May 12, 1964 J. A. KILE 3,132,451

ABRADING MACHINE

Filed Oct. 9, 1961 3 Sheets-Sheet 1

FIG. 1

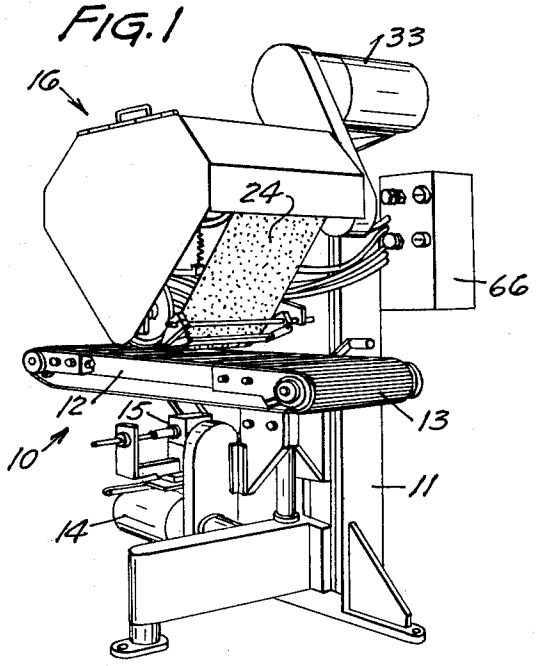


FIG. 4

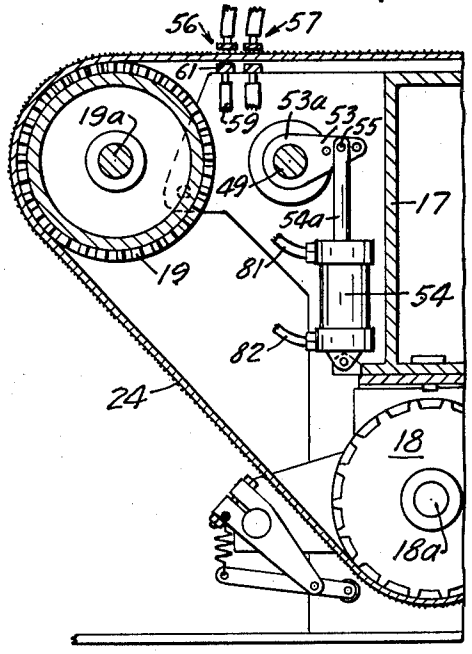


FIG. 2

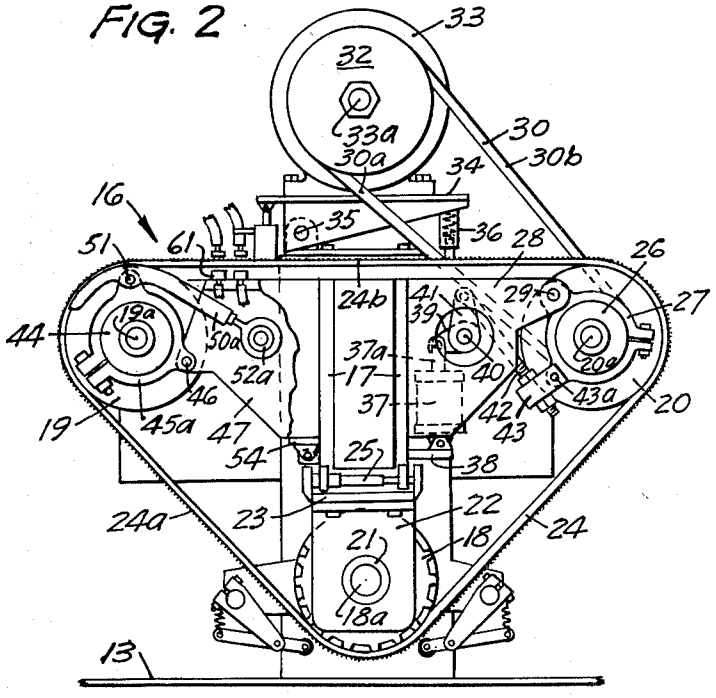
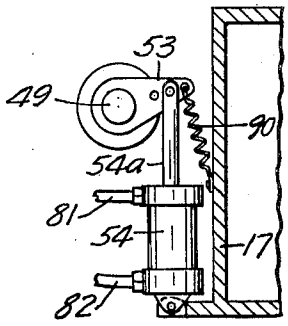


