from the motor 42 which in Fig. 1 is shown mounted on the column 12 and around whose pulley 44 the belt 40 is trained. The forward end of shaft 34 projects through the front wall of housing 32 and into the lower portion of a governor housing 46 which is mounted on the front wall of housing 32 as by the screws 48. Within the governor housing 46, the shaft 34 extends through suitable bearings 50 and has on its extreme forward end a bevel gear 52. Gear 52 meshes with a bevel gear 54 on the lower end of governor shaft 56 which is vertically disposed within the upstanding portion of the governor housing 46. Vertical shaft 56, mounted in lower bearings 58 and upper bearing 60 within the housing, has the pivoted, weighted governor arms 62 thereon, the position of which under centrifugal force controls an electric switch 64 for a purpose later to be described. As shown in Fig. 4, the horizontal shaft 34 is in two parts to facilitate assembly, with a driving inter-engagement of the two parts at 66.

A second horizontal shaft 68 is mounted in the combined radial and thrust bearings 70 in housing 32, below the shaft 34. This shaft 68 has a spur gear 72 keyed thereon and meshing with the pinion gear 36 on shaft 34. It constitutes a spindle for receiving and driving the tool shaft 74, for which purpose it has an axial hole extending from end to end, the forward tapering portion 76 of which receives the tapered portion 75 of the tool shaft, and the rearward portion 78, of smaller diameter, receiving the draw-bolt 80 whose forward end is screw-threaded into the end of tapered part 75 of the tool shaft and whose head engages the rear end of the spindle 68. A non-round flange 82 on the tool shaft fits into a complementary socket 84 in the front face of the spindle and provides a drive connection between spindle and shaft, maintained by the drawbolt 80. The tool shaft extends forwardly through a bearing 86 on bracket 88 which is adjustably mounted on the vertical carriage 28 as by the bolts 90. These bolts have their heads slidably engaged in the horizontal T-slots 92 in the vertical carriage 28 and their shanks extending out of the slots and through the base of bracket 88, with nuts 94 screwed on their ends for clamping the bracket in any adjusted position thereof.

The cutting tool 96 is mounted on the reduced portion 74*a* of the tool shaft, being keyed to the shaft by the ends of pins 98 projecting from the forward face of spindle 74 and engaging in sockets 100 in the rear end face of the tool 96. A retaining nut 102 screws on the reduced portion 74*a* of the shaft for holding the tool in keyed engagement with the key pins 98. The extreme forward end of shaft 74, further reduced as at 74*b*, has a bearing 104 in a second bracket 106 which is adjustable along a horizontal T-slot 108 in a forwardly projecting part 29 of the bracket 88, with the bolts 110 and nuts 112 for clamping the bracket in adjusted positions. This adjustable bracket 106 facilitates mounting and removal of a cutting tool. The bracket may be loosened and drawn forward to permit a tool to be slipped on or off the shaft after removal of the retaining nut 102.

When the machine is in operation for cutting a profile on a work piece, the vertical carriage 28, carrying the housings 32, 46 and the shafts 34, 56, 68 and 74 mounted therein, rests by gravity on a profile cam 114 mounted on the work carriage 14, and the vertical carriage 28, with its appurtenances including cutter 96 is caused

to rise and fall according to the contour of the cam as the latter moves with the work carriage 14 in direction along the bed 10 of the machine. For this purpose, a roller 116 is mounted in bearings 118 in an under part of the housing 32 directly over the cam 114, and rides on the top profile surface of the cam. The roller is vertically under but set rearward of the milling cutter 96, and is of the same diameter as the cutter. Preferably, as illustrated, the roller has a slight taper and the cam surface has a complementary inclination, so that a slight adjustment of the cam in direction along the axis of the tapered roller 116 can effect a slight vertical adjustment of the cutting tool 96.

