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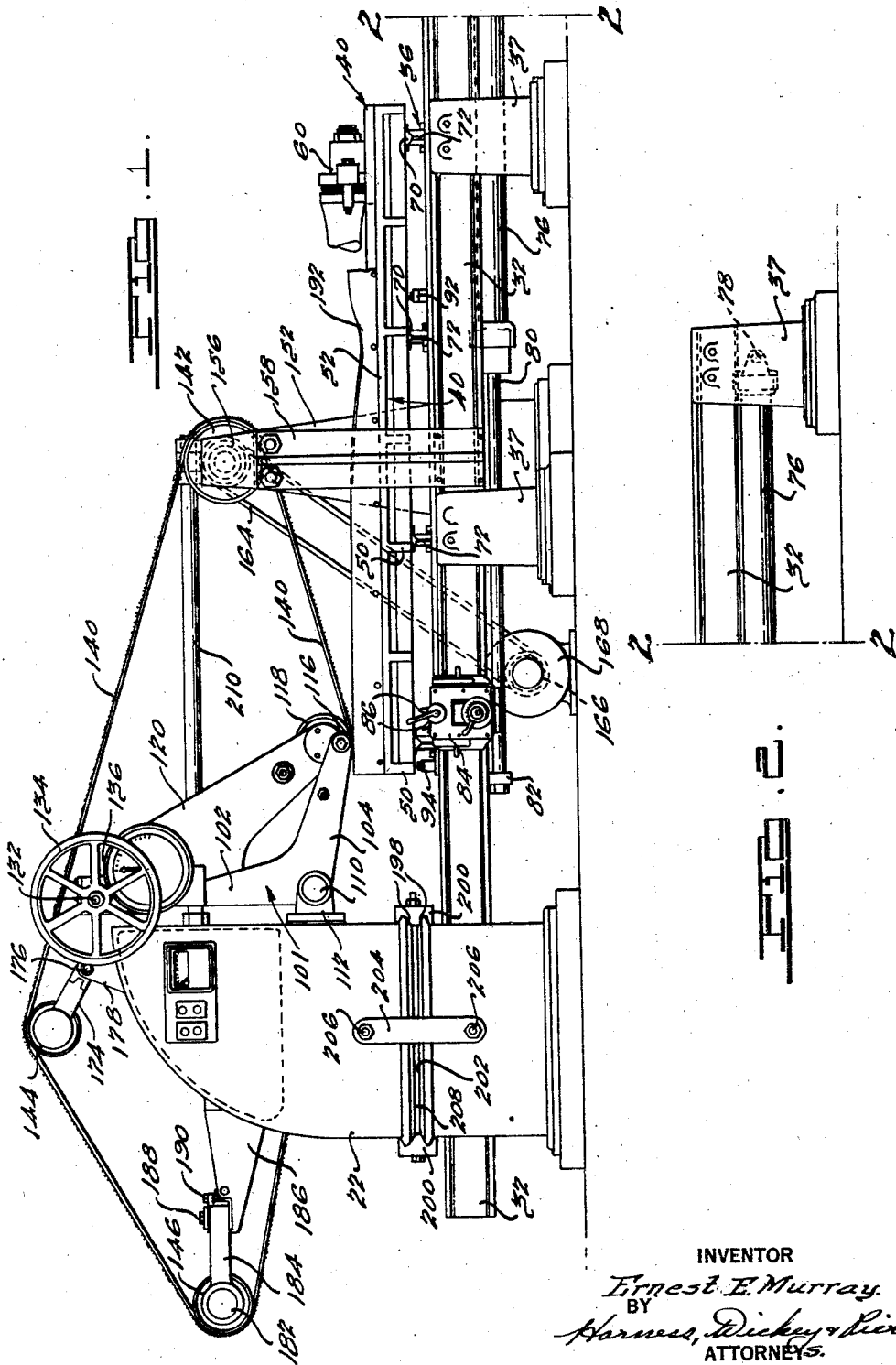
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2,431,822

ABRASIVE BELT POLISHING MACHINE

Filed May 13, 1942

7 Sheets-Sheet 1



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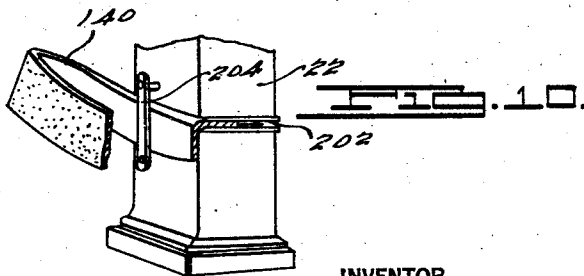
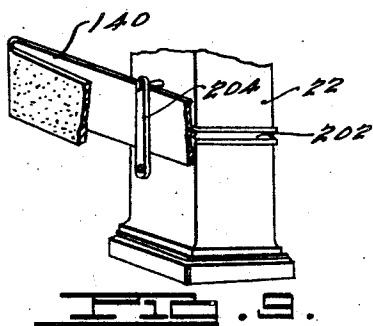
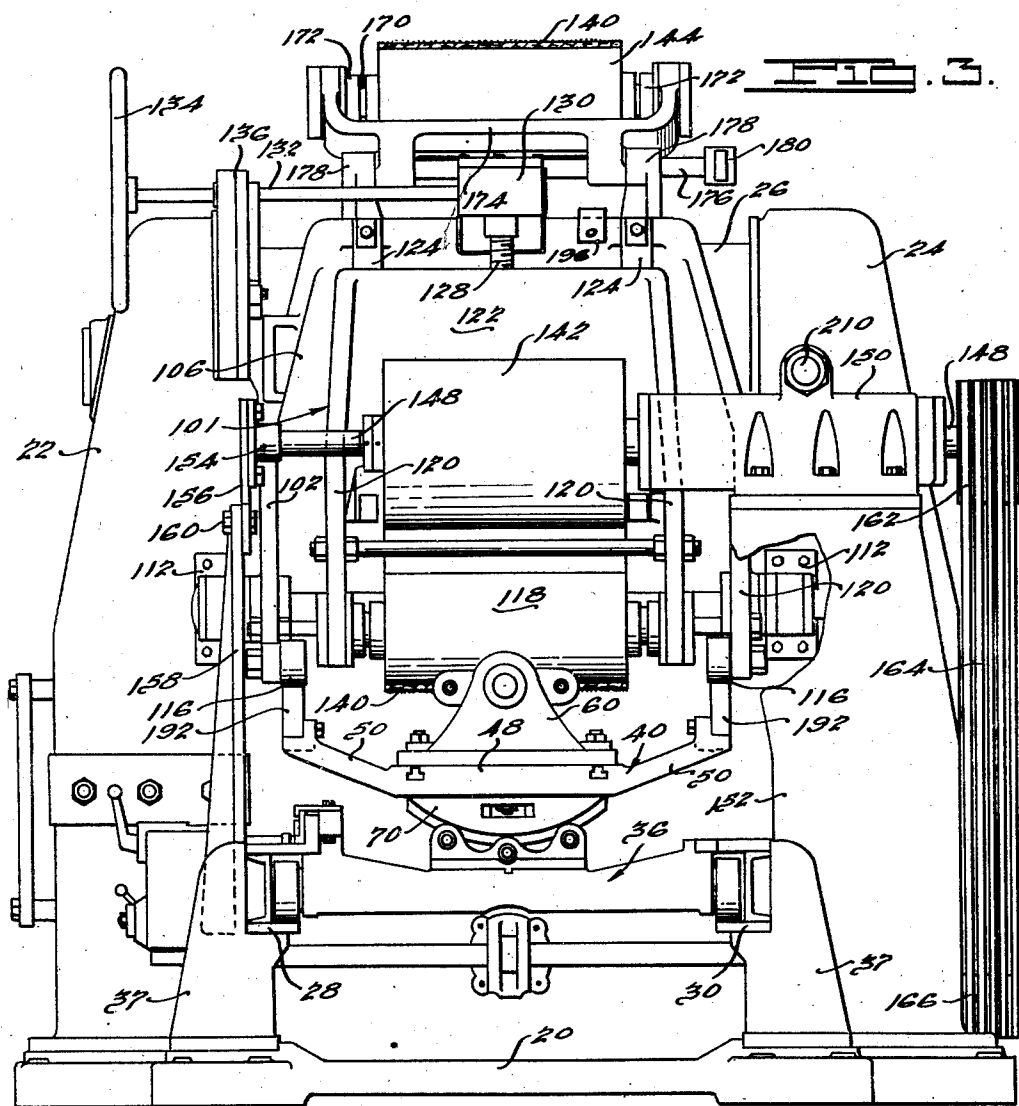
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7 Sheets-Sheet 2