FIG. 10



INVENTOR
JOHN A. KILE
BY
Williamson & Palmatier
ATTORNEYS

May 12, 1964 J. A. KILE 3,132,451

ABRADING MACHINE

Filed Oct. 9, 1961 3 Sheets-Sheet 2

FIG. 3

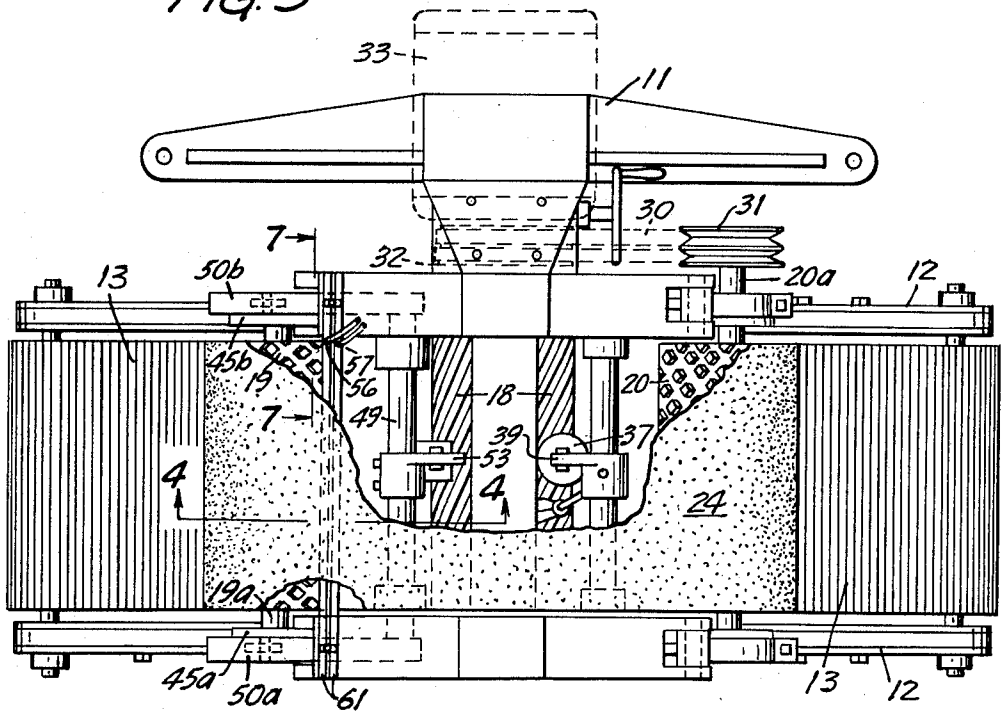


FIG. 8

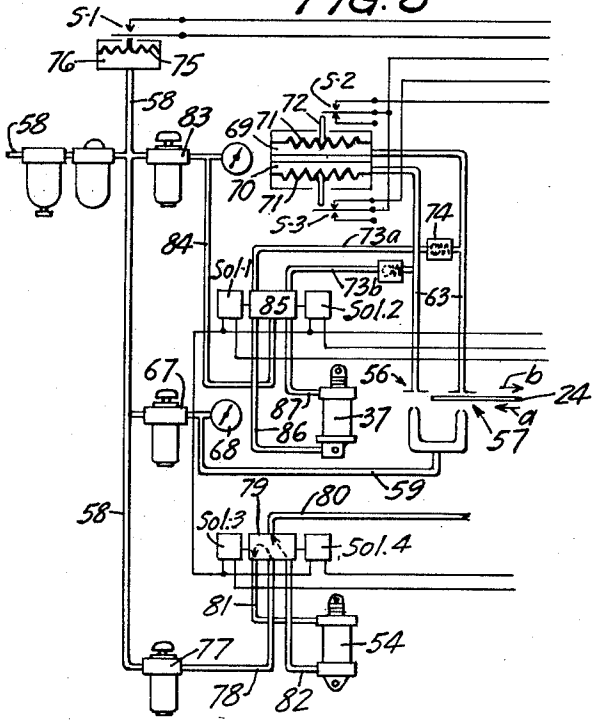
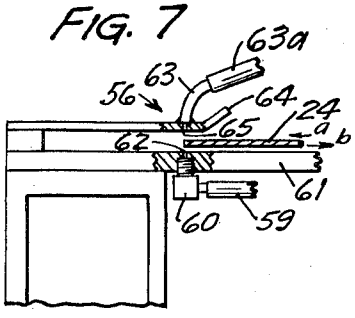