Cam 114 is in the nature of a heavy plate as best seen in Figs. 5 and 7. It is secured by bolts 120 on the front face of an upstanding cam bracket 122 whose base has the slots 124, 126 for securement of the bracket as by bolts 128 in adjusted positions on a rearward part of the work holding jig, indicated generally at 130, and mounted on work carriage 14 in a manner later to be described. An adjusting screw 132 loose in lug 134 of bracket 122 threadedly engages a rear upstanding part of the work holding jig 130. The head of the screw may be in the form of a graduated dial 136 for micro-adjustment of the bracket and cam in directions along the axis of the cam roller 116, thereby to adjust the tool 96 slight amounts, as to compensate for wear of the cutting edges of the tool.

The work which is to be machined by tool 96 may be mounted on the work carriage in any suitable work holding jig. As illustrated in the drawings, and more particularly in Figs. 2, 9, 10 and 11, a jig is represented for mounting crank shafts whose balancing webs are to be profiled by the tool 96, which in the present case is a milling cutter, the cutting edges of which at its generally cylindrical side act on the work, as distinguished from milling operations in which the machining is an end-milling accomplished by the end of a milling cutter.

The jig as shown has a base 138 resting on work carriage 14 and adjustable on the carriage in directions longitudinally of the machine by reason of the bolts 140 whose head ends engage in longitudinal T-slots 142 in the carriage 14 and whose shanks extend thence through the base of the jig and have nuts 144 threaded on their ends for clamping the jig to the carriage in adjusted positions therealong. A key plate 146 on the under side of the jig engages in a longitudinal groove 148 in the carriage 14 for maintaining a precise predetermined alignment of the jig on the carriage.

A crank shaft such as that shown in Fig. 12 whose endmost balancing webs are to be profiled in the machine, is disposed crosswise of the machine with its opposite ends engaging in forward and rear half-round cradle bearings which upstand from the jig base respectively at 150 and 152. The rear bearing 152 may be capped by a half-round bearing piece 154 which may be secured in place by screws 155. The forward bearing 150, however, preferably has a half-round bearing cap piece 156 which is pivoted at 158 at one end and has a swingable bolt and nut securement at its other end. As seen in Figs. 9–11, the bolt 160 is pivoted at 162 in a groove in the forward upstanding cradle bearing 150 and is swingable into and out of a groove 164 in the cap piece, with a nut 166 on the end of the bolt for clamping the cap piece over the end of a crank shaft. This structure facilitates insertion and removal of crank shafts in that by merely loosening nut 166 the bolt 160 may be swung out of engagement with the cap so that the cap may be swung to open position about its pivot 158. The rear end of the crank shaft fits nicely in the rear cradle bearing and can be withdrawn axially when the front cradle cap piece is opened, to remove a crank shaft. To insert a crank shaft in the jig, the rear end is thrust axially into the rear cradle bearing and the forward end is laid in the front cradle bearing, after which the hinged cap piece is closed and clamped by the bolt and nut 160, 166.

Between the forward and rear cradle bearings of the jig, an upstanding part 168 is shaped at its upper portion to engage and position a mid web of the crank shaft so that the outermost web will be properly positioned for profiling by the milling cutter 96. Also a longitudinal screw 170 has its rear end carrying a clamping element 172 which coacts with the fixed clamp element 174 on the jig for engaging and holding the rearmost web of the crank shaft.

Hence, assuming that cam 114 has its top edge shaped to provide the desired profile of approximately one-half of the balancing web of the crank shaft, movement of the work carriage to the left in Fig. 1 moves the crank shaft and the cam as a unit, with the cam roller 116 of the tool carriage riding on the cam and causing the milling cutter to rise and fall according to the contour of the cam as the crank shaft balancing web which is being profiled moves past and in contact with the cutter. When approximately one-half the periphery of a web has been profiled, the work carriage 14 is moved back to the right in Fig. 1, and the crank shaft is transferred to the other profiling machine for a similar profiling of the other half of the same web. Then with the proper work holding jigs on another machine like that of Fig. 1, or substituted on the same machine, the other balancing web may be similarly profiled.