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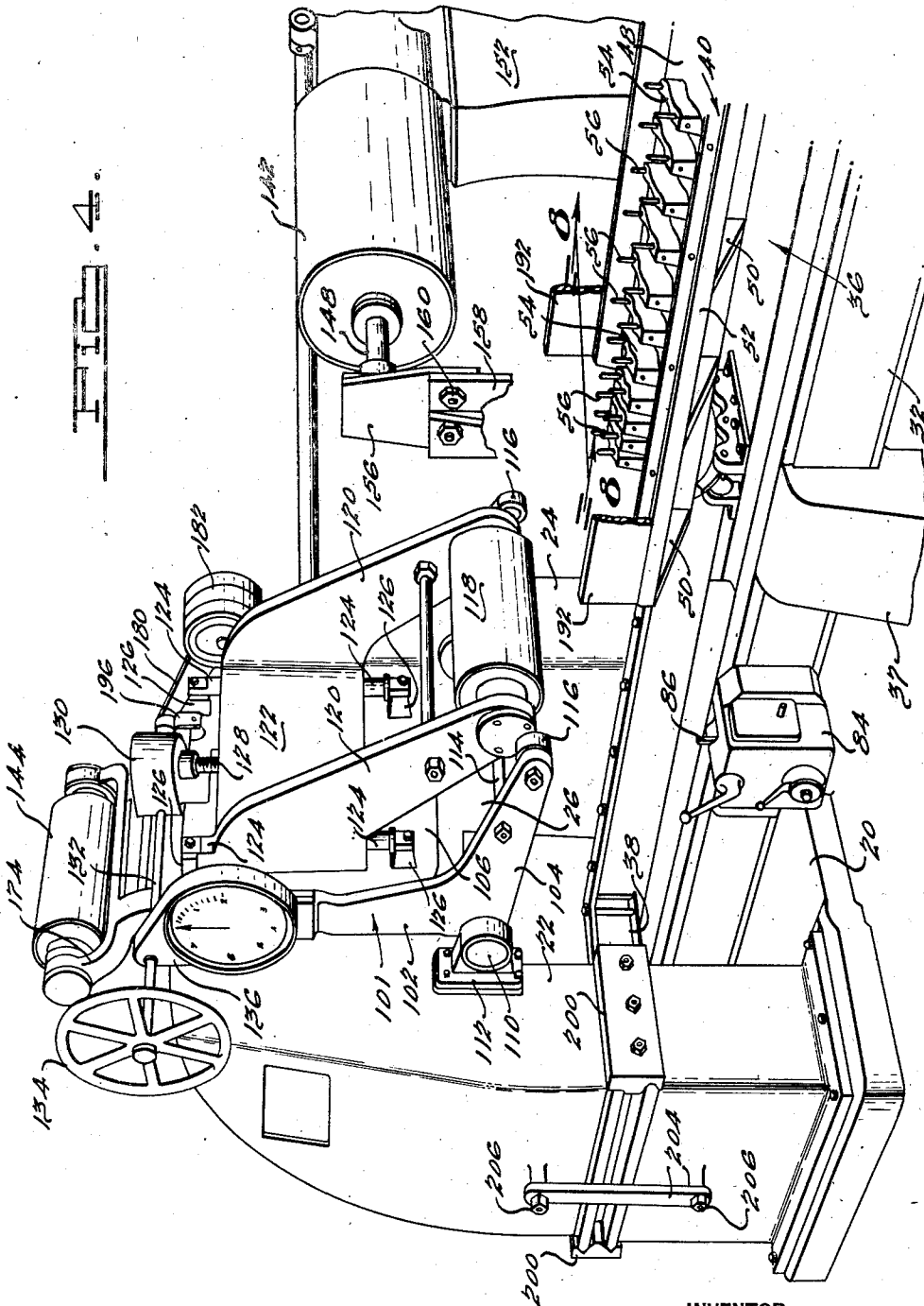
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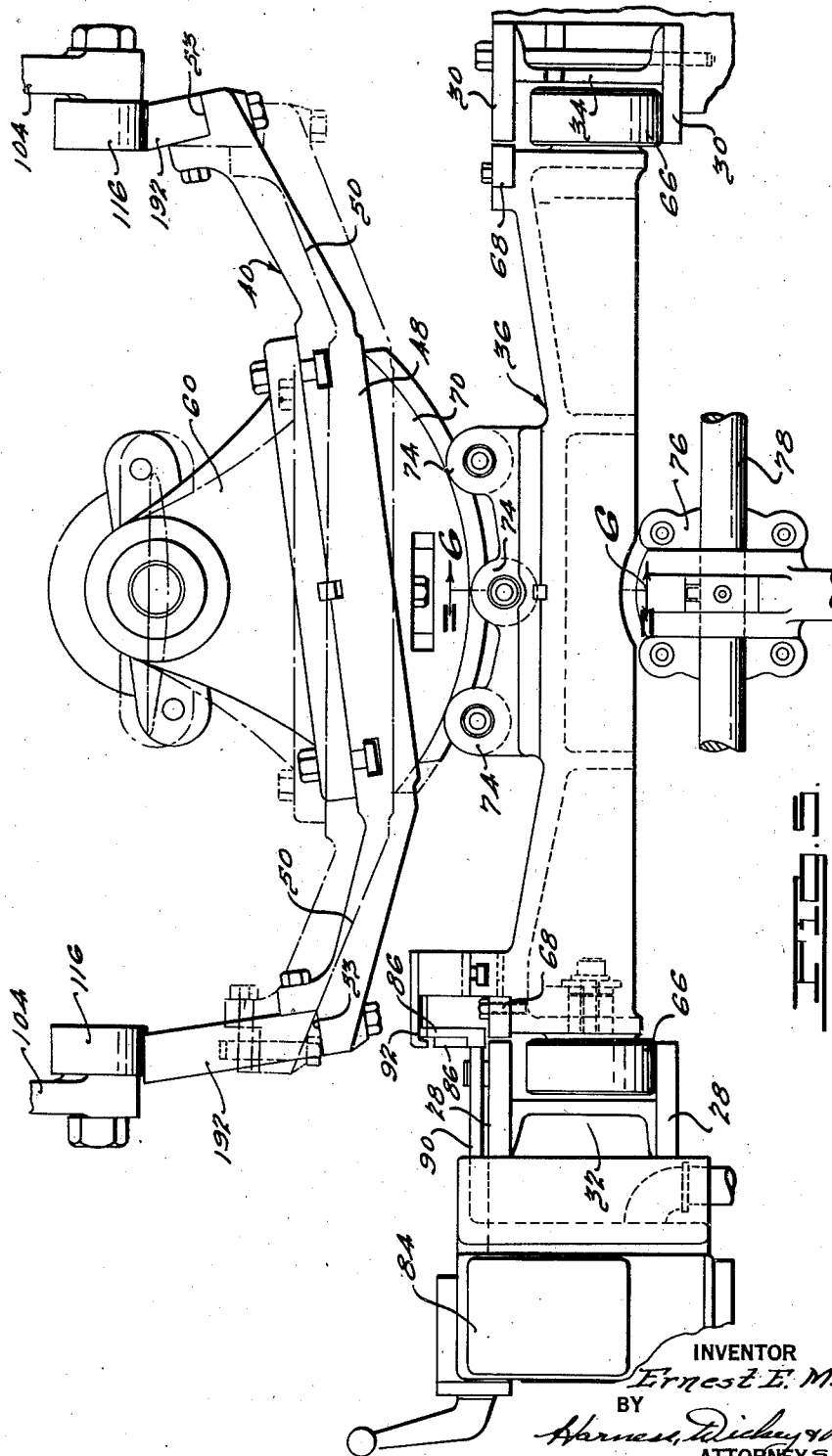
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ABRASIVE BELT POLISHING MACHINE