FIG. 7



INVENTOR
JOHN A. KILE
BY
Williamson & Palmatier
ATTORNEYS

May 12, 1964 J. A. KILE 3,132,451

ABRADING MACHINE

Filed Oct. 9, 1961 3 Sheets-Sheet 3

FIG. 9

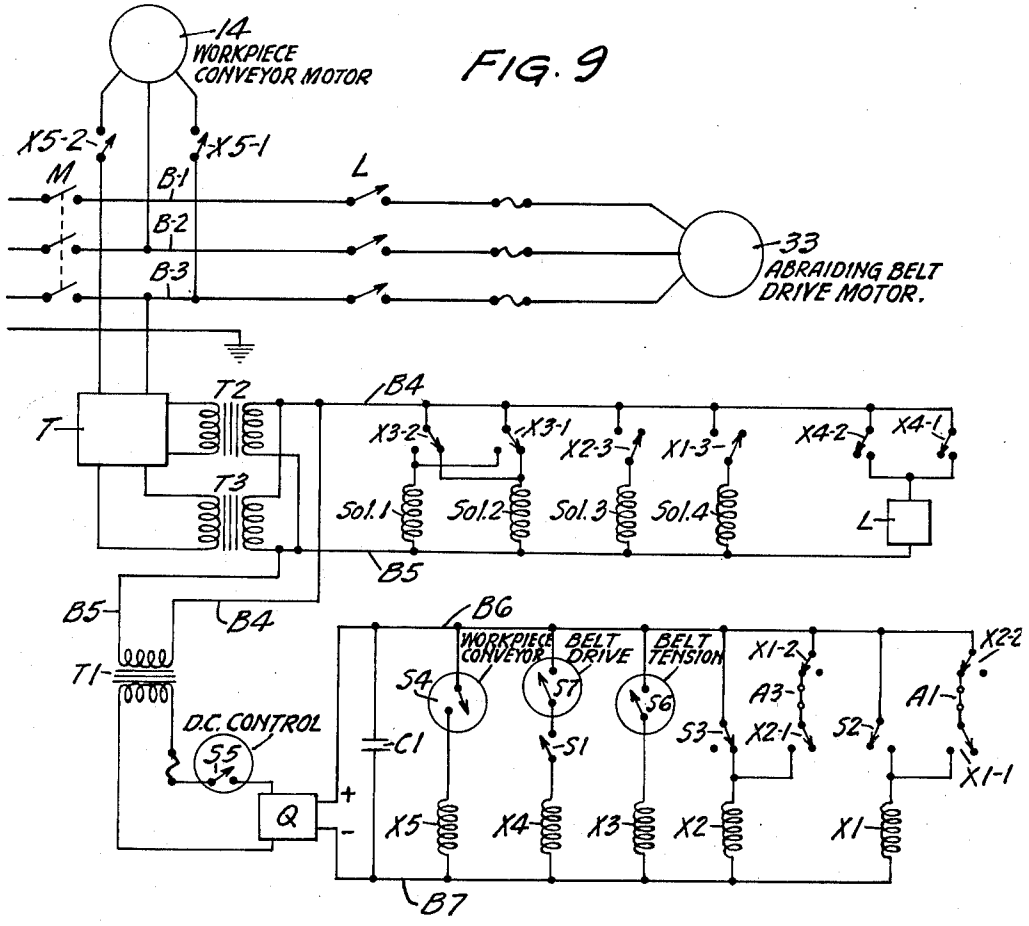


FIG. 5

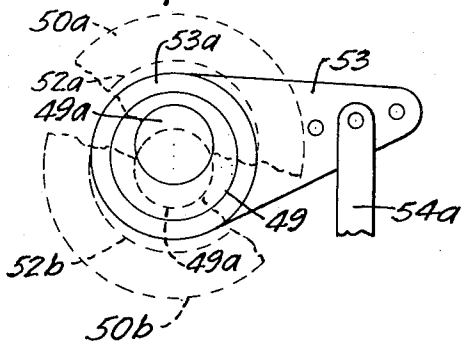
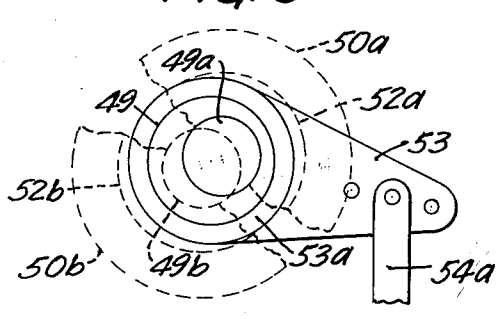


FIG. 6



INVENTOR
JOHN A. KILE
BY
Williamson & Talmatier
ATTORNEYS

United States Patent Office 3,132,451 Patented May 12, 1964

3,132,451
ABRADING MACHINE

John A. Kile, St. Cloud, Minn., assignor, by mesne assignments, to Barnes Drill Co., Rockford, Ill., a corporation of Illinois

Filed Oct. 9, 1961, Ser. No. 153,774
8 Claims. (Cl. 51—138)

This invention relates to a high speed belt-type abrading machine and more particularly relates to apparatus in such a machine to effect steering of the belt.

Abrading machines of this general type have been known in the past and have employed various means for steering the belt. All such means that have been employed in the past have had distinct disadvantages. It will be understood that in steering the belt of such a high speed abrading machine, the tension on the belt must not be materially changed. The contact idler roll, which guides or carries the abrading belt into engagement with the workpiece, is in many instances made of extremely soft rubber so as to minimize the pressure applied to the abrading belt at its engagement with the workpiece. Many of these contact idler rolls are provided with only a few very soft ribs on the periphery thereof to further decrease the pressure exerted by the roll against the belt at the point of engagement with the workpiece. When such an extremely soft contact idler roll is employed slight variations in the tension on the belt will adversely affect the abrading function being performed. The need for carefully controlling the tension on the belt becomes quite obvious.

In steering the high speed abrading belt, the position of the belt on the supporting rolls is detected and then the belt is steered in a certain direction, depending on its momentary position. Various sensing media have been employed in the past for determining the actual position of the belt and all such means known in the past have had certain limitations and disadvantages. Electric eyes or photocells have been used for sensing the position of the edge of the belt. It will be understood that the lenses of such photocell systems will quickly become clouded with oil, moisture, and dust which are inherently present in most abrading operations. The clouding becomes particularly acute when a wet abrading process is being carried out. The clouding of the lense system of the photocell decreases the sensitivity of such a system and in this situation the steering will be considerably less precise than is desired.