The means for manually moving the work carriage 14 and for controlling its automatic screw feed are best seen in Figs. 2 and 14–16. As shown, carriage 14 has a hollow depending apron 176 between which and the front wall of bed 10 the feed screw shaft 16 extends from its inner end bearing at 178 on the bed 10 longitudinally to the left end of the machine where it passes through bearing 180 on bed 10 and thence into gear housing 182 suitably mounted at the end of the bed. Within housing 182 (Fig. 17) the shaft 16 has keyed thereon a worm gear 184 which meshes with worm 186 keyed on shaft 188 of electric motor 18. The motor is mounted on the end of bed 10 as by the screws 190, and its shaft 188 extends into housing 182 and has bearings 192 in the housing on opposite sides of worm 186. Hence, so long as motor 18 is running, screw shaft 16 is rotated thereby for automatic feed of the work carriage 14 if and when the carriage is operatively connected to the feed screw 17. Motor 18 has at least two speeds for a purpose which later will appear.

Work carriage 14 may be connected to or disconnected from the feed screw 17 by a mere partial rotation of a handle 194 at the front of carriage apron 176. The hollow nature of the apron provides front and rear apron walls, the rear one of which is provided with vertical ways 196 on which the two half nuts 198 are mounted for vertical movement on opposite sides of feed screw 17. Each half nut has a screw 200 therein whose head projects forward between the apron

walls for engagement in cam slots 202 in the rear face of an enlargement 204 of the shaft of handle 194, said shaft being horizontally disposed in a suitable bearing 206 in the front wall of apron 176. The cam slots, as seen in Fig. 15, are such that when handle 194 is turned counter-clockwise, the half nuts 198 will be drawn into engagement with the feed screw to provide automatic feed of the work carriage 14. Turning of the handle 194 in clockwise direction will spread the half nuts out of engagement with the feed screw leaving the work carriage at rest and in condition for manual movement thereof.

Manual control of carriage 14 may be effected by rotation of hand wheel 208 which is mounted at the front of apron 176 on shaft 210. Referring to Fig. 16, the hand wheel shaft 210 is mounted on the front wall of the carriage apron, projecting through that wall and having on its inner end a pinion gear 212. The pinion meshes with a spur gear 214 on a shaft 216, the inner end of which shaft is formed with gear teeth as at 217 which mesh with a gear rack 218 secured as at 220 at an under forwardly projecting part of bed 10. Whenever the automatic feed is disconnected, the carriage 14 may be manually moved in either direction by rotation of hand wheel 208.

The vertically movable tool carriage 28, during milling of a crank shaft web, rests by gravity on the cam 114. In order to raise it for loading and unloading, there is provided on the top of column 12, above the vertical carriage, a cylinder 222 (Figs. 1, 2 and 18) wherein a piston 224 is vertically operable. The piston rod 226 extends through suitable packing 227 at the bottom of the cylinder and has its end adjustably secured as at 228 to a bracket 230 on the tool carriage 28 so that the carriage and the piston move as a unit in vertical directions. A pipe 232 leads from a suitable source of compressed air and opens into cylinder 222 on the under side of the piston, a suitable two-way valve 234 in the pipe line providing for manual control of the compressed air. Hence, in Fig. 2, with the handle 236 of valve 234 in the upper position as shown, air is directed into cylinder 222 elevating the piston 224 therein. Tool carriage 28 is correspondingly elevated as a result of its connection at 228, 230 to the piston. Movement of the valve handle to its lowermost position closes the passage from the air source and opens cylinder 222 through the valve to atmosphere so that the carriage can descend into working position by gravity with the piston tending to cushion its descent. Also, because the cylinder 222 continues open to atmosphere during milling operations of the machine, the piston 224 is free to move in the cylinder in response to vertical movements imparted to the tool carriage by engagement of cam roller 116 with cam 114.