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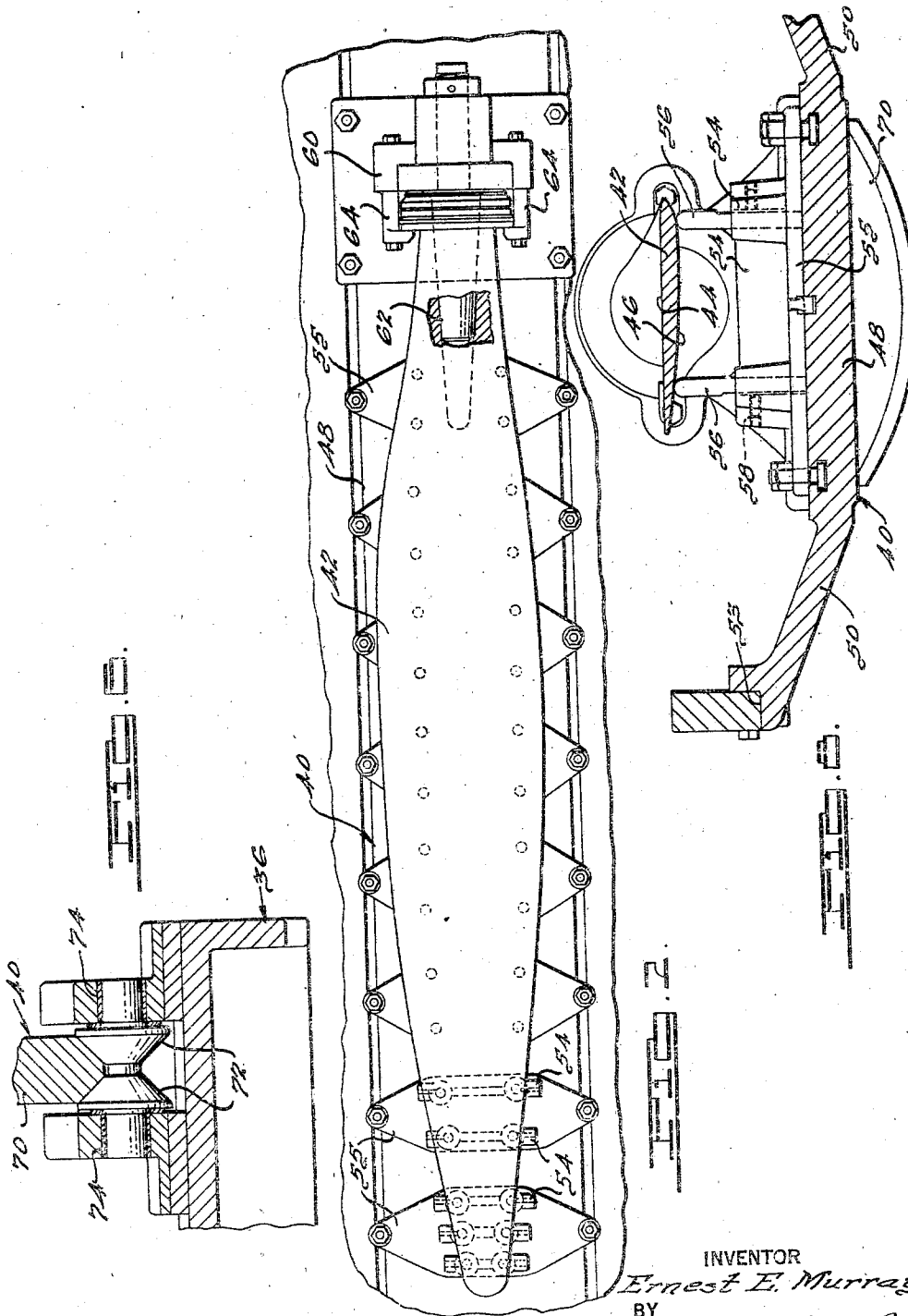
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7 Sheets-Sheet 5



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ABRASIVE BELT POLISHING MACHINE

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FIG. 11.

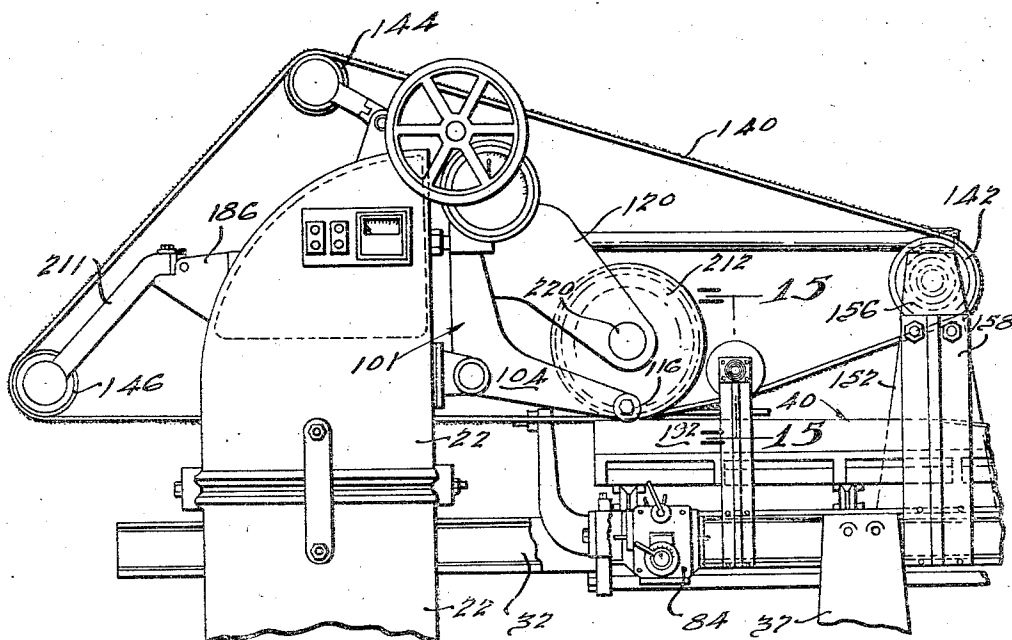
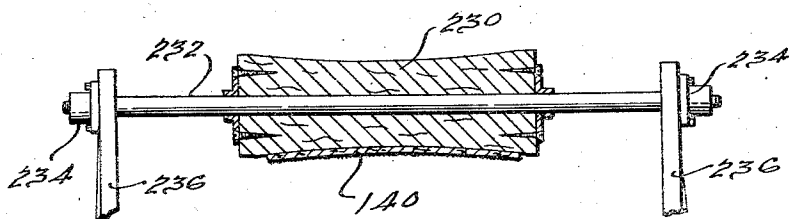


FIG. 15.