Vacuum systems have also been employed for detecting the position of the edge of the belt. The belt edge portion is used to cover the end of a hole to restrict inflow of air into a pipe connected to the hole, and when the edge of the belt moves away from the hole, the vacuum is broken so as to actuate a pressure-sensitive apparatus. However, it has been experienced that practically all abrading belts have these edges at least slightly curled when operating so as to be concave in shape in one direction or the other with the effect that a vacuum seal cannot be maintained between the belt and the end of the hole. As a result of this curling or curvature at the edge of the belt, sensitivity of the vacuum system is materially decreased and of course the steering will be less precise. The same general arrangement has also been employed where the air pressure in the hole which is covered by the belt is in excess of atmospheric so that the belt actually comprises an air pressure-confining cover for the hole. The disadvantages of such a system are essentially the same as with a vacuum type system.

With these comments in mind it is to the elimination of these and other disadvantages to which the present invention is directed along with other novel and desirable features.

An object of my invention is to provide in a high speed belt-type abrading machine, a new and improved apparatus of simple and inexpensive construction and operation for controlling the steering of the belt.

Another object of my invention is to provide in a high speed belt-type abrading machine, of a novel apparatus for effecting steering of the belt with a minimum of change in tension on various portions of the belt across its width.

Still another object of my invention is the provision of a new and novel apparatus for accurately detecting the position of the edge of a high speed abrading belt to cause precise steering of the belt in relation to the position of the edge.

A further object of my invention is the provision in a high speed belt-type abrading machine which is interchangeably operable under wet or dry conditions and which is provided with improved self-cleaning apparatus for detecting the position of the edge of the belt so that precision in belt-position detection and weather effect will remain constant regardless of the operating conditions.

These and other objects and advantages of my invention will more fully appear from the following description made in connection with the accompanying drawings wherein like reference characters refer to the same or similar parts throughout the several views and in which:

FIG. 1 is a perspective view of the abrading machine;

FIG. 2 is an enlarged detail front elevation view of a portion of the abrading machine;

FIG. 3 is a top plan view, partly broken away;

FIG. 4 is a detail section view taken approximately at 4—4 in FIG. 3;

FIGS. 5 and 6 are diagrammatic sketches of a portion of the belt-steering mechanism and showing alternate positions thereof;

FIG. 7 is a detail section view, partly broken away and taken approximately at 7—7 in FIG. 3;

FIG. 8 is a diagrammatic view of the air and electrical control system;

FIG. 9 is a schematic diagram of the electrical circuitry associated with the air controls seen in FIG. 8; and

FIG. 10 is a detail section view similar to a portion of FIG. 4 and showing the abrading machine modified slightly for substantially linear running.

The abrading machine is indicated in general by numeral 10 and includes a supporting frame structure 11 upon which is mounted a conveyor frame structure 12, movable upwardly and downwardly for adjusting the position of the workpiece-supporting and conveying belt 13 which is driven by motor 14 through a suitable power transmission mechanism 15.

The abrading machine 10 has an abrading belt-mounting head structure 16 supported on the frame structure 11 and includes a cantilever beam 17 affixed at its rear end as by welding to frame structure 11. A contact idler roll 18, a steering roll 19 and a belt-driving and tensioning roll 20 are all supported from the cantilever beam 17 on individual shafts 20*a*, 19*a* and 18*a* respectively. The ends of shaft 18*a* are supported in suitable bearings 21 which are affixed in mounting plates 22 which plates are rigidly affixed to a removable sub-frame 23 which is adjustably secured to the cantilever beam 17 so as to align the contact idler roll 18 with respect to the movement of endless abrading belt 24. The contact idler roll 18 is constructed of soft resilient material such as rubber and the softness of the rubber may vary over a wide range, depending upon the nature of abrading work being performed. Rolls made of thirty durometer rubber to one hundred durometer rubber are frequently used in the roll 18. The outer periphery of roll 18 may be

provided with spirally extending ribs to give additional softness and the roll may have as few as six ribs in certain instances.