An important feature of the invention is that the feed of the work past the milling cutter 96 can be at one speed during milling of a portion of the profile and at a slower speed during milling of another portion of the profile. This is desirable to maintain the cutting speed substantially constant both when the milling cutter is working down the relatively steep incline, at A in Fig. 21, and when it is working up the relatively long and gradual incline at B in Fig. 21. The invention accomplishes this substantially constant cutting speed by employing a motor 18 having at least two speeds for feed of the work carriage 14. For example, motor 18 may have one speed of 1200 R. P. M. and another of 600 R. P. M., and means is provided for automatically shifting from one motor speed to the other during a profiling operation, so that feed of the work carriage 14 and of the work thereon may be slowed by one-half while the milling cutter 96 is working down the sharp incline A and will feed at the higher speed during other portions of the profiling operation.

Fig. 2, and more especially Fig. 19, and the diagrammatic showing of Fig. 20, illustrate the means for automatic control of the work carriage feed. Referring to Fig. 19, a switch casing 238 is mounted on a base part of the relatively fixed column or head 12 at the rear of the machine as viewed in Fig. 1. The long shaft 240 is slidably and non-rotatably mounted in the bearings 242, 244 of the end walls of the casing, extending in a horizontal plane generally longitudinally of the bed 10 of the machine. It projects at both ends of casing 238 and has its right hand end connected as at 246 to a smaller diameter rod 248 which extends slidably through a bracket 250 upstanding from a rear part of work carriage 14. Two collars 252 are adjustably fixed on rod 248, by set screws 254, on opposite sides of bracket 250, the collars being shown spaced apart a distance greater than the axial extent of the bracket so that there is lost motion as the bracket moves from engagement with one collar into engagement with the other. A tubular housing 256, mounted on casing 238, encloses substantial portions of the shaft 240 and rod 248 where they extend to the right of the casing 238 in Fig. 19. Hence, it will be obvious that when the work carriage 14 moves to the left, as when advancing a piece of work thereon to the action of the milling cutter, shaft 240 will be moved to the left by engagement of bracket 250 with the left hand collar 252 on rod 248. Movement of carriage 14 to the right similarly will cause movement of shaft 240 to the right by engagement of the bracket with the right hand collar 252.

Within casing 238 are the two switches 258, 260 connected in the electrical circuit of the machine as indicated diagrammatically in Fig. 20. Switch 258 is of a type whose switch element 262 (Fig. 20) is movable to cause shifting from one to another speed of motor 18. In Fig. 19 switch element 262 is shown spring-urged to its open position. A switch actuating member is pivoted at 264 on the switch housing and has one arm 266 engaging the end of the switch element and another arm 268 with a roller 270 on its end engaging the bottom of a longitudinal groove 272 in the shaft 240. A shorter groove 274 to the left of and aligned with groove 272 can similarly receive roller 270, a short non-grooved portion 276 of the shaft being adapted to cam the roller in direction toward the switch when the shaft 240 is shifted to bring the non-grooved portion 276 opposite the roller, thus causing switch element 262 to be depressed to closed position. The grooves 272 and 274 are so positioned that the roller will be riding on the periphery of the non-grooved portion 276 of the shaft when the milling cutter 96 is working down the relatively steep incline A of the profile of a crank shaft web, thereby to cause the feed of the work to be diminished one half in speed while the cutter traverses the incline. At the start of a milling operation, the roller will be in the left hand groove 274 so that the initial feed of the work toward the cutter will be at the higher speed. When the roller reaches the right hand end of groove 274 it rides onto the non-grooved portion 276 and the work feed is dropped to the lower speed until the roller rides into the longer groove 272, to cause a return to the higher speed of work feed.

