Feb. 13, 1962 J. T. LEWIS, JR., ETAL 3,020,678

ABRADING MACHINE FOR SURFACE FINISHING WORK PIECES

Filed Dec. 23, 1958 8 Sheets-Sheet 1

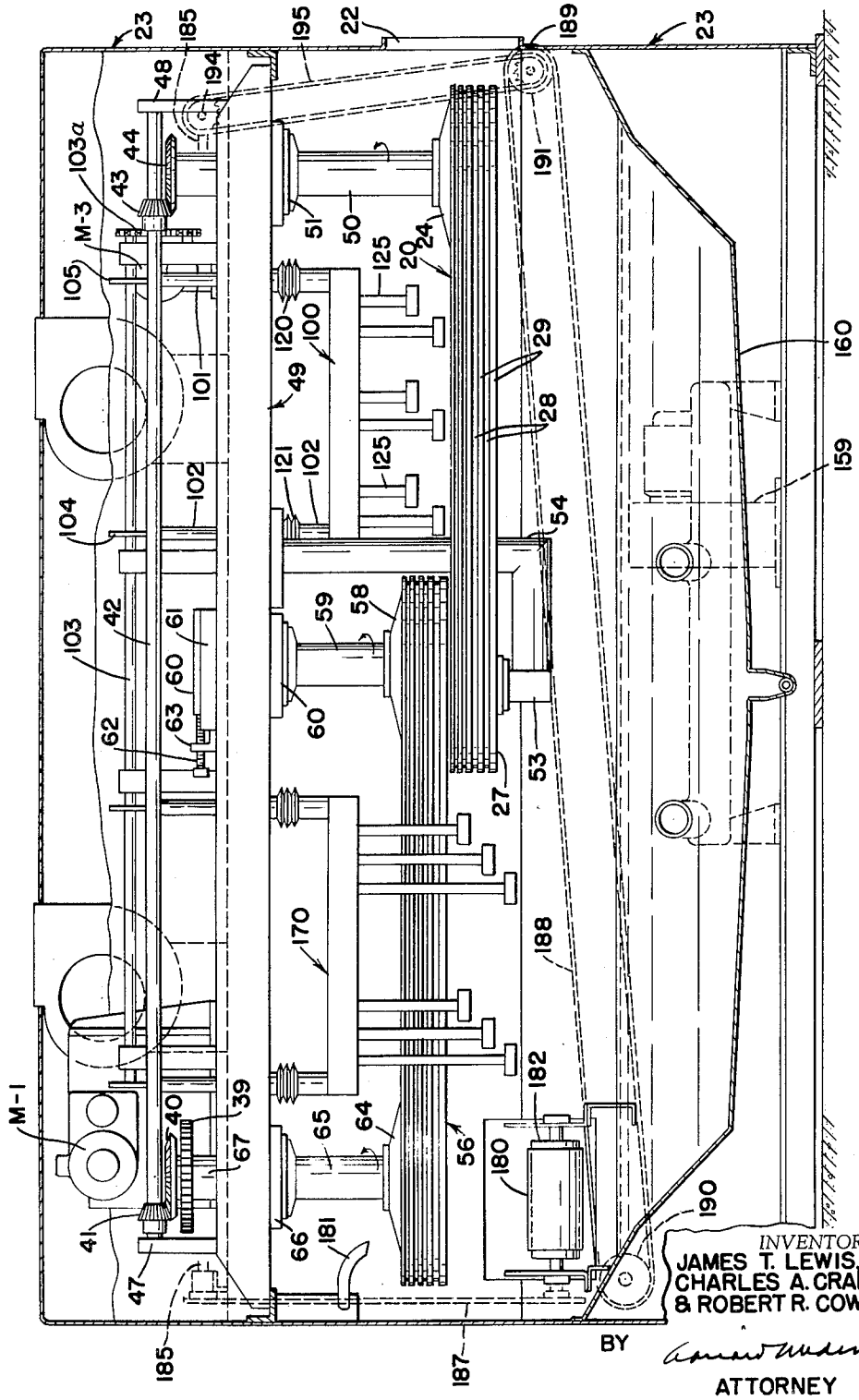


FIG. 1

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ABRADING MACHINE FOR SURFACE FINISHING WORK PIECES

Filed Dec. 23, 1958 8 Sheets-Sheet 2