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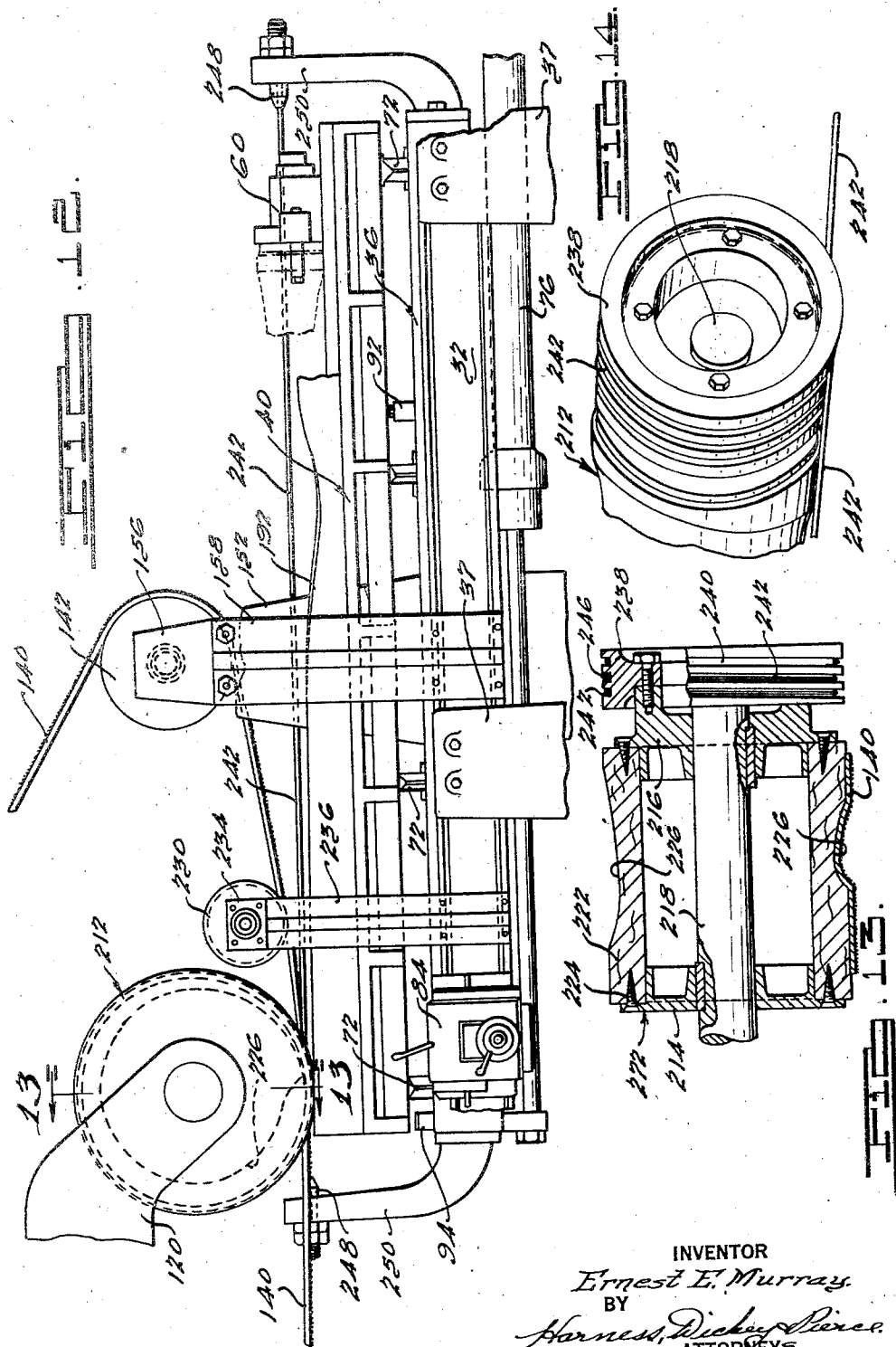
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7 Sheets-Sheet 7



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UNITED STATES PATENT OFFICE

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ABRASIVE BELT POLISHING MACHINE

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Application May 13, 1942, Serial No. 442,787

6 Claims. (Cl. 51-143)

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The present invention relates to finishing or polishing machines, and particularly relates to apparatus for finishing or polishing elongated metal articles which are of a twisted or substantially helical form along the longitudinal axis; for example, airplane propeller blades.

One of the primary objects of the present invention is to provide machines by which the surfaces of the type of articles mentioned above may be finished or contoured or polished.

Another object of the invention is to provide machines to finish or polish elongated metal articles which have a twisted or substantially helical form along the longitudinal axis and which are transversely flat on one side and cambered on the opposite side.

Another object of the invention is to provide a machine by which articles of the type mentioned above may be uniformly finished or polished so that the propeller blades so finished have uniform characteristics and will be in dynamic balance when assembled with other blades similarly finished.

Another object of the invention is to provide a machine of the type mentioned by which there is effected considerable saving in time with material production increase.

A further object of the invention is to provide sturdy, accurate machines of the type mentioned which are adapted for accurate mass production.

Other objects of the invention will become apparent from the following specification, the drawings relating thereto, and from the claims hereinafter set forth.

In the drawings, in which like numerals are used to designate like parts in the several views throughout:

Figure 1 is a partial side elevational view of a machine for finishing or polishing one side of an airplane propeller blade;

Figure 2 is a view similar to Figure 1, showing the remaining end of the machine as continued from line 2-2 of Figure 1;

Figure 3 is a righthand elevational view of the machine shown in Figure 1, with a portion of the endless belt removed;

Figure 4 is a perspective view of a portion of the machine shown in Figure 1, with the endless abrading belt removed;

Figure 5 is an enlarged, transverse, elevational view of a portion of the machine shown in Figure 1, illustrating the manner in which the article support is mounted on the reciprocating carriage and showing the relationship of the sup-

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port with other co-operating parts of the machine;

Figure 6 is a cross-sectional view taken substantially along the line 6-6 of Figure 5;

Figure 7 is a top plan view of a portion of the machine, showing a propeller blade mounted on the article support;

Figure 8 is a partial, cross-sectional view taken substantially along the line 8-8 of Figure 4 and showing a propeller mounted on the support;

Figure 9 is a fragmentary perspective view of a portion of the machine, illustrating the manner in which the belt is applied;

Figure 10 is a view similar to Figure 9, showing another step in the application of the belt;

Figure 11 is a fragmentary, side elevational view of a portion of the machine, illustrating another form of the invention for finishing or polishing the cambered side of the propeller blade;

Figure 12 is an enlarged view of a portion of the structure shown in Figure 11 and showing other portions in greater detail;

Figure 13 is a cross-sectional view taken substantially along the line 13-13 of Figure 12;

Figure 14 is a partial perspective view of the structure shown in Figure 13;

Figure 15 is a cross-sectional view taken along the line 15-15 of Figure 11.