The switch 260 is a stop switch for stopping motor 18 when the work has been acted upon by the milling cutter and has passed beyond the cutter. Its switch element 278 is spring-urged to circuit closing position and continues closed during a complete milling operation. Its switch actuating member is pivoted at 280 on the switch housing and has arm 282 engaging the end of the switch element and arm 284 equipped with roller 286 riding in the bottom of groove 272 of shaft 240. This roller 286 continues in the same groove 272 throughout a milling operation but rides out of the groove to open the motor circuit when shaft 240 has moved to the left an amount sufficient to bring the right hand end of groove 272 into contact with the roller to cam it out of the groove with resulting opening of the switch 260.

Another feature of the invention is the provision for stopping the work feed in case the speed of the tool spindle drops below a predetermined speed, as from a too heavy cutting load. The governor within housing 46 accomplishes this automatic stoppage of the work feed in conjunction with the governor controlled switch 64, also in housing 46. This switch is connected in the secondary control circuit of motor 18 and is open whenever the tool spindle is at rest. It is closed whenever the tool spindle, driven by motor 42, is rotating above a predetermined speed, the weighted governor arms 62 acting under centrifugal force to elevate the switch element 64 to close the switch and hold it closed so long as the speed of the spindle is maintained. Any substantial drop in spindle speed, bringing it below the predetermined minimum, permits the switch element to open the control circuit of the motor 18 that drives the work carriage.

The electrical system of the machine is illustrated in simplified form in the diagram of Fig. 20. Both motors 18 and 42 are three phase induction motors connected in the high tension side of the system. This high tension circuit is controlled by switch 288 whose closing starts the spindle-driving motor 42.

In order to start motor 42, however, preparatory to the start of a work stroke, the switch 258 must be open with the roller 270 riding in the left hand groove 274 of the shiftable shaft 240, and the switch 260 must be closed with roller 286 riding in groove 272. Also a manually operable stop switch 290 will be closed, and a manually operable starting switch 292 will be open. Closing of the starting switch 292 energizes a relay 294 which draws armature 296 to the left in Fig. 20 to close the main motor control switch 288. Armature 296 also closes a switch 298 in a shunt circuit around the starting switch 292 so that relay 294 continues energized when starting switch 292 is released and returns to open position.

Closing of switch 288 results in starting of motor 42. When it attains a predetermined cutting speed, the governor-controlled switch 64 closes. Then, by manually closing a feed off and on switch 300, motor 18 will be started and will operate at whichever of its two speeds has been determined by the position of shiftable shaft 240 relative to switch 258. In Fig. 20, rod 240 is in its position ready to start a work stroke to the left and both the primary and the secondary circuits are open. Hence motor 18 when started will operate at its higher speed of 1200 R. P. M.

Operation of motor 18 is controlled by two relay operated switches, one in the low speed motor circuit as indicated at 302 in Fig. 20 and the other in the high speed motor circuit at 304. A relay 306 and armature 308 operate the low speed switch 302, and a similar relay 310 and armature 312 operate the high speed switch. Both of these armatures are shown as switch elements in the secondary circuit and both are normally closed until their respective relays become energized to open them. However, still another relay 314 in the secondary circuit controlled by switch 258 has an armature 316 which normally closes a circuit through the relay 310 of the high speed motor control circuit so that, when motor 42 is operating and switches 64 and 300 are closed, the relay 310 is energized to close the high speed motor switch 304, and motor 18 will operate at the high speed so long as switch 258 remains open. When roller 270 rides up on the part 276 of shaft 240, however, switch 258 is closed to energize the relay 314 which shifts armature 316 from its normal position closing a circuit through high speed relay 310 to a position closing a circuit through the low speed relay 306. Hence high speed motor switch 304 opens and low speed motor switch 302 is closed by armature 308, and motor 18 operates at the low speed so long as roller 270 is on the part 276 of shaft 240. As soon as roller 270 rides into groove 272 of shaft 240, switch 258 opens to de-energize relay 314, which permits armature 316 to move back to position closing a circuit through high speed relay 310 and opening the circuit through low speed relay 306, thereby to cause a return to high speed operation of motor 18 until roller 286 rides out of groove 272 to stop motor 18 by opening of switch 260. The carriage 14 then will be disconnected from the feed screw 17 for manual return of the carriage to unloading position.