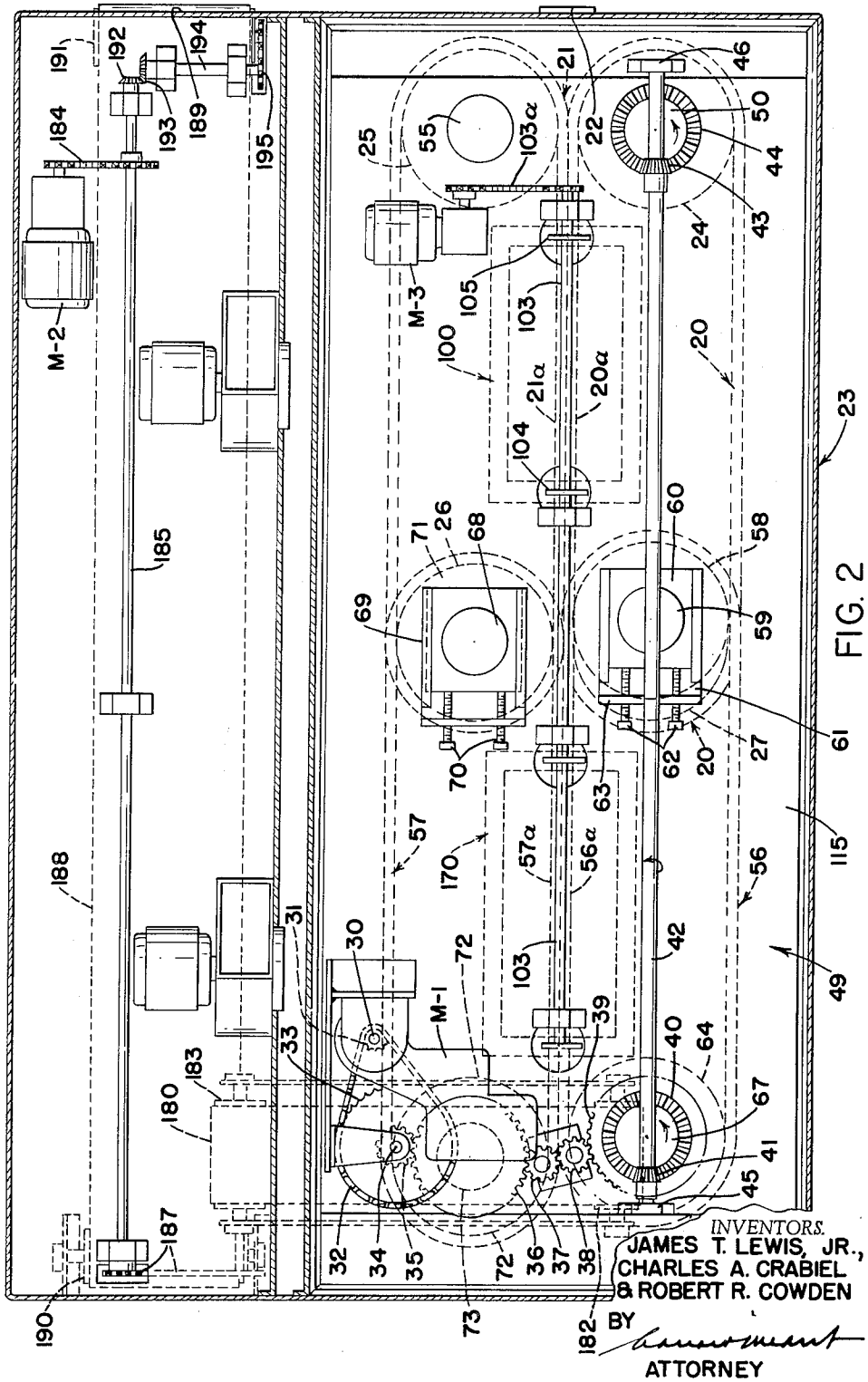


FIG. 2

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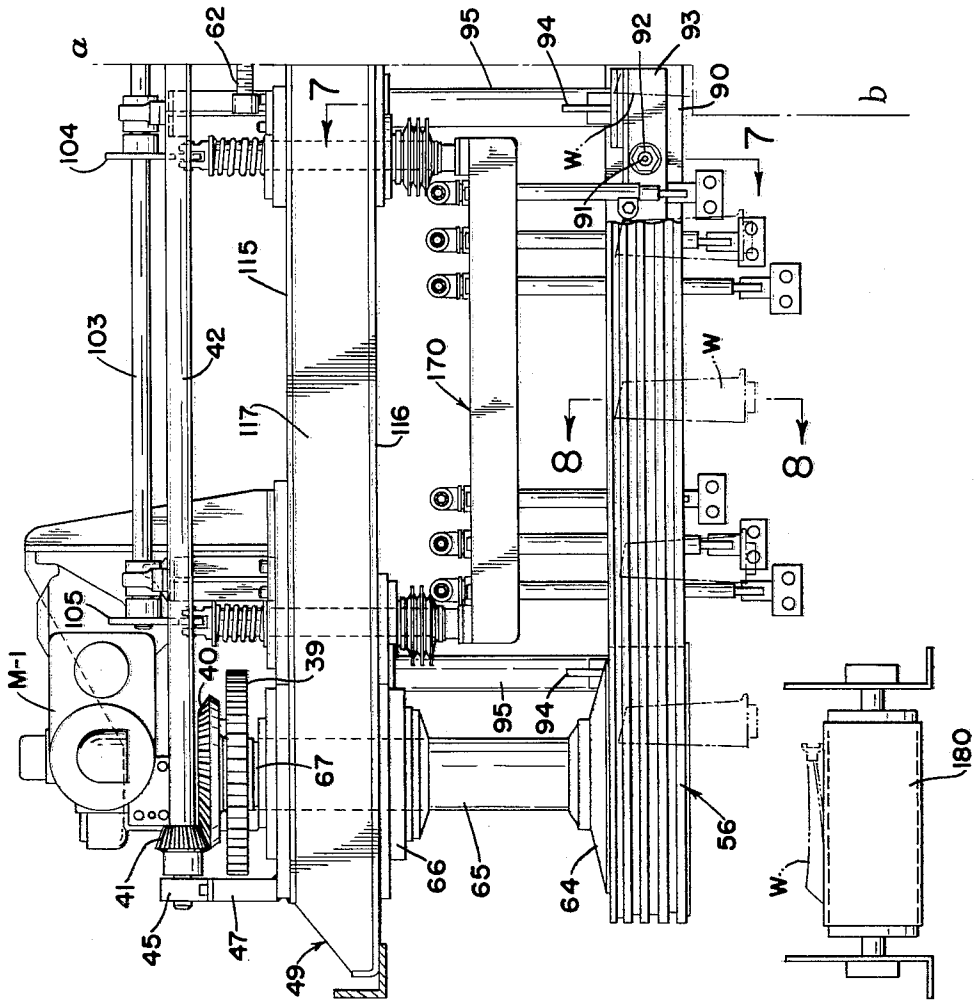


FIG. 3A

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ABRADING MACHINE FOR SURFACE FINISHING WORK PIECES

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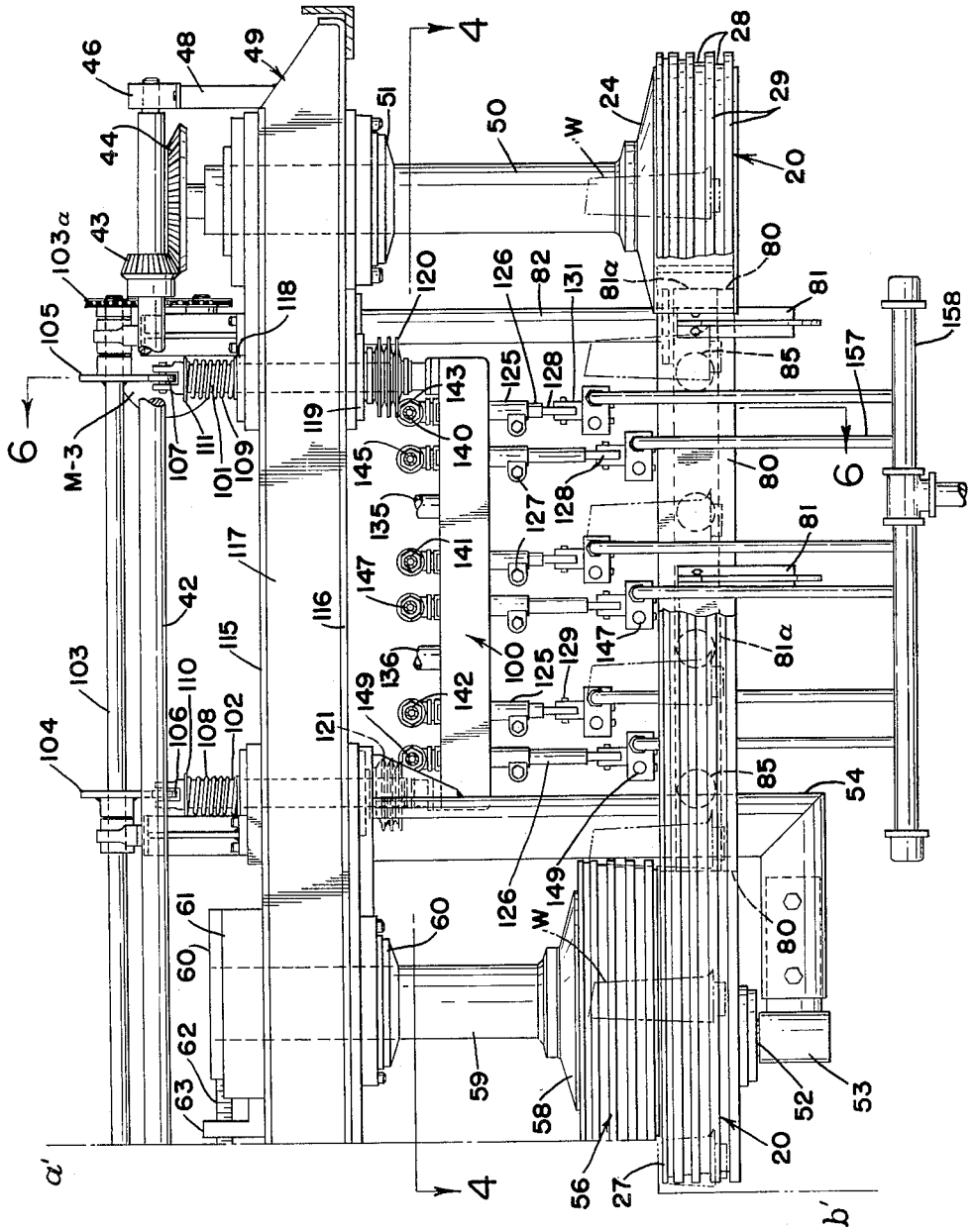