Between the sub-frame 23 and cantilever beam 17 an adjustable apparatus 25 is provided for assuring proper positioning of the sub-frame and roll 18 with respect to the belt.

The belt-driving roll 20 which has a diamond tread on its periphery, is carried by a pair of bearings 26 at opposite ends of the shaft 20*a* and the bearings 26 are confined in the bearing holders 27 which are mounted on frame members 28 by pivot pins 29 so as to permit the roll 20 to be swung outwardly toward the belt for tensioning the same, or inwardly away from the belt for releasing the tension thereon. It will be noted that when the belt is tensioned as seen in FIG. 2, a plane which includes the axes of pivot 29 and the rotation of shaft 20*a* and roll 20 lies along the bisector between the two legs 30*a* and 30*b* of the drive belt 30 which is trained over a pulley 31 on the end of shaft 20*a* and which is also trained over the pulley 32 on the drive shaft 33*a* of drive motor 33. When the bearing mounts 27 are moved to swing the roll 20 inwardly to release tension on the belt 24, the tension on the drive belt 30 is not materially changed. The motor 33 is carried on a mounting plate 34 which is hinged at pivot 35 to the frame structure 11 and is also supported by a spring mounting 36 which is slightly yieldable to accommodate slight movement of the motor 33.

Inward and outward movement of bearing mounts 27 is controlled by operation of a double-acting pneumatic cylinder 37 which is mounted on a bracket 38 on the cantilever beam 17. The piston rod 37*a* of the double-acting pneumatic cylinder 37 is connected with a radial arm 39 which is rigidly affixed on a control shaft 40 suitably mounted in bearings in the frame members 28. A second pair of arms 41 on shaft 40 are swingably connected to connecting links 42 which are connected to the bearing mounts by fittings 43 and pivots 43*a* so as to cause swinging movement of the bearing mounts and roller 20 when the piston rod 37*a* of pneumatic cylinder 37 is extended and retracted.

The belt-mounting and steering roll 19 also has a rubber diamond tread on its periphery to effect a non-slip relation between the roll and the abrading belt 24. Ends of shaft 19*a* are mounted in bearings 44 and the front and rear bearings 44 are respectively carried in front and rear bearing mounts 45*a* and 45*b* respectively. Each of the bearing mounts 45*a* and 45*b* are swingably mounted by pivots 46 to frame members 47 which are welded to the cantilever beam 17. It should be particularly noted that a plane including the pivot axes of pivots 46 and the rotation axis of shaft 19 lies substantially on the bisector of the angle between legs 24*a* and 24*b* of the abrading belt, 24.

Means are provided for producing movement of each end of shaft 19*a* in a direction substantially normal to the bisector of the angle between abrading belt legs 24*a* and 24*b*; and for causing the opposite ends of shaft 19*a* to be moved in opposite directions with respect to each other, to thereby effect steering of the belt 24. As best seen in FIGS. 5 and 6, such means include a shaft 49 suitably journalled in the front and rear frame members 47 having eccentrics 49*a* and 49*b* on the front and rear ends thereof. Eccentrics 49*a* and 49*b* are eccentric with respect to shaft 49 and are also eccentric with respect to each other and are phased about the rotation axis of shaft 49 at approximately 180° with respect to each other. Front and rear connecting rods 50*a* and 50*b* are respectively connected by pivots 51 to the front and rear bearing mounts 45*a* and 45*b* respectively, and the connecting rods 50*a* and 50*b* are provided with suitable bearings 52*a* and 52*b* which are mounted on the front and rear eccentrics 49*a* and 49*b* respectively. The shaft 49 will be oscillated through only a few degrees as is depicted in FIGS. 5 and 6 by the positions shown of arm 53 which is affixed to the shaft 49 by collar 53*a*, and positioning of the shaft 49 is controlled by operation of a double-acting pneumatic cylinder 54, the piston rod 54*a* of which is connected to the arm 53 as by pin 55 in one of the plurality of holes provided in arm 53. It will therefore be seen as the piston rod 54*a* is sequentially projected and retracted the shaft 49 is oscillated, and during any one movement of shaft 49 one of the connecting rods 50*a* and 50*b* is moved outwardly and the other connecting rod is moved inwardly so as to produce simultaneous but oppositely directed movement of the opposite ends of shaft 19*a* and roll 19 along a line which is substantially normal to the bisector of the angle between abrading belt legs 24*a* and 24*b*.