We claim as our invention:

1. In a milling machine having a rotating cutter and a work holding carriage movable to present work held thereon to the action of the cutter, the combination therewith of means for feeding the carriage in direction toward the cutter including a plural-speed electric motor, a track on the carriage extending longitudinally of the machine generally in the directions of travel of the carriage, electrical connections between the motor and carriage including a speed-change switch constantly engaging said track and relative to which said track is bodily movable in the directions of its longitudinal extent, and means on said track for effecting a speed-changing actuation of said switch and for maintaining the switch in the actuated position throughout only a predetermined distance of movement of said carriage.

2. In a milling machine having a rotating cutter and a work holding carriage movable to present work held thereon to the action of the cutter, the combination therewith of means for feeding the carriage in direction toward the cutter including a plural-speed electric motor, means in the motor circuit for shifting from one motor speed to another, and an actuator having length at least equal to the travel of the work carriage in one direction and linearly movable with the work carriage and constantly engaging said speed shifting means and operative on said means for causing a shift from one motor speed to another at an intermediate point in the travel of the carriage, thereby to change the speed of feed of the carriage.

3. In a milling machine having a rotating cutter and a work holding carriage movable to present work held thereon to the action of the cutter, the combination therewith of means for feeding the carriage in direction toward the cut-

ter including a plural-speed electric motor, a switch in the motor circuit normally connecting the motor for operation at one speed and movable to connect the motor for operation at a different speed, and an actuator for said switch, said switch and actuator being longitudinally movable relatively generally in the directions of travel of the carriage in response to movements of the carriage and said actuator being constantly engaged with the switch and having a switch actuating portion operative to shift said switch at an intermediate point in the travel of the carriage, thereby to change the speed of the motor with resulting change of speed of feed of the carriage.

4. In a milling machine having a rotating cutter and a work holding carriage movable to present work held thereon to the action of the cutter, the combination therewith of means for feeding the carriage in direction toward the cutter including a plural-speed electric motor, means in the motor circuit for shifting from one motor speed to another, and an actuator for said means, said means and said actuator being bodily movable relatively with motion of translation in response to movement of the carriage, and said actuator having substantial extent in the directions of movement of the carriage and being constantly engaged by said speed shifting means, and having a fixed cam portion operative on said means at an intermediate point in the travel of the carriage for causing a shift from one motor speed to another with resulting change of speed of feed of the carriage.

5. In a milling machine having a rotating cutter and a work holding carriage movable to present work held thereon to the action of the cutter, the combination therewith of means for feeding the carriage in direction toward the cutter including a plural-speed electric motor, a switch in the motor circuit at a fixed location on the machine, said switch being movable between a position closing a circuit for operation of the motor at one speed and a position closing a circuit for operation of the motor at another speed, a bar slidably mounted on the machine and extending generally in the direction of travel of the carriage and connected to the carriage for bodily movement therewith, said bar being constantly in engagement with said switch and having means thereon for camming engagement with said switch, and connection between said bar and the carriage whereby the bar moves with the carriage and shifts said switch at an intermediate point in the travel of the carriage thereby to change the speed of feed of the carriage.

6. In a milling machine having a rotating cutter and a work holding carriage movable to present work held thereon to the action of the cutter, the combination therewith of means for feeding the carriage in direction toward the cutter including a plural-speed electric motor, a switch in the motor circuit at a fixed location on the machine, said switch being movable between a position closing a circuit for operation of the motor at one speed and a position closing a circuit for operation of the motor at another speed, means yieldably maintaining the switch in position for operation of the motor at one speed, a bar slidably mounted on the machine adjacent to said switch and extending generally in the direction of travel of the carriage, said bar constantly engaging said switch and having a portion thereof adapted to shift said switch when the bar is moved relative to the switch, and connection between the bar and the carriage whereby the bar moves with the carriage longitudinally past the switch to cause a shifting of the switch at an intermediate point in the travel of the carriage, thereby to change the speed of feed of the carriage at said intermediate point in its travel.