FIG. 3B

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ABRADING MACHINE FOR SURFACE FINISHING WORK PIECES

Filed Dec. 23, 1958 8 Sheets-Sheet 5

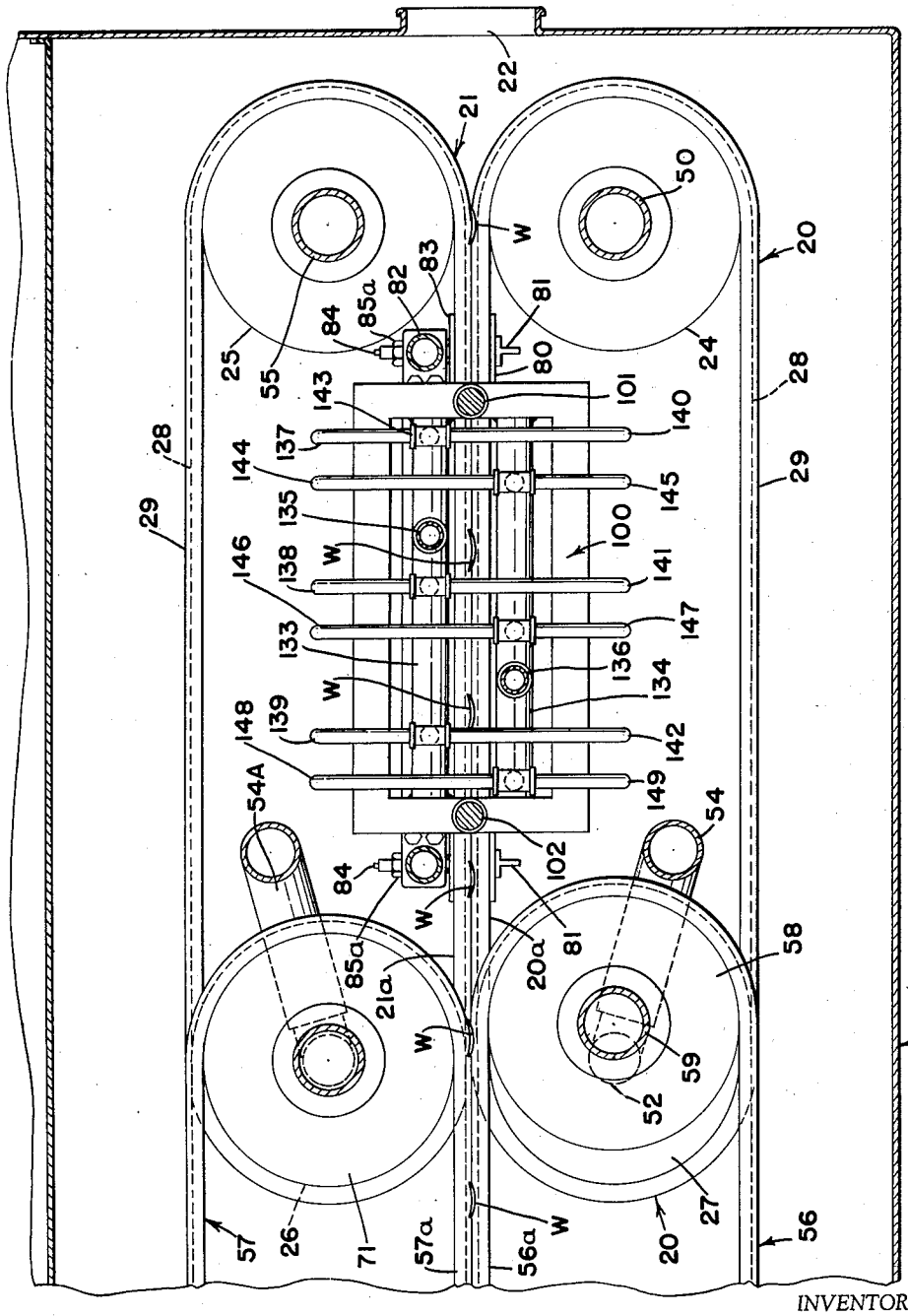


FIG. 4

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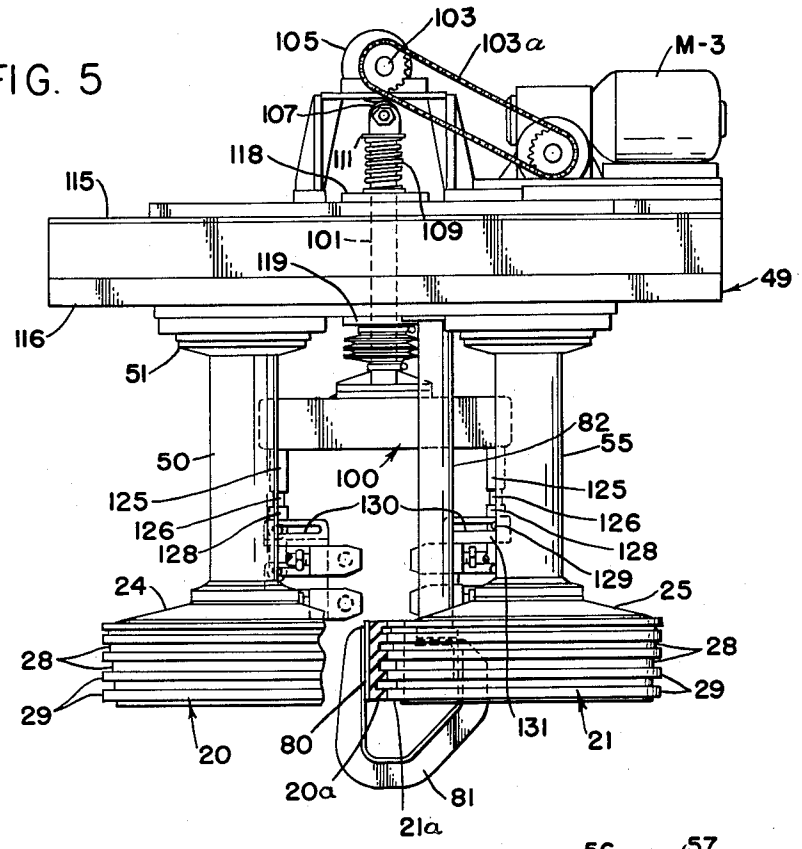
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ABRADING MACHINE FOR SURFACE FINISHING WORK PIECES

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FIG. 5



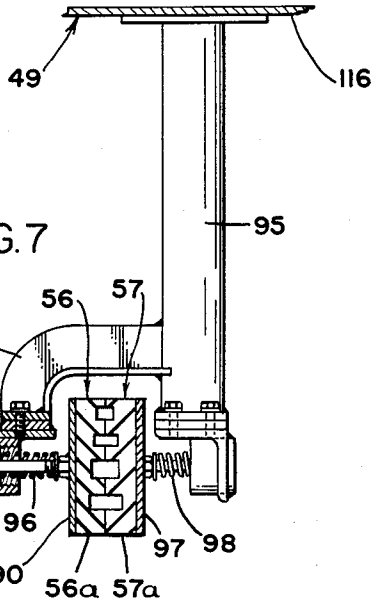


FIG. 7

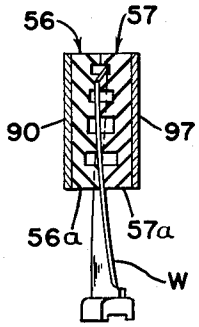


FIG. 8

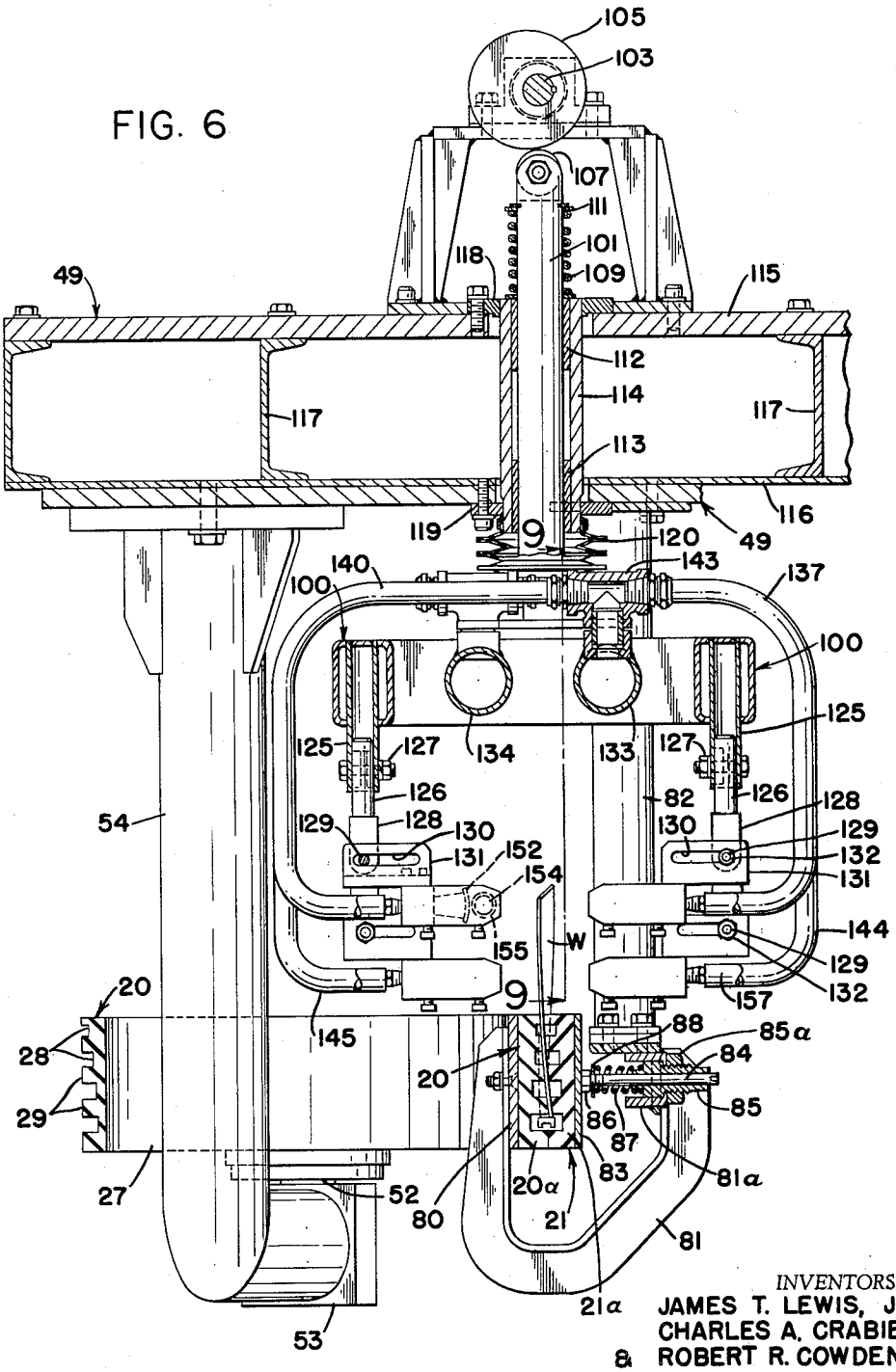
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ABRADING MACHINE FOR SURFACE FINISHING WORK PIECES