The present invention is particularly adapted for the finishing or polishing of airplane propeller blades; but it will be understood by those skilled in the art that according to its broader aspects the present invention is adapted for finishing or polishing other articles having contours generally similar to such blades.

According to the present practice, propeller blades are finished or polished by hand-controlled methods. In such methods, the operator polishes a portion of the blade under hand control and by the use of templates checks the blade against a master blade. Such hand methods are unsatisfactory because they are slow, since a substantial amount of time must be spent in checking. Furthermore, it is difficult for the operators to obtain uniformity in the finished blades, which results in a further loss of time, in that time must be spent in selecting blades which are all uniform, so that the blades will be in dynamic balance when mounted on the engine.

According to the present invention, machines are provided by which both the flat and cambered sides of the blade may be finished. Not all of the surface of the blade is finished by the present machine, in that a minor portion of the blade

adjacent the hub must still be hand finished. However, the major portion of the blade is finished by machines of the present invention.

It will be understood that the propeller blades are twisted about their longitudinal axis and that the thickness of the blade increases from the tip to the hub. When finishing the flat side, there is a straight line at any point along the blade transverse to the longitudinal axis. The blade is mounted upon a reciprocating carriage and is so mounted upon the carriage that it may tilt transversely thereof. Such tilting carriage is reciprocated with respect to an abrading means.

The abrading means includes an endless abrading belt having a cylindrical roller engaging the side of the belt opposite to that of the blade so that the roller urges the rotating belt into engagement with the surface of the propeller. Longitudinal cam elements are disposed on the side of the carriage, and the top surfaces of such cam elements are shaped to correspond to the twist in the propeller blade. The surfaces of the cam elements are such that at any point therealong, a transverse line across the surfaces of the opposite cam elements would be coincident with or parallel to a transverse line across the propeller blade.

The roller is mounted for pivotal movement about a fixed pivot axis and roller elements are mounted for pivotal movement about the same axis and are integral with the roller mounting. Such roller elements are adapted to engage the cam surfaces and cause the propeller blade carriage to tilt as it reciprocates with respect to the roller. The pivotal movement of the pressure roller permits the proper finishing along the blade due to the variation in thickness along its length. Due to the tilting of the blade, a transversely straight line on the blade is presented to the abrading belt under the roller as the blade passes under such roller. The pressure roller is mounted for accurate vertical adjustment so as to control the amount of surface material that is removed.

In finishing the cambered side, a roller is provided which is annularly grooved corresponding to the contour of the cambered side of the blade from the tip to a point adjacent the hub end thereof. Such roller has a circumference corresponding to the length of that part of the blade to be finished and it is caused to rotate in synchronism with the reciprocation of the carriage so that the abrading belt is given the proper contour as it engages the blade at the various points along the length thereof. The blade carriage is at the same time caused to tilt during its reciprocation to take care of the twist in the blade.

For a better understanding of the invention, reference may be had to the drawings and particularly to Figs. 1 through 10 thereof, in which a machine is illustrated for finishing or polishing the flat side of the blade. The structure comprises a mounting standard including a base plate 20 and unstanding sides 22 and 24, which are mounted upon the base plate 20 and which are connected together adjacent the upper ends thereof by a transverse integral portion 26. The standard thus forms a tunnel or aperture there-through, through which the blade carriage can pass during its reciprocable movement.

A pair of longitudinally extending members 28 and another pair of longitudinally extending members 30 are connected to longitudinally extending channel beams 32 and 34, respectively, and are spaced from each other to provide trackways for supporting the reciprocable blade car-

riage, generally indicated at 36. Such members 28, 30, 32 and 34 extend within the tunnel or opening and are connected to the standards 22 and 24 and also to longitudinally spaced standards 37, which serve to mount the trackway above the floor. The ends of the members 32 and 34 may be connected and braced by transversely extending channel members 38.

The carriage 36 has a transversely tiltable blade support and carriage 40 mounted thereon for reciprocation therewith, upon which the propeller blade 42 is mounted. Such propeller blade 42 is, in the embodiment illustrated, the Duralumin type and is twisted about its longitudinal axis and has a flat side 44 and a cambered side 46, as shown in Fig. 8. The carriage 40 is formed with a central bed portion 48 having a plurality of longitudinally spaced, outwardly and upwardly disposed side arms 50. The outer ends of the arms are interconnected by integral, longitudinally extending sides 52, the upper surfaces of which are formed with angle grooves 53.

A plurality of transversely extending members 54 are formed on plate members 55 which are fixedly mounted on the bed 52. The members 54 are provided with vertical apertures therein within which vertically adjustable supporting pins 56 having rounded upper ends are mounted. Such pins 56 are adapted to be vertically adjusted within the apertures in the members 54 and are set in their vertical positions by means of set screws 58. It will thus be seen that the pins 56 may be set so that the upper ends thereof properly engage and support the curved surface of the blade 42, whether the cambered or flat side is disposed downwardly. The blade may thus be properly supported on the carriage 40.

In order to fix the blade on the carriage, a chuck or clamp 60 is mounted on the carriage 40 adjacent the trailing end thereof. Such chuck may be of conventional construction and includes a tapered mandrel 62, which is properly centered and which is adapted to be received within the tapered opening formed in the hub of the blade 42. It will be understood that such tapered opening is formed in the hub prior to the time that the blade is received for the finishing operation accomplished by the machines of the present invention, so that when the hub is mounted on the chuck or clamp 60, the blade is properly centered. The chuck 60 may be of conventional construction and in the one illustrated, it includes clamps 64, which are adapted to engage the periphery of the hub, and is formed with releasable screw means so that the blade may be quickly attached or disengaged from the chuck.

The carriage 36 has longitudinally spaced rollers 66 rotatably mounted at the sides thereof and such rollers are adapted to ride upon the lower track plates 28 and 30. Longitudinally extending guide bars 68 are fixedly mounted to the top of the carriage 36 adjacent the sides thereof and the outer faces of such members 68 are adapted to bear against the facing edges of the upper members 28 and 30 so that the carriage 36 is accurately guided during its reciprocable movement.

The carriage 40 is adapted to be mounted on the carriage 36 for reciprocable movement therewith and for transverse tilting movement with respect thereto. To so mount the carriage 40 on the carriage 36, longitudinally spaced, depending members 70 are fixed to the underside of the bed 48 of the carriage 40. Such members have arcuate lower edges which are struck upon an arc having a center coincident with the longitudinal

center line of the blade, which may be considered as the center line of the mandrel 62. The arcuate edges of the member 70 are generally V-shaped in section, as best shown in Fig. 6. The arcuate edges of the member 70 are adapted to be supported upon frusto-conical shaped roller members 72. Such roller members 72 have projecting shafts which are rotatably received within bearings 74 mounted upon the top surface of the carriage 36. The centers of the bearings 74 and, consequently, the centers of the rollers 72 are disposed on an arc about the same center as the arcuate edges of members 70. With this construction, it will be seen that due to the V-edge of the member 70 and the engagement with the roller 72 that the carriage 40 will reciprocate with the carriage 36 but may transversely tilt with respect thereto.