7. In a milling machine having a rotating cutter and a work holding carriage movable to present work held thereon to the action of the cutter, the combination therewith of means for feeding the carriage in direction toward the cutter including a plural-speed electric motor, a switch in the motor circuit yieldably urged to position connecting the motor for operation at one speed and movable to connect the motor for operation at a different speed, a second switch in the motor circuit yieldably urged to closed circuit position and movable to an open circuit position wherein it stops the motor, a common actuator for both switches arranged adjacent to the switches and constantly inter-engaged with both switches, and mounted for sliding movement in the direction of travel of the carriage, and connections between the actuator and the carriage whereby the actuator moves with the carriage, there being means on the actuator for shifting the first said switch at an intermediate point in the travel of the carriage thereby to change the speed of feed of the carriage, and for shifting the second said switch at a predetermined limit of travel of the carriage thereby to stop the feed of the carriage.

8. In a milling machine having a rotating cutter and a work holding carriage movable to present work held thereon to the action of the cutter, the combination therewith of means for feeding the carriage in direction toward the cutter including a plural-speed electric motor, means in the motor circuit responsive to movement of the carriage and operative to shift from one motor speed to another at an intermediate point in the travel of the carriage thereby to change the speed of feed of the carriage, said means comprising a switch arm yieldably urged to position for operation of the motor at one speed, a grooved actuating bar adjacent to the switch arm and movable with the carriage, and a bell crank lever having one arm in position to engage the end of the switch arm and to depress it when the bell crank lever is rocked and having its other arm engaging in the groove of the bar, and adapted to be cammed out of the groove by an end wall of the groove thereby to rock the bell crank lever and shift said switch for operation of the motor at a different speed, said end wall of the groove being located to cause change of the motor speed at an intermediate point in the travel of the carriage.

9. In a machine tool, the combination of a tool support, a work support, a variable speed electric motor for driving the work support, a switch in the motor circuit operative to cause a change from one motor speed to another thereby to change the rate of travel of the work support, an actuator for said switch, and means carried by said work support movable therewith in a straight line past said actuator and constantly slidably engaging said actuator during movements of the work support, said means having a portion at an intermediate location therealong for causing an actuation of said switch and maintenance thereof in the actuated position throughout a predetermined intermediate distance of travel of the work support.

10. In a machine tool, the combination of a tool support, a work support, a variable speed electric motor for driving the work support, a

switch in the motor circuit operative to cause a change from one motor speed to another thereby to change the rate of travel of the work support, a second switch in the motor circuit operative to cause stopping of the motor, a separate actuator for each said switch, and means carried by said work support constantly slidably engaging each said actuator during movements of the work support, said means having a portion at an intermediate location therealong for causing an actuation of said speed change switch and maintenance thereof in the actuated position throughout a predetermined intermediate distance of travel of the work support, and having another portion located for causing actuation of said stop switch at the end of a travel of the work support in one direction.

11. In a machine tool, the combination of a work support, variable speed power means for driving the work support, power connections between said power means and the work support including means operative to cause a change from one to another speed of the power means thereby to change the rate of travel of the work support, linear means carried by the work support having substantial extent in the directions of travel of the work support, said means operative to cause a change from one to another speed being constantly in resilient engagement with said linear means carried by the work support, and the latter said means having a portion at a predetermined location along its linear extent for actuating said speed change means at an intermediate stage of travel of the work support in one direction, thereby to change the rate of travel of the work support.