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FIG. 6



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ABRADING MACHINE FOR SURFACE FINISHING WORK PIECES

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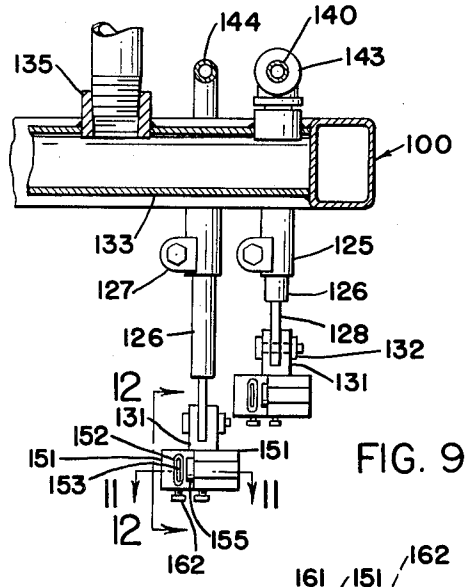


FIG. 9

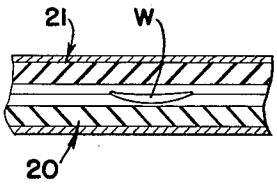


FIG. 10

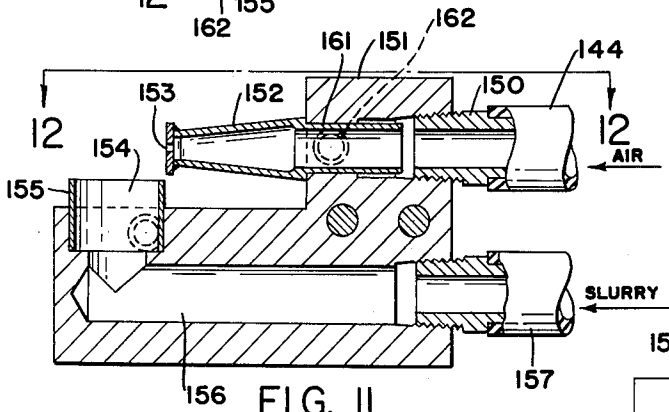


FIG. 11

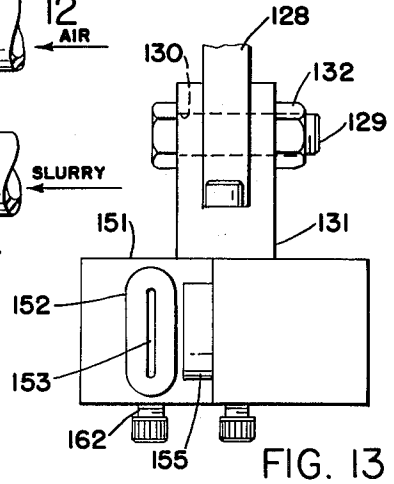
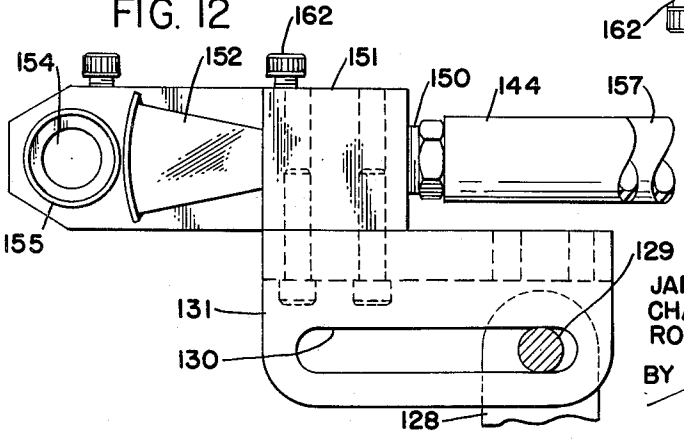


FIG. 13

FIG. 12



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United States Patent Office 3,020,678 Patented Feb. 13, 1962

3,020,678

ABRADING MACHINE FOR SURFACE FINISHING WORK PIECES

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Filed Dec. 23, 1958, Ser. No. 782,438
20 Claims. (Cl. 51—14)

This invention relates to an abrading machine for surface finishing work pieces.

It has been recognized that the liquid abrasive spray process is particularly well suited for finishing metal parts by removing rust, scale produced by previous heat treatment, or other undesirable surface conditions. In addition, the liquid abrasive spray may be used to improve the quality of the surface of the work piece, imparting to it a clean, smooth texture suitable for subsequent plating or other final finishing treatment.

The present invention is directed to an improved machine which is capable of handling a wide variety of work pieces entirely automatically and subjecting them to a abrasive spray which produces the desired surface finish on the work pieces. The abrasive spraying action in the present machine produces a uniformity of surface finish not obtainable heretofore at comparable cost. In addition, the spraying arrangement in the present invention is capable of virtually infinite adjustment to suit the particular work pieces being treated and to produce any desired finish thereon, as well as other advantages specifically pointed out hereinafter.

Accordingly, it is among the objects of the present invention to provide a novel and improved abrading machine.

It is a further object of the invention to provide an abrading machine having a novel abrasive spraying arrangement which produces an exceptionally uniform surface finish on the work pieces being treated.

Another object of the invention is to provide an abrading machine having a novel abrasive spraying mechanism which may be adjusted readily to produce any desired abrading effect on the particular work pieces being treated.

Another object of the invention is to provide a novel abrading machine which is entirely automatic in its operation and which is capable of surface finishing a variety of different work pieces at low cost.

Another object of the invention is to provide a novel conveyor arrangement which is particularly adapted to convey a variety of work pieces, particularly irregularly shaped work pieces, for surface treatment.

A further object of this invention is to provide in an automatic abrading machine a novel conveyor mechanism for conveying the work pieces through successive abrading stations and exposing different portions of the work pieces to treatment at the successive abrading stations.

A further object of this invention is to provide a novel and improved abrasive spray gun.

A still further object of this invention is to provide a novel abrasive spray gun which is not subject to appreciable wear and which is readily adjustable to impart the desired abrading action to the particular work pieces being treated.

Other objects and advantages of the present invention will become more apparent from the following detailed description of a presently-preferred embodiment thereof, taken in conjunction with the accompanying drawings wherein corresponding reference characters denote corresponding parts.

In the drawings:

FIGURE 1 is a front elevational view of the present machine, with the front of the housing removed and with

certain of the elements of the machine shown schematically for simplicity;

FIGURE 2 is a top plan view of the machine of FIGURE 1 with the top of the housing removed;

FIGURES 3A and 3B are views similar to FIGURE 1, but on an enlarged scale and with certain of the elements illustrated in greater structural detail, showing successive portions of the machine;

FIGURE 4 is a horizontal sectional view taken along the line 4—4 of FIGURE 3B and looking down on the first pair of conveyor belts in the machine and the first abrasive gun assembly;

FIGURE 5 is an enlarged end elevational view, partly broken away, showing the first pair of conveyor belts at the inlet end of the machine;

FIGURE 6 is a vertical sectional view taken along the line 6—6 of FIGURE 3B;

FIGURE 7 is a vertical sectional view taken along the line 7—7 of FIGURE 3A;

FIGURE 8 is a vertical sectional view taken along the line 8—8 of FIGURE 3A;

FIGURE 9 is an enlarged fragmentary plan view showing a pair of the abrasive guns at one side of the line of movement of the work pieces in the first part of the machine;

FIGURE 10 is an enlarged fragmentary horizontal sectional view showing a work piece gripped by a pair of conveyor belts in the machine;

FIGURE 11 is an enlarged sectional view lengthwise through one of the abrasive guns, taken along the line 11—11 of FIGURE 9;

FIGURE 12 is an enlarged fragmentary side elevational view showing one of the abrasive guns, taken along the line 12—12 of FIGURE 9; and

FIGURE 13 is a fragmentary front elevational view of the gun shown in FIGURE 12.