Means are provided for reciprocating the carriage 36, and, in the embodiment illustrated, such means is an hydraulic means. The hydraulic reciprocating means here shown is formed of conventional elements and includes an hydraulic cylinder 76 having one end thereof pivotally connected to a transverse pivot shaft 78. Such pivot shaft 78 is mounted upon the end upright members 37, as indicated in Fig. 2. The cap end of the cylinder 76 has the usual reciprocating piston rod 80 projecting therefrom, and the end of such piston rod 80 is connected to the forward end of the table 36 through a depending bracket 82.

Fluid under pressure, from a suitable source, not shown, is introduced into the opposite ends of the cylinder 76 for the purpose of reciprocating the piston rod 80. A conventional control means indicated at 84 is provided in the hydraulic system for controlling the flow of fluid under pressure to the opposite ends of the cylinder 76. Such control means 84 has a hand control thereon for starting and stopping the machine and also has upstanding control fingers 86, which are operatively connected to the control means 84 through a shaft 90. The fingers 86 are of different lengths and are laterally offset and are adapted to be engaged by actuating fingers mounted on the carriage 36 as it reciprocates. One of such fingers is indicated at 92 and it is mounted upon one of the side edges of the carriage 36. It is mounted within a longitudinal groove on the carriage 36 and may be adjustably set within such groove so that the length of stroke, or the point of reversal, of the hydraulic cylinder and piston may be varied. The finger 92 is suitably positioned in the proper location along the length of the carriage 36 and another similar finger 94 is similarly adjustably positioned at a point spaced from the finger 92. It will thus be seen that as the carriage reciprocates in one direction, the finger 92 engages and pivots one of the fingers 86 to rotate shaft 90 to thereby reverse the control valve 84; and when the carriage moves in the opposite direction, the finger 94 engages and pivots the other finger 86 to effect a reversal. Thus, the carriage is caused to reciprocate as long as the fluid pressure is supplied to the hydraulic cylinder.

The abrading means includes a pivotally mounted abrading head generally indicated at 101. Such abrading head 101 includes a pair of side arms having upstanding portions 102 and longitudinally projecting portions 104. A transverse mounting plate 106 is formed integral with the upright portions 102 of the side arms and extends therebetween. The side arms, together

with the mounting plate 106 are pivotally mounted to the standards 22 and 24 by means of aligned, horizontal stub shafts 110 which are supported within bearing brackets 112 mounted on the standards 22 and 24.

The arm portions 104 may be connected together by means of a bracing rod 114 adjacent the free ends thereof. Roller elements 116 are pivotally mounted on aligned, horizontal pivot shafts to the free ends of the arm portions 104. The function of such rollers 106 will be described in detail hereinafter.

A cylindrical pressure roller 118 is pivotally mounted to the lower ends of the arms 120 of a mounting bracket 122. Such mounting bracket 122 has a transverse portion which is integral with the upper ends of the arms 120. The mounting bracket 122 is mounted to the mounting plate 106 for vertical adjustment thereon. In order to so mount the bracket, vertical guide posts 124, which are cylindrical in form, are mounted on the face of the mounting plate 106 in spaced relation thereto. The ends of such guide bars are secured to outwardly projecting brackets 126 which are fixed to the front of the plate 106 adjacent the upper and lower ends of the guide bars. Such guide posts 124 are, of course, parallel and are slidably received within bearing sleeves secured to the rear face of the transverse portion 122.

The mounting bracket 122 may be vertically adjusted with respect to the plate 106 and is held in adjusted position by means of a depending screw 128, the lower end of which is threaded and is threadably received within a nut fixed to the back face of the bracket 122. The upper end of the shaft 128 is supported within a worm gear housing 130 so that the bracket 122 together with the roll 118 is held in its vertically adjusted position. The upper end of the screw shaft 128 has a worm wheel attached thereto which meshes with a worm on the end of shaft 132. The shaft 132 projects from within the housing and has a hand wheel 134 connected thereto. The shaft 132 passes through and is supported by an indicator housing 136 which is mounted upon the upper end of one of the side arms 102. That portion of the shaft 132 within the housing 136 is connected through suitable gears with the indicator means so that as the wheel is turned the amount of vertical adjustment of the roll 118 is indicated.

In the embodiment illustrated, the indications are in thousandths of an inch and the scale would indicate forty thousandths for one revolution of the indicator. It will thus be seen that the indication is quite accurate in that the present invention is designed for precision work. It will also be understood that the gearing which controls the vertical adjustment of the roll 118 must be accurate and such gears have substantially zero back lash.

An endless abrading belt 140 is provided which is trained about roller 118, drive roller 142, and guide rollers 144 and 146. The rollers 118, 142, 144 and 146 are covered with a suitable resilient material, such as rubber.

The abrading belt 140 is attainable on the commercial market. It is flexible in character and has the abradant secured to the outer surface thereof. Such abradant may be of the required and predetermined grade and fineness. It will be appreciated that for the roughing work, a belt having a relatively coarse abradant thereon may be used, while for the finishing operations a belt

having a relatively fine abrading thereon is used. The machine may either be used by changing the belt for the different finishing operations, or a plurality of machines may be employed in which the different machines have belts with abrading of different fineness thereon, in which event the propeller is transferred from one machine to another for the purpose of performing the finishing operations.

The driving roller 142 is keyed to a drive shaft 148. One of the ends of the drive shaft 148 is supported in bearings 150, which are mounted upon a standard 152 which rests upon the floor. The opposite end of the shaft 148 is supported within a bearing 154 which is mounted upon a mounting plate 156. Such mounting plate 156 is removably mounted to an upstanding standard 158 by means of bolts 160, and the lower end of the standard is secured to the frame member 32. The removable plate 158 is provided so that it may be removed in order to place the belt 140 over the drive roller 142, or remove it therefrom.

A pulley 162 is keyed to one end of the shaft 148 and is driven through belts 164 and a pulley 166. The pulley 166 is keyed to the drive shaft of an electric motor 168. The electric motor 168 is of the conventional variable speed type and is connected to a suitable source and provided with conventional control means for controlling the drive of the roll 142.

The roll 144 is keyed to a shaft 170, the ends of which are mounted within bearings 172. The bearings are mounted in the arms of a yoke bracket 174, and such bracket is keyed to a pivot shaft 176. Such pivot shaft 176 is pivotally received within the brackets 178 which are mounted to the transverse portion 26 of the head standard. The shaft 176 has a counterweight arm 180 fixed to one end thereof and a plurality of weights 182 are removably mounted on the outer end of the arm 180. The roller 144 may thus be pivoted about the shaft 176 and serves as a belt tightener.

The roller 146 is mounted upon a shaft, the ends of which are supported within aligned bearings 182 which are mounted within the arms of a yoke bracket 184. Such yoke bracket 184 is pivotally mounted to an outstanding bracket 186, which is fixed to the rear face of the transverse head standard 26. The bracket 184 is pivotally mounted to the bracket 186 by means of a pivot pin 188 which may be tightened to fixedly position the bracket 184 for the purpose of properly aligning the belt 140. Another set screw 190 may be associated with the bracket 184 and with the bracket 186 for locking the bracket 184 in its pivotally adjusted position.

While the roller 146 is here illustrated as being the one that is pivoted for aligning the belt 140, it will be understood that the mounting for roller 146 may be fixed and the mounting for roller 144 pivoted, so that such roller 144 may be used as the one to properly align the belt.