12. In a machine tool, the combination of a work support, a variable speed electric motor for driving the work support, electrical connections between the motor and the work support including a speed change switch operable between open and closed positions and constantly resiliently urged to one of said positions, means carried by the work support constantly engaging said switch and movable with the work support linearly past the switch and having an intermediate portion operative to cause operation of said switch from one of its said positions to the other and adapted to maintain it in the new position throughout a predetermined intermediate distance of travel of the work support.

13. In a profile milling machine, the combination of a vertically slidable milling cutter support, a horizontally movable work support, a profile guide track mounted on the work support and movable therewith, said tool support resting by gravity on said profile guide track, power means for lifting the tool support away from the profile guide track, a plural speed electric motor for driving the work support, electrical connections between the motor and the work support including speed-change means mounted stationarily relative to the work support, means carried by the work support constantly inter-engaged with said speed-change means, said means carried by the work support having an intermediate portion for causing actuation of said speed-change means to and holding of it in a speed-changing position throughout a predetermined intermediate distance of travel of the work support.

14. In a profile milling machine, the combination of a vertically slidable milling cutter support, a horizontally movable work support, a profile guide track mounted on the work support and movable therewith, said tool support resting by gravity on said profile guide track, a plural speed electric motor for driving the work support, electrical connections between the motor and the work support including a speed-change switch mounted stationarily relative to the work support, a longitudinally grooved bar carried on the work support, actuating means associated with said switch and intervening between said switch and bar constantly urged resiliently against the bar and having a portion engaging in the groove of the bar for riding therealong during movements of the work support, said bar having means thereon for displacing said actuating means out of said groove at an intermediate location in the travel of the work support.

15. In a profile milling machine, a vertically slidable milling cutter support, a horizontally movable work support, a profile guide track mounted on the work support and having a relatively steep sloping portion, said cutter support resting by gravity on the track and riding thereon during movements of the work support, a plural speed electric motor for driving the work support, electrical connections therefor including a speed-change switch stationarily mounted relative to the work support, means carried by the work support constantly slidably engaged with said switch and having an intermediate portion for causing actuation of the switch from one position thereof to another, and for causing return of the switch after a predetermined intermediate travel of the work support, said intermediate portion being positioned relative to said switch and said steep sloping portion of the guide track so that the speed of the motor is changed while the milling cutter support is riding on said steep sloping portion of the guide track.

16. In a machine tool having a rotating tool support and a work support, the combination therewith of means for feeding one of said supports in general direction toward the other on a working stroke, said means including a variable speed electric motor, a linear track mounted on one of said supports, electrical connections between the motor and the other of said supports including a speed-change switch having an actuator constantly engaging said track, said track and actuator having relative linear movement in response to movement of said one support toward the other and means on the track for effecting a speed-changing actuation of said switch and for maintaining the switch in actuated position throughout only a predetermined distance of movement of said one support toward the other.

17. In a machine tool having a rotating tool support and a work support, the combination therewith of means for feeding one of said supports in general direction toward the other on a working stroke, said means including a variable speed electric motor, a track fixed relative to one of said supports, electrical connections between the motor and one of said supports including a pair of switches each having an actuator constantly engaging said track, one of said switches being a motor-speed-change switch and the other being a motor-stop switch, means on the track for effecting a speed-changing actuation of said motor-speed-change switch at a predetermined intermediate location in a said working stroke, and additional means on said track for effecting a motor-stopping actuation of said motor-stop switch at the end of a said working stroke.

18. In a machine tool having a rotating tool support and a work support, the combination therewith of means for feeding one of said sup-

ports in general direction toward the other on a working stroke, said means including a variable speed-electric motor; a track fixed relative to one of said supports, electrical connections between the motor and one of said supports including a speed-change switch having an actuator constantly engaging said track, means on the track for effecting a speed-changing actuation of said switch at a predetermined intermediate location in a said working stroke, a second switch in said electrical connections, a second electric motor for rotating the tool support, and centrifugal means for actuating said second switch to stop one of said motors when rotation of the tool support drops below a predetermined speed.

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