Referring first to FIGURES 1 to 4 inclusive, the abrading machine of the present invention embodies a novel conveyor arrangement for advancing the work pieces through successive stations where abrasive is sprayed onto the work pieces to surface finish them. In the drawings the work pieces are shown as jet engine turbine blades which, because of their irregular shape and the precision with which they must be manufactured, have been considered difficult to finish in automatic abrading machines of previous types.

The conveyor includes two pairs of confronting endless belts, the belts of each pair gripping the work pieces between them and holding the work pieces substantially vertical as they are conveyed through the machine. The first pair of belts grip the lower half of each work piece while the upper half of the work piece is being subjected to an abrading action. Thereafter, the second pair of belts grip the upper half of each work piece while the lower half of the work piece is being subjected to abrasive finishing.

The first pair **20** and **21** of these belts (FIGURES 2 and 4) are located just inside the entrance opening **22** at one end of the housing **23** of the machine. The front ends of belts **20** and **21** extend around a first pair of drums **24** and **25** which are mounted for rotation about vertical axes. At their back ends these belts extend around a second pair of similar drums **26** and **27**. Between the drums **24, 25** at one end and the drums **26, 27** at the opposite end the belts **20, 21** present elongated, straight advance track portions **20***a* and **21***a*, respectively, which are in face-to-face, confronting relationship and which run contiguous to each other. The work pieces are gripped between these confronting advance track portions **20***a* and **21***a* of the belts.

As best seen in FIGURES 1, 3B and 6, each of these belts is formed on its outer face with a plurality of length-

wise grooves 28 which alternate with lengthwise ribs 29. The grooves are successively deeper downwardly along the belt, as shown clearly in FIGURE 6. The belts are of suitable flexible, compressible, resilient material, such as rubber or the like. The shape of the belts hereinabove described and illustrated in the drawings is most suitable for the turbine blade illustrated, however, the gripping surface of the belts may be varied or modified to accommodate a wide variety of work piece configuration.

The belt 20 is arranged to be driven continuously at suitable speed from a motor unit M–1 (FIGURE 2). The motor unit has an output shaft 30 which carries a sprocket 31 driving a chain belt 32 which, in turn, drives a larger sprocket 33. The latter is secured to a rotatable shaft 34 which carries a small gear 35 meshing with a larger gear 36. The gear 36 drives a smaller gear 37 which drives another small gear 38. The latter meshes with a larger gear 39 which is secured to a bevel gear 40. The latter meshes with a bevel pinion 41 secured to an elongated rotary shaft 42 at one end thereof. Toward its opposite end the shaft 42 carries a bevel pinion 43 which drives a bevel gear 44 attached to the upper end of a vertical rotary shaft 50 (FIGURE 3B) which carries the drum 24 at its lower end.

As best seen in FIGURES 3A and 3B, the shaft 42 is rotatably supported at its opposite ends by bearings 45 and 36 carried by brackets 47 and 48 which extend up from the horizontal frame portion 49 of the machine. The frame portion 49 of the machine also supports a bearing arrangement 51 for the shaft 50. With the foregoing drive arrangement the drum 24 is driven in a positive manner from the motor M–1. Drum 24 causes the flexible endless belt 20 to advance continuously at a suitable constant speed.

The drum 27 at the opposite end of belt 20 is mounted on the upper end of a rotary upstanding shaft 52 (FIGURE 3B), which is carried by a bearing sleeve 53. The latter is supported by the horizontal leg of a generally L-shaped hollow support member 54 which is connected at its upper end to the frame 49 and extends downwardly therefrom between the advance and return tracks of the endless belt 20. Drum 27 is simply an idler which rotates in response to the advance of the belt 20. The drum 25, around which the front end of the other belt 21 of the first pair extends, is carried on the lower end of a shaft 55 (FIGURE 4), which at its upper end has a bearing support (not shown) carried by the horizontal frame 49. The drum 26 at the back end of belt 21 is rotatably supported from the horizontal frame 49 by means of a depending L-shaped support member 54A (FIGURE 4), which is similar to the just described support member 54 for drum 27. Both belts 20 and 21 are provided with suitable tensioning means (not shown) engaging their respective return track portions. The second pair of endless belts 56 and 57 have their forward ends extending just above the back ends of the first belts 20 and 21. The belt 56 has its forward end extending around a drum 58 (FIGURE 1) carried on the lower end of a rotary shaft 59 which has a bearing support at 60. As best seen in FIGURE 2, the bearing support 60 is slidably adjustable horizontally on a bracket 61 carried by the horizontal frame 49. A pair of adjustable bolts 62 are threadedly mounted on an upstanding wall 63 of this bracket. At their inner ends these bolts engage the bearing support 60 for shaft 59. By turning these bolts the position of this bearing support can be adjusted along the bracket 61 to adjust the position of drum 58 accordingly. As shown in FIGURE 2 the rotational axis of drum 58 is positioned slightly forward of the rotational axis of drum 27. The adjusting mechanism for the drums thus described serves to tension the belt 56 so that it with belt 57 are effective to grip and carry along a work piece. Similar adjusting mechanism not shown in the drawings is provided for each of drums 24 and 25 to effect tensioning of belts 20 and 21.

The back end of belt 56 extends around a drum 64 (FIGURE 1) connected to the lower end of a rotary shaft 65. This shaft has a bearing support at 66 on the horizontal frame 49 and has an upper extension 67 which carries gear 39 and bevel gear 40. Thus, drum 64 is driven through the previously-described drive from motor M–1 to gear 39. Belt 56 is provided with other suitable tensioning means (not shown) engaging its return track.

The other belt 57 of the second pair at its forward end extends around a drum 71 (FIGURES 2 and 4) which is supported rotatably from the overlying horizontal support frame 49 in the same manner as drum 58. As shown in FIGURE 2, such support for said drum includes a bearing support 68 slidable along a bracket 69. Threaded bolts 70 are provided for adjusting the position of this bearing support to position the drum 71 accordingly and thus provide means for maintaining tension on the belt 57. As shown in the drawings this drum is concentric with the drum 26 for the back end of belt 21 and is disposed just above drum 26.

The back end of belt 57 extends around a drum 72 (FIGURE 2) carried on the lower end of a rotary shaft 73 which is rotatably supported in a bearing support on the horizontal frame 49. This shaft at its upper end carries the previously-described gear 36.

With this arrangement drum 72 is driven clockwise in FIGURE 2 while drum 64 is driven counter-clockwise, both in a positive fashion from motor M–1. The drums 58 and 71 which engage the front ends of the respective belts 56 and 57 are simply rotary idlers. These drums are positioned just above the drums 27 and 26 which engage the back ends of the first pair of belts 20 and 21. Between their drums the belts 56 and 57 present confronting advance track portions 56*a* and 57*a* which are in face-to-face relationship and which run contiguous to each other, gripping between them the upper halves of the work pieces. As shown in FIGURE 2, the front edge of drum 58 is slightly forward of the front edge of drum 71. This arrangement is particularly adaptable to accommodate the particular shape of turbe blade previously noted to avoid any damage to the leading edge of the blade as it is passed from one set of belts to the other, the precise relative position of the drums can be changed to accommodate work pieces of different configuration.

The construction of the belts 56 and 57 of the back pair is identical to that of the front belts 20 and 21, there being alternate lengthwise grooves and ribs in the outer face of each belt. This rib and groove construction of the belts greatly enhances their resilient gripping effect on the work pieces.

In accordance with the present invention, there is provided a spring bias ararngement for maintaining the work-piece gripping action between the belts of each pair at their confronting, advance track portions. Referring to FIGURES 3B and 6, there is provided a rigid elongated flat plate 80 which extends behind the flat inner face of belt 20 throughout its advance track portion. As shown in these figures, this plate is attached to a pair of spaced, rigid, generally U-shaped brackets 81 connected to an elongated, horizontal channel member 81*a* which, in turn, is attached to the lower end of a support 82 which extends down from the horizontal frame 49. Plate 80 provides a rigid backing across which the advance track portion 20*a* of belt 20 slides as this belt is advanced continuously through its endless path.

A similar rigid elongated plate 83 extends behind the flat inside face of belt 21 at the advance track portion 21*a* of this belt. Plate 83 is carried by a plurality of rods 84 which extend horizontally perpendicular to the horizontal channel member 81*a*. Each rod 84 is slidable in a sleeve 85 which is mounted in the channel member

81*a*. A nut 85*a* behind the channel member 81*a* threadably engages each sleeve 85 to lock the sleeve in this position. Each rod carries a nut 86 threaded onto its inner end. A coil spring 87 is engaged under compression between the sleeve 85 and a washer 88 located just behind the nut 86. With this arrangement at each of the rods 84 the respective spring 87 biases the backing plate 83 inward to force the advance track portion 21*a* of belt 21 snugly against the opposite, rigidly backed, advance track portion 20*a* of belt 20. The lower half of each work piece W is gripped securely between these belts and is carried thereby in a straight line path continuously through the advance track portions of these belts.