The roller 142 is preferably so driven that the belt 144 moves in a counterclockwise direction, viewing Fig. 2.

As discussed above, as the carriage 40 reciprocates with respect to the roll 118 and, therefore, with respect to that position of the belt 140, which is engaged by roll 118, such table is caused to tilt transversely of the direction of reciprocation. The tilting is such that as the propeller is engaged by the belt 140, in transverse line contact, that portion of the propeller which is engaged is presented to the engaging portion of

the belt in a horizontal line which is normal to the axis of reciprocation of the support 40.

In order to so control the tilting of the table that the propeller is engaged by the belt in the horizontal, transverse line contact, elongated, cam guide plates 192 are fixedly mounted on the carriage within the corners 53 at the outer ends of arms 50, as best shown in Fig. 5. The upper edges of such plates 192 are shaped to correspond to the twist in the propeller blade around the longitudinal axis of such plate. The upper surfaces of the members 192 are complementary to each other in that at any point therealong, transversely of the carriage, a transverse line engaging the upper edges of the members 192 corresponds to a transverse line on the propeller blade. Such first mentioned line is, therefore, in the vertical plane passed through a corresponding, transverse line in the blade. When the table 40 is reciprocated, the top edges of the members 192 are engaged by the rollers 116 on the head 101. The axis of such rollers 116 is horizontal and is parallel to the axis of the roller 118. The head 101 cannot transversely tilt so that as the rollers 116 engage the upper edges of members 192 the table 40 is tilted corresponding to the cam shape of the upper edges of members 192. Thus, the propeller is presented to the belt 140 in transverse line contact as it is reciprocated, as discussed above.

To provide for over-travel at the ends of the stroke the members 192 are of the same height and have upper edge surfaces which are horizontal when the carriage 40 is in its center position. This is to provide for easy removal of the propeller blade 42 in that it may be withdrawn far enough from the point of contact with the belt for ready removal while at the same time, the head 101 is in engagement through rollers 116 with the bars 192.

In the operation of the device above described, it will be understood that such device is for finishing or polishing the flat side of the propeller blade. Such propeller blade is positioned on the carriage as discussed above and with the motor operating so that the belt 140 is driven in a counter-clockwise direction, the carriages 36 and 40 are reciprocated through the hydraulic system described above. During such reciprocation the carriage 40 is caused to transversely tilt and the roller 118 forces the belt 140 into its transverse line contact with the propeller as it is reciprocated. The height of the roller 118 controls the extent a depth of cut and such height may be controlled, as discussed above, through the vertical adjustment of the bracket 120 through hand wheel 134, and its associated mechanism. In order to compensate for the variations in thickness of the propeller blade from one end to the other, the entire head 101, including the roller 118, may pivot about the shaft 110.

In order to limit the downward pivotal movement of the head 101 a stop bracket 196 is fixed to the transverse portion 26, and has a depending finger which lies in spaced relation to the front face of the plate 106 and is adapted to be engaged by the plate 106 to limit its pivotal movement.

To provide for ready application of the belt 140 and its removal from the machine, the standard 22 is built into separable upper and lower sections, as best shown in Figs. 1 and 4. The adjacent sections of the standard 22 are formed with V-flanges therearound, as indicated at 198. Complementary V-members 200 are adapted to be

removably fixed to the V-flanges 198 and provide for fixing the two sections together across the space 202 therebetween. The belt is adapted to be passed through the space 202 as shown in Figs. 9 and 10. While the upper section of member 22 is of a rugged character and would probably support itself during the period that the members 200 are removed during the application of the belt, a temporary supporting bar 204 is removably mounted to the two sections through bolts 206.

The members 200 are held together by means of tie bolts 208 which are passed between the members 200 within the space 202.

To apply a new belt, the member 204 is first removed and the inside loop of the belt 140 positioned as shown in Fig. 9. The bar 204 is then fixed in position and the tie bolts 208 removed so that the members 200 may be removed. The bracket portion 156 is also removed. The belt may then be passed through the space 202 as indicated in Fig. 10 and may then be positioned about the rollers 118, 142, 144 and 146. Thereafter, the members 200 may be repositioned and fixed in position as shown in Figs. 1 and 4.

A bracing rod 210 has one end thereof fixed to standard 24 and the opposite end thereof fixed to standard 152 so that these elements of the machine are properly spaced and placed with respect to each other.

Referring to Figs. 11 through 15, the machine of the present invention is illustrated wherein it is adapted for the finishing or polishing of the camber side of the propeller blade. The machine is generally similar to that described above and corresponding reference numerals have been used to designate corresponding parts. The main differences in the structure, over that for the flat side described above, are that the roller 146 is so positioned that the belt approaches the propeller blade for engagement therewith in a substantially horizontal plane or at a slight angle to the horizontal so that the blade is only engaged in line contact under the contact roll. The contacting roller is of a different structure in that its peripheral surface is contoured completely therearound to correspond to the contour of the camber along the length of the blade.

The propeller blade is fixed to the carriage 40 in the same manner as that described above except that the cambered side of the blade is disposed upwardly. It will be understood that the camber on the blade varies from one end of the blade to the other and that the width and the thickness of the blade also vary. The blade is twisted about its longitudinal axis on substantially a helix so that the cambered side is twisted as well as the flat side.

The roller 146 is mounted to a depending yoke bracket 211, which corresponds to the bracket 184 above described, and the bracket 211 is disposed downwardly so that the belt 140 approaches the point of contact with the blade in a substantially horizontal plane, or a plane which is at a very slight angle to the horizontal. The reason for this is to insure line contact only with the blade while providing for easy shaping of the belt when it is engaged by the pressure roller and forced into transverse line contact with the blade.

Instead of using the pressure roller 118, above described, a pressure roller 212 is used. Such roller 212 is formed with hub portions 214 and 216, which are keyed to the shaft 218. Such shaft

218 is mounted within end bearings 220, which are mounted to the lower end of the arms 120.

The peripheral portion of the roller 212 is built up of wooden edge pieces 222, which are disposed on inwardly directed peripheral flanges on the end members 214 and 216, and which may be secured thereto by screws 224 passed through radial flanges formed adjacent the periphery of the end members. The circumference of the roller 212 is the same as the length of the propeller blade to be finished. The edges of the wooden members 222 are then formed to provide an annular groove which when developed corresponds to the cambered side of the blade. Such groove is indicated at 226.

The groove is accurately formed so that it has transverse portions which correspond to transverse portions along the length of the blade. One manner in which the groove 226 may be accurately formed is to first form a rough groove which generally corresponds to the finished groove. Then a master blade may be mounted on the machine and the abrading belt reversed so that the smooth side of the belt is on the outside and the abrading side disposed to engage the peripheral surface of the roller 212. By then reciprocating the carriage in the same manner that is used when finishing a blade, and driving the belt and at the same time interconnecting the wheel 212 with the reciprocating carriage so that it moves in synchronism therewith, the blade will be forced to follow the contour of the master blade and will be forced into engagement with the peripheral surface of the wheel in such shapes as to accurately finish the groove 226. Such groove 226 will then conform exactly to the cambered contour of the blade.

The groove 226 may be more deeply formed, to a predetermined amount, than the finished article and then such peripheral portion may be covered with an asbestos material, or the like, to take up the oversize, if desired.