A slightly different spring bias arrangement is provided for the back pair of belts 56 and 57. Referring to FIGURE 7, both of these belts are provided with spring-biased backing plates at their confronting advance track portions 56*a* and 57*a*, respectively. The backing plate 90 for belt 56 is mounted on a plurality of rods 91 which are slidable in bushing sleeves 92 carried by the elongated horizontal channel member 93. This channel member is bolted to an inverted L-shaped arm 94 connected to a support member 95 which extends down from the overlying horizontal frame 49. A plurality of coil springs 96 bias the backing plate 90 inwardly in the same manner as the spring bias on the backing plate for belt 21. The backing plate 97 for belt 57 has a similar spring bias provided by springs 98 which are positioned at the lower end of the depending support 95. As shown in FIGURE 8, the upper half of each work piece W is gripped between the confronting, spring-biased, advance track portions 56*a* and 57*a* of the second pair of belts. From FIGURE 4 it will be apparent that the second pair of belts 56 and 57 receive the work pieces W as the latter reach the end of the advance track of the first belts 20 and 21.

Turning now to the abrasive gun assembly which is intended to abrade hte upper halves of the work pieces W as the latter are advanced by the belts 20 and 21, this assembly includes a vertically oscillatable platform 100, shown best in FIGURES 3B, 4 and 6. As shown in FIGURE 4, this platform is of open rectangular configuration, viewed from above. This platform extends horizontally above the advance track portions 20*a* and 21*a* of belts 20 and 21 (FIGURE 3B) and is connected to the lower ends of reciprocatory vertical rods 101 and 102.

For reciprocating the platform 100 up and down there is provided a rotary cam shaft 103 which carries a pair of cams 104 and 105 (FIGURE 3B). These cams ride on top of followers 106 and 107 respectively, which are rollers rotatably mounted on the upper ends of the rods 102 and 101 respectively. Coil springs 108 and 109 ear engaged between the top of the horizontal frame 49 and collars 110 and 111 carried by the respective rods 102 and 101 just below the cam followers on their upper ends. These coil springs bias the respective rods upward to maintain their cam followers 106 and 107 in continuous engagement with the cams 104 and 105.

The cam shaft 103 is driven rotatably from a motor M–3 through a chain 103*a* (FIGURES 1 and 5). As shown in FIGURE 6, the reciprocatory vertical shaft 101 is slidably received in spaced sleeve bearings 112 and 113 carried by an elongated sleeve 114. The horizontal frame 49 at this location is constituted by spaced upper and lower horizontal plates 115 and 116 which are rigidly interconnected by channels 117 running lengthwise of the machine. At its upper end the sleeve member 114 is connected to a collar 118 which is bolted to the upper plate 115. A similar collar 119 is connected to the sleeve member 114 toward the latter's lower end and is bolted to the underside of the lower plate 116. A suitable flexible bellows type sleeve 120 is securely clamped at its upper end to the lower end of the stationary sleeve member 114. At its lower end this bellows is secured to the reciprocatory rod 101. This bellows has a tendency to expand downward, so that it will serve to protect rod 101 and its bushings 112 and 113 from abrasive material circulating in the chamber of the device. An identical bearing arrangement and bellows 121 is provided for the rod 102 which carries the vertically reciprocable platform 100.

As shown in FIGURES 3B and 6, a plurality of abrasive guns are suspended from the vertically reciprocable platform 100. In the illustrated embodiment there are twelve such blast guns carried by platform 100, six on each side of the path of movement of the work pieces. The support for each gun includes a hollow tube 125 (FIGURE 6) secured at its upper end to the corresponding side of platform 100 and extending vertically downward therefrom. A rod 126 is telescopically received in the lower end of tube 125 and attached thereto by means of a bolt and nut assembly 127. At its lower end the rod 126 carries a bifurcated sleeve 128 which carries a cross pin 129 slidably received in an elongated horizontal slot 130 in the holder 131 for the blast gun. A lock nut 132 is threaded onto the cross pin for adjustably clamping the gun holder 131 at any desired lateral position. As shown in FIGURE 3B the six abrasive guns at each side of the path of movement of the work pieces are grouped in three pairs, each pair having one gun disposed at a higher level than the other.

The several guns are supplied with air from manifolds 133 and 134 (FIGURES 4 and 6) carried by the platform 100. As shown in these figures, these air manifolds extend horizontally lengthwise of platform 100 and are closed at their ends by the end rails of the platform. The air manifold 133 carries an upstanding fitting 135 and the manifold 134 carries a similar fitting 136, both for connection to hoses (not shown) which lead from a suitable source of compressed air (not shown).

The air manifold 133 is connected through flexible hoses 137, 138 and 139 (FIGURE 4) to every other gun at one side of the line of movement of the work pieces W, and through similar hoses 140, 141 and 142 to every other gun on the opposite side. Referring to FIGURE 4, the hoses 137 and 140 are connected to the opposite ends of a T-fitting 143 which has its lower end coupled to the air manifold 133 to receive air therefrom. Identical connectors are provided for the other paired hoses 138 and 141, and 139 and 142.

In like manner, the other air manifold 134 is connected through hoses 144 to 149 inclusive, to the remaining six guns, three on each side of the path of movement of the work pieces.

FIGURES 9 and 11 to 13 inclusive show in detail the novel structure of each blast gun. Referring first to FIGURE 11, the air hose 144 leading from the manifold 134 is connected to a fitting 150 which is threadedly mounted in the back end of the base 151 of the gun. A nozzle 152 is mounted at the front of this base and communicates with the fitting 150 to receive air from the hose 144. As shown in FIGURE 11, the air nozzle has a cylindrical stem 161 at its back end which is slidably received in a complementary opening in the front of the base 151. A set screw 162 is provided for releasably locking the nozzle in place on the base. As best seen in FIGURES 9 and 13, the nozzle 152 presents a discharge opening 153 which is elongated vertically, having rounded top and bottom ends and closely spaced, vertical sides. As shown in FIGURE 12 the passage through the nozzle 152 flares upward and downward toward its outer end so as to produce a high velocity flow of the air. The air discharged by the nozzle is directed straight toward the work pieces W (i.e., perpendicular to the line of movement of the work pieces).

The gun also includes a circular discharge opening 154 for the abrasive slurry, this opening having its axis extending horizontal and perpendicular to the horizontal

axis of the air nozzle **152**. That is, the axis of the slurry discharge opening **154** extends parallel to the line of movement of the work pieces W. The slurry discharge opening **154** is located just beyond the discharge opening **153** of the air nozzle **152**, so that the slurry is caught up by the air flow from nozzle **152** and blown directly against the adjacent faces of the work pieces W.

The slurry discharge opening **154** is defined by a cylindrical ring **155** which is seated on the base **151** of the gun. This opening communicates with a pasage **156** in the base which leads from a hose **157**. As shown in FIGURE 3B, this hose is connected at its lower end to a slurry manifold **158**. The slurry manifold is connected to a pump **159** (FIGURE 1), which draws the slurry from the receptacle **160** at the bottom of the machine and pumps it up through the manifold **158** and thence through the hoses **157** to the slurry passages **156** in the respective guns. Since all of the guns are identical, this detailed description of one gun will suffice for all the rest.

With this novel gun arrangement, which constitutes an extremely important aspect of the present invention, as long as the pump is running the abrasive slurry is pumped in a continuous stream out through the discharge opening **154** at a relatively low velocity.

The flow of the slurry through each gun to its discharge opening **154** is at rather low speed, since the gun does not require that this flow provide the force necessary to spray the slurry vigorously against the work pieces. Instead, the present gun provides a completely separate flow of air to the nozzle **152** which picks up the slurry just beyond the slurry discharge opening **154** and blows the slurry vigorously against the work pieces.

The high velocity abrasive flow pattern produced by this action of the air nozzle is long and narrow. With the nozzle positioned as shown in FIGURE 13, the long axis of this pattern extends vertically, while the narrow axis extends horizontally. However, this can be changed simply by loosening the set screw **162** and turning the nozzle about its own longitudinal axis to adjust the angularity of its oblong discharge opening **153** with respect to the horizontal. Furthermore, by replacing the above described nozzle with nozzles of other shapes and flow characteristics, virtually any spray pattern and velocity of impact of the abrasive slurry can be obtained on the work piece.

This novel gun arrangement has several advantages:

(1) The wear on the gun is minimized. The only high velocity flow which takes place inside the gun consists entirely of air. The flow of the abrasive slurry in the gun is at a sufficiently low velocity as to cause no appreciable wear.

(2) The rate of flow of the slurry through the gun can be metered or varied to suit the particular work pieces being finished, simply by changing the operation of the slurry pump. Such adjustment is independent of the rate of flow of air through the gun.

(3) The composition of the abrasive slurry can be varied as desired to produce the desired surface finish without affecting the operation of the gun since the flow of abrasive in the gun is at low velocity and is not appreciably constricted by the gun itself.

(4) The velocity with which the slurry is discharged against the work pieces can be varied, simply by varying the flow rate of the air through the nozzles **152**, again to suit the particular work pieces being treated. Such adjustment of the air flow rate is made independent of the flow rate of the abrasive slurry.

(5) The abrasive flow pattern against the work pieces can be varied simply by turning the nozzle, as just described.

(6) The air nozzle can be removed simply by loosening the set screw **162** and a new air nozzle having a different shaped discharge opening substituted in its place. By so changing the air nozzle in the gun, the shape and density of the blast pattern formed by the slurry as it impinges on the work pieces W can be changed accordingly.

The overall effect of the above-noted novel characteristics of the present invention is that the abrasive spray is capable of virtually infinite adjustment to produce the desired surface finish on the work pieces being treated.

As shown in FIGURE 13, in the normal position of the air nozzle the height of the air discharge opening **153** is slightly greater than the height of the horizontal stream of abrasive slurry being discharged out of the slurry discharge opening **154**. The horizontal width of this air discharge opening is narrow. With this construction, substantially all of the abrasive slurry is caught up and blown by the air stream against the work pieces. At the same time, the abrasive pattern on the work pieces is rather narrow horizontally.

In previous abrading machines for the same general purpose it has been the usual practice to employ blast guns which incorporate an ejector. In such guns, the flow of air through a venturi at high velocity draws the slurry into and through the gun. The high velocity flow of the abrasive slurry inside the gun caused rapid erosion of the gun, which required replacement frequently.

Also, in such ejector type guns the slurry flow depended upon the height of the gun above the slurry tank. Any variation in the height of the gun would produce a corresponding variation in the rate of the slurry flow. Thus, where the guns are mounted to move up and down continuously, so as to produce a uniform abrading action on the work pieces, the slurry would be discharged at a rate which varies with such up and down movement and is completely beyond the operator's control. Because of this, the abrading action on the work pieces would tend to be non-uniform. Moreover, guns of this type did not lend themselves to the selective variation of the slurry concentration so as to treat different types of work pieces differently.

All of these disadvantages associated with the previously used ejector-type abrasive guns are completely avoided by the novel gun of the present invention. In the present machine as the work pieces are advanced through a horizontal path, the abrasive guns are reciprocated vertically while they discharge their vertically elongated, oblong sprays of slurry against the work pieces. The overall effect, therefore, is a generally elliptical spray pattern produced by each gun. This has been found to produce an extremely uniform finish which is completely free of the striping and mottling produced by abrasive guns previously used for such purposes. From FIGURE 3B it will be apparent that the six guns on each side are arranged in vertically staggered relationship, every other gun being at a higher level than the immediately preceding gun, to further enhance the uniformity of coverage of the work pieces.

With the foregoing arrangement, the upper halves of the work pieces W are evenly sprayed with abrasive as the work pieces are advanced continuously by the first pair of belts **20** and **21**. Then the work pieces pass into engagement with the second pair of belts **56** and **57**. These belts grip the upper halves of the work pieces (which have just been abraded), leaving the lower halves of the work pieces exposed to the action of the next set of abrasive guns.

As shown in FIGURES 1 and 3A, this next set of abrasive guns is suspended from a vertically reciprocable platform **170**, which is operated from the cam shaft **103** in the same manner as the first such platform **100**. The mounting of the second platform **170** is essentially the same as that of the first platform **100**, and the details of such mounting will be omitted here for the sake of brevity.

Twelve abrasive guns, all identical to the gun already described in detail, are suspended from the platform **170**. These guns are arranged with six on each side of the line of movement of the work pieces. The guns on each side

are arranged in groups of threes, vertically staggered to give uniform coverage of the work pieces. Except for such grouping, these guns and their air and slurry connections are essentially the same as already described in detail.

With this arrangement, the platform **170** reciprocates up and down, carrying with it the twelve abrasive guns. As these guns move up and down continuously, they spray abrasive onto the exposed lower halves of the work pieces.

At the back end of the advance tracks **56***a* and **57***a* of the belts **56** and **57** the finished work pieces W drop down onto an underlying conveyor belt **180** (FIGURES 1 and 2). As the finished work pieces drop from between the belts **56** and **57** they are sprayed with water from a nozzle **181** (FIGURE 1) to rinse off any adherent abrasive particles.

The conveyor belt **180** extends perpendicular to the line of movement of the overlying conveyor belts **56** and **57** and presents horizontal upper and lower advance and return track portions. One end of the conveyor belt **180** extends around an idler roll **182**, while the opposite end extends around a power driven roller **183**. The latter is driven from a motor M–2 through a chain **184**, shaft **185** and chain **187** (FIGURE 2).

The finished work pieces W drop from the conveyor belt **180** at the roller **183** onto another conveyor belt **188**, which extends lengthwise of the machine, inclining upwardly to an exit opening **189** in the same end wall of the machine housing where the entrance opening **22** is located, as best seen in FIGURE 1. Belt **188** extends around an idler roller **190** at its lower end and around a driven roller **191** at its upper end. The drive roller is driven from motor M–2 through chain **184**, shaft **185**, bevel gears **192** and **193**, shaft **194** and chain **195**.

Summarizing the overall operation of the present machine, the work pieces W are inserted through the entrance opening **22** at one end of the machine. The confronting advance track portions **20***a* and **21***a* of the first pair of endless belts **20** and **21** grip the lower halves of the work pieces and carry them past the twelve abrasive guns suspended from the first vertically reciprocatory platform **100**. As this platform moves up and down, the abrasive guns move up and down with it and discharge the abrasive slurry forcefully against the opposite faces of the work pieces. In this manner the upper halves of the work pieces are abraded uniformly.

Then, the work pieces pass between the second pair of conveyor belts **56** and **57**. The latter grip the just-finished upper halves of the work pieces, leaving the lower halves exposed. The conveyor belts **56** and **57** carry the work pieces past the twelve abrasive guns suspended from the vertically reciprocating second platform **170**. The lower halves of the work pieces are abraded uniformly in substantially the same manner as the upper halves.

Following this, the completely abraded work pieces are sprayed and drop down onto conveyor belt **180**, which carries them to conveyor belt **188**. The latter carries the work pieces up and back to the exit opening **189** at the same end of the machine as the inlet opening.

From the foregoing it will be apparent that the illustrated embodiment of the present invention constitutes an improved abrading machine which has a number of important practical advantages over previous machines for the same purpose. However, it is to be understood that, while there has been described in detail herein and illustrated in the accompanying drawings a particular presently-preferred embodiment of the present invention, various modifications, omissions and refinements which depart from the disclosed embodiment may be adopted without departing from the spirit and scope of this invention.

We claim:

1. In an abrading machine, a pair of endless flexible compressible conveyor belts having contiguous portions for conveying work pieces in a substantially vertical position along a predetermined path of movement, means for resiliently biasing the contiguous portion of at least one of said belts toward the contiguous portion of the other, a reciprocable support mounted for vertical transverse movement with respect to said path of movement of the work pieces, a plurality of guns carried by said reciprocable support and positioned on opposite sides of said path of movement of the work pieces and at successive locations along said path of movement of the work pieces, and means for operating said guns to discharge abrasive material onto the work pieces as the latter are moved by said conveyor means along said path of movement and the guns are reciprocated transverse to said path of movement of the work pieces.

2. The machine of claim 1, wherein said pair of endless flexible belts have elongated straight portions running contiguous to each other for gripping the work pieces between them, and wherein each gun has a passage for abrasive slurry and a separate air passage, means defining a slurry discharge opening of relatively large cross-sectional area at the end of the slurry passage, and an air nozzle at the end of said air passage for discharging air therefrom transverse to the flow of the slurry being discharged through said slurry discharge opening, said air nozzle having a discharge opening adjacent said slurry discharge opening which is of appreciably small cross-sectional area than said slurry discharge opening.