In finishing a blade, the belt 140 is, of course, positioned with the abradant disposed outwardly. Such belt is driven counterclockwise, viewing Figure 12, and as it approaches the roll 212, it is engaged by the peripheral surface of such roll and urged against the cambered side of the blade. The belt is caused to follow the contour of the peripheral surface of the roller 212, as shown in Figure 13.

The purpose of leading the belt 140 to the wheel 212 in a substantially horizontal plane is that there is a tendency for the belt to curl transversely and by bringing it into contact with the roller 212 in this position, the belt will conform more readily to the peripheral contour of the wheel 212 than it would if it were brought in at an angle.

Also, it will be seen that when the belt 140 leaves the roller 212, it must be angled upwardly to its position about the drive roller 142. While in contact with the roller it is curved upwardly, as shown in Figure 13, and it is difficult to bend the belt in the required direction. To decrease this quick change in direction of the belt and to facilitate the change in direction of travel of the belt, a straightening roller 230 is disposed between the rollers 212 and 142. Such roller 230 has its peripheral surface slightly curved as shown in Figure 15 so that it partially straightens the belt transversely and reduces the angle which the belt must turn in passing from roller 212 to the roller 142.

The roller 230 is mounted upon a shaft 232, the

ends of which are disposed within suitable bearings 234. Such bearings 234 may be removably mounted to the upper ends of standards 236 which are fixed to the side members 32.

Means are provided for synchronizing the movement between the carriage 40 and the roller 212 as the carriage is reciprocated with respect to the roller so that the proper transverse line of the groove 226 will engage the belt 140 to give it the proper contour for the corresponding transverse line on the cambered side of the blade. In the embodiment here illustrated, such means includes an annular drum member 238 which is fixed to the end member 216. Such member 238 is provided with a spiral groove 240 therein, and the circumference of the member 238 is the same as the length of the blade. A cable 242 is disposed within the groove 240 and is welded to the groove, as indicated at 246. The ends of the cable 242 are crossed and extend in opposite directions. Such ends are secured within clamps 248, which are mounted to brackets 250. The brackets 250 are secured to the ends of carriage 36. The ends of the clamps 248 are threaded and have nuts associated therewith so that they may be drawn up to tension the cable 242 and to take up any elongation which may develop therein.

It will thus be seen that as the carriages 36 and 40 reciprocate, the carriage 40 transversely tilts and the roller 212 is caused to rotate in synchronism with the reciprocation of the carriage.

Instead of using the cable and drum connection here shown, it will be understood that the same synchronous movement between the pressure roller and the blade or blade carriage may be obtained by the use of a gear and rack. In such event, the rack would be mounted on the carriage 36 and would be adapted to mesh with a spur gear which would correspond in position to the drum 238. With the rack and gear, adjustments may be more easily made.

What is claimed is:

1. Apparatus for finishing and contouring a propeller blade, comprising a standard, an elongated article support mounted on said standard for reciprocable movement thereon, an endless abrading element mounted above and adjacent said article support, a roller element having a length greater than the width of the article being formed, means pivotally mounting said roller transversely of said article support above the lower reach of said abrading element for free vertical movement so that said roller element is disposed to engage and urge said abrading element into engagement with the article, means mounting said article support for tilting movement with respect to said roller element in a plane substantially normal to the direction of said reciprocable movement, elongated cam means mounted on said article support for movement therewith and having a cam surface facing said roller element, follower means mounted on said mounting means for the roller element and movable therewith, said follower means engaging said elongated cam means to cause said support to tilt to various angles as it reciprocates with respect to said roller element, means for adjusting said roller with respect to the article support independently of the position of the follower means, means for reciprocating said support, and means for driving said abrading element.

2. Apparatus for finishing and contouring a propeller blade, comprising a standard, an elongated article support mounted on said standard for reciprocable movement thereon, an endless

abrading element mounted above and adjacent said article support, a roller element having a length greater than the width of the article being formed, means pivotally mounting said roller transversely of said article support above the lower reach of said abrading element for free vertical movement so that said roller element is disposed to engage and urge said abrading element into engagement with the article, means mounting said article support for tilting movement with respect to said roller element in a plane normal to the direction of said reciprocable movement, elongated cam elements mounted on said article support along the sides of the article on said support and having cam surfaces facing said roller element, followers mounted on said mounting means for the roller element above said cam elements and movable therewith, said followers engaging said cam elements to cause said support to tilt to various angles as it reciprocates with respect to said roller element and to control the pivotal movement of said roller about its pivot mounting means for adjusting said roller with respect to the article support independently of the position of the followers, means for reciprocating said support and means for driving said abrading element.

3. Apparatus for finishing and contouring a propeller blade, comprising a standard, an elongated article support mounted on said standard for reciprocable movement thereon, an endless abrading element mounted above and adjacent said article support, a roller element having a length greater than the width of the article being formed, means pivotally mounting said roller transversely of said article support above the lower reach of said abrading element for free vertical movement so that said roller element is disposed to engage and urge said abrading element into engagement with the article, means mounting said article support for tilting movement with respect to said roller element in a plane normal to the direction of said reciprocable motion, elongated cam elements mounted on said article support and having cam surfaces facing said roller element, roll followers mounted on said mounting means for the roller element and movable therewith, said followers being disposed outwardly of said roller element and engaging said cam elements to cause said support to tilt to various angles as it reciprocates with respect to said roller element, means for adjusting said roller with respect to the article support independently of the position of the follower means, means for reciprocating said support and means for driving said abrading element.

4. In a blade finishing machine, in combination, a frame, a blade support on said frame, a head bracket adjustable on said frame relative to said support, a roll carrying bracket supported on said head bracket and adjustable relative to the latter and to said support, a pressure roll carried by said last mentioned bracket and adjustable therewith, a plurality of guide rollers carried by said frame in parallel relation with said roll on opposite sides of said roll and having their axes of rotation disposed within the vertical limits of said roll, an abrasive belt running over said rollers and having its lower reach passing beneath said roll and in engagement therewith, and means on said frame for maintaining said belt under substantially constant tension during operation for various adjustments of said brackets.

5. In a blade finishing machine, in combina-

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tion, a frame, a horizontal blade support on said frame, a head bracket adjustably supported on said frame, a roll carrying bracket adjustably supported on said head bracket, a pressure roll carried by said last mentioned bracket adjustable therewith, a plurality of guide rollers carried by said frame in parallel relation with said roll on opposite sides of said roll and having their axes of rotation disposed within the vertical limits of said roll, an abrasive belt running over said rollers having one reach thereof passing between said roll and the blade on said support, means for reciprocating said support longitudinally of the blade supported thereon, means including a driving pulley fast on one of said rollers for moving said belt over the blade on said support, and means carried by said support and roll for oscillating said roll in timed relation to the reciprocations of said blade.

6. In a blade finishing machine, in combination, a frame having a generally horizontal bed, a carriage movable along said bed, a blade supporting cradle carried by said carriage and rockable transversely thereof, a head bracket adjustably supported on said frame, a roll carrying bracket adjustably supported on said head bracket toward and from the blade on said supporting cradle, a plurality of guide rollers carried by said frame in generally parallel relation on opposite

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sides of said roll, an abrasive belt running over said rollers having a reach thereof passing between said roll and the blade on said cradle, means for reciprocating said carriage to move the blade longitudinally beneath said roll, means for reversely rotating said roll by the reciprocation of said carriage, and means for adjusting said roll carrying bracket to move said roll toward and from said blade.

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