3. In an abrading machine, a pair of endless flexible compressible conveyor belts which present elongated straight portions running contiguous to each other, said straight portions of the respective belts having vertical outer faces which are in confronting face-to-face relationship throughout the length of said straight portions for gripping the work pieces between them and holding the work pieces upright with portions of the work pieces beyond the belts being exposed, rigid backing plates in back of said contiguous straight portions of the belts, resilient means biasing at least one of said backing plates against the corresponding belt to force said belt against the other belt at said contiguous straight portions of the belts, a vertically reciprocable platform above said belts, a plurality of guns suspended from said platform and positioned on opposite sides of said contiguous straight portions of the belts at successive locations therealong, each of said guns having a passage for abrasive slurry and a separate air passage, an air nozzle at the front of the gun communicating with said air passage to receive air therefrom and pointing toward the work pieces carried by said conveyor belts, and means defining a slurry discharge opening which communicates with said slurry passage in the gun and is positioned to discharge the slurry therefrom in a stream across the front of said air nozzle substantially parallel to the path of movement of said contiguous straight portions of the belts, means for flowing slurry at relatively low velocity through the slurry passage in each gun and out the slurry discharge opening across the front of the air nozzle on each gun, and separate means for flowing air at substantially higher velocity through the air passage in each gun and out the respective air nozzle to blow the slurry directly forward from the gun in an unconfined stream against the work pieces carried by said conveyor belts while the gun-carrying platform is reciprocated up and down.

4. In an abrading machine, a pair of endless contiguous compressible conveyor belts having contiguous portions for conveying work pieces along a predetermined path of movement, means for resiliently biasing the contiguous portion of at least one of said belts toward the contiguous portion of the other, and an abrasive gun at one side of said path of movement of the work pieces, said gun having an abrasive passage and a separate air passage at substantially right angles thereto, means defining an abrasive discharge opening leading from said abrasive passage to discharge a stream of abrasive substantially parallel to said path of movement of the work

pieces, and said gun having an air nozzle leading from said air passage and positioned adjacent to said abrasive discharge opening, said air nozzle pointing away from the gun substantially perpendicular to said path of movement of the work pieces to discharge a stream of air which blows said abrasive stream against the work pieces.

5. The machine of claim 4, wherein there are provided means for flowing abrasive through said abrasive passage and out said abrasive discharge opening in the gun at relatively low velocity, and means for flowing air at substantially higher velocity through said air passage in the gun and out said air nozzle to blow the unconfined stream against the work pieces.

6. In an abrading apparatus, the combination of an abrasive gun having a passage for abrasive slurry and a separate air passage, means defining a slurry discharge opening at the end of said slurry passage, and an air nozzle at the end of said air passage having a discharge opening spaced from and projecting perpendicular to said slurry discharge opening for discharging air at right angles to and transverse of the flow of the slurry out of said slurry discharge opening; means for flowing abrasive slurry at relatively low velocity through said slurry passage and out said slurry discharge opening; and separate means for passing air at substantially higher velocity through said air passage and out said air nozzle to blow the slurry in an unconfined stream away from the gun.

7. In an abrading apparatus, in combination; an abrasive gun having a passage for abrasive slurry and a separate air passage, an air nozzle at the front of the gun communicating with said air passage to receive air therefrom and discharge the air directly away from the gun, and means defining a slurry discharge opening spaced from said nozzle which communicates with said slurry passage in the gun and is positioned to discharge the slurry therefrom in a path at substantially right angles to the flow of air from said air nozzle and across the front of said air nozzle; means for flowing abrasive slurry at relatively low velocity through said slurry passage in the gun and out said slurry discharge opening; and means for flowing air at substantially higher velocity through said air passage in the gun and out said air nozzle to blow the slurry directly forward from the gun in an unconfined stream.

8. In an abrading apparatus, in combination; an abrasive gun having a passage for abrasive slurry and a separate air passage, an air nozzle at the front of the gun communicating with said air passage to receive air therefrom and discharge the air directly forward from the gun, and means defining a slurry discharge opening spaced forward of the end of said air nozzle which communicates with said slurry passage and which is positioned to discharge a stream of slurry at right angles to the flow of air to said air nozzle and across the front of said air nozzle; means for flowing abrasive slurry at relatively low velocity through said slurry passage and out said slurry discharge passage across the front of said air nozzle; and separate means for flowing air at substantially higher velocity through said air passage in the gun and out said air nozzle to blow the slurry directly forward from the gun in an unconfined stream.

9. The apparatus of claim 8, wherein said discharge opening in the air nozzle is narrow horizontally.

10. The apparatus of claim 8, wherein said discharge opening in the air nozzle has a height from top to bottom substantially at least as great as the height of said horizontal slurry stream discharged from the slurry discharge opening, and has a horizontal width substantially smaller than its height.

11. The apparatus of claim 8, wherein said discharge opening in the air nozzle is oblong, and said air nozzle is mounted to be turned on the gun to adjust the angularity of its oblong discharge opening with respect to the horizontal slurry stream being discharged out of said slurry discharge opening.

12. An abrasive gun comprising means defininging a passage for abrasive slurry, means defining a slurry discharge opening of relatively large cross-sectional area at the end of said passage, means defining an air passage separate from said slurry passage, and an air nozzle at the end of said air passage spaced from and projecting at right angles to said discharge opening for discharging air therefrom perpendicular to and transverse of the flow of the slurry being discharged through said slurry discharge opening, said air nozzle having a discharge opening adjacent said slurry discharge opening which is of appreciably smaller cross-sectional area than said slurry discharge opening.

13. An abrasive gun having a passage for abrasive slurry and a separate air passage, means defining a slurry discharge opening of relatively large cross-sectional area at the end of said slurry passage projecting at right angles to the axis of said air passage, and an air nozzle at the end of said air passage having a discharge opening positioned spaced from said slurry discharge opening for discharging air perpendicular to and transverse of the flow of the slurry out of said slurry discharge opening, said discharge opening in the air nozzle being narrow in the direction of the flow of slurry out of said slurry discharge opening.

14. An abrasive gun having a passage for abrasive slurry and a separate air passage, means defining a slurry discharge opening of relatively large cross-sectional area at the end of said slurry passage projecting at the right angles to the axis of said air passage, and an air nozzle at the end of said air passage, said air nozzle having an oblong discharge opening spaced from said slurry discharge opening for discharging air substantially perpendicular to the flow of the slurry out of said slurry discharge opening, said air discharge opening being narrow in the direction of the flow of slurry out of said slurry discharge opening and having a dimension substantially perpendicular to said flow which is at least substantially as large as the corresponding dimension of the slurry discharge opening.

15. The gun of claim 14, wherein said air nozzle is mounted to be turned selectively to adjust the angularity of its oblong discharge opening with respect to the flow of slurry out of said slurry discharge opening.

16. In a machine for the surface treatment of work pieces, a first pair of endless flexible conveyor belts which present elongated straight portions running contiguous to each other to grip the work pieces between them and hold the work pieces upright while conveying the work pieces from the front end of said first pair of belts to the back end thereof, and a second pair of endless flexible belts which run at the next level adjacent to the level at which the first belts run, the front end of said second pair of belts overlapping the back end of said first pair of belts to receive the work pieces therefrom, said second pair of belts presenting elongated portions which extend from said front end thereof to the back end thereof and run contiguous to each other to grip the work pieces between them and hold the work pieces upright while conveying the work pieces from the front end of said second pair of belts to the back end thereof.

17. In a machine for the surface treatment of work pieces, a first pair of endless flexible conveyor belts which present elongated straight portions running contiguous to each other, said straight portions of the respective belts having vertical outer faces which are in confronting face-to-face relationship throughout the length of said straight portions for gripping the work pieces between them and holding the work pieces upright through a first course of movement with portions of the work pieces beyond the belts being exposed for surface treatment, and a second pair of endless belts which present elongated straight portions running contiguous to each other, said straight portions of the second belts at one end being positioned to engage said exposed portions of

the work pieces at the end of said first course of movement thereof, said straight portions of the second belts having vertical outer faces which are in confronting face-to-face relationship throughout the length of said straight portions of the second belts for gripping between them the previously exposed portions of the work pieces and holding the work pieces upright through a second course of movement with the portions of the work pieces which were gripped by the first belts being exposed beyond the second belts.

18. The machine of claim 17, wherein at each pair of belts there is provided means resiliently biasing said elongated straight portion of one belt toward the confronting elongated straight portion of the other belt of said pair for engagement therewith.

19. The machine of claim 17, wherein each of said belts is compressible, and wherein there is provided a rigid backing plate in back of said elongated straight portion of each belt, and at each pair of belts means resiliently biasing one of the backing plates against the corresponding belt to force said belt against the other belt throughout said confronting straight elongated portions thereof.

20. The machine of claim 19, wherein each of said belts is formed on its outer face with alternating ribs and grooves which run lengthwise of said belt.

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