It is emphasized that in this steering operation, only the light weight bearings and bearing mount are moved and because the weight or mass of these parts is relatively small, steering will be accomplished quickly and at a high rate of change. The rate of steering will of course, depend partly upon the speed of travel of belt 24 and will depend in part upon the magnitude of transverse movement of the belt desired. It is sufficient at this point to point out that it is not at all unusual to steer the belt first in one direction and then the other at a rate of five times per second, and in many instances, the belt will be steered ten times per second. It will be understood that the belt may be driven at speeds varying, in most cases, from two hundred feet per minute to five thousand feet per minute, and in many instances, the belt will travel at speeds outside these ordinary speed ranges.

Means are provided for controlling the operation of cylinder 54 so as to effect steering of the belt. A pair of belt edge-positioning sensing devices 56 and 57 are provided for detecting the position of the belt. The sensing devices 56 and 57 are substantially identical with each other, except for an adjustment which will be more fully described hereinafter but an understanding of one will suffice for an understanding of both.

A source of air under pressure, at about three to five p.s.i., is provided through a pipe or conduit 58 (see FIG. 8) and air is constantly supplied to the air supply conduits 59 which in the form shown is a rubber hose connecting to a fitting 60 which is threaded into a supporting bar 61 mounted for longitudinal adjustment at its opposite ends on the front and rear frame members 47 adjacent the roll 19. The supporting bar 61 has a small nozzle orifice 62 therethrough to receive air from the fitting 60 and to discharge a jet of air upwardly through the atmosphere. In a typical installation, the hole 62 is made with a #60 drill.

Directly above and in alignment with the nozzle orifice 62 is provided the air jet-receiving open end of jet-receiving pipe 63. The end of pipe 63 is affixed as by welding or brazing to a supporting bar 64 which is affixed to the bar 61, and the bar 64 has an aperture 65 therein which is disposed in alignment with the nozzle orifice 62 so as to receive the jet of air therefrom. The bar 61 and bar 64 are respectively disposed below and above the plane of the abrading belt 24 so that the edge of the belt 24 may move into and out of obstructing relation with respect to the jet of air from nozzle 62. When the jet of air from nozzle 62 is permitted to enter the jet-receiving pipe 63 the pressure in the pipe 63 is increased, and when the belt edge obstructs the jet of air, the air pressure in the pipe 63 returns to atmospheric because the end of pipe 63 is open to the atmosphere. As seen in FIGS. 3 and 8, the aligned nozzle orifice and jet-receiving aperture of the sensing device 57 are disposed slightly inwardly of the belt from the corresponding nozzle orifice 62 and jet-receiving aperture 65 of the sensing device 56. Normally the edge of belt 24 obstructs the jet of air from the nozzle orifice 62 of sensing device 57 and normally, the jet of

air from nozzle orifice 62 of the sensing device 56 is unobstructed.

The jet-receiving pipe 63 is also connected to a flexible hose or pipe 63a. All of the hoses to and from the sensing devices 56 and 57 extend to the control cabinet 66 which is mounted on the frame structure 11 of the machine. The air connections are shown schematically in FIG. 8.

It will be seen that the main supply conduit 58 is connected to the air supply conduit 59 by a pressure regulator 67 and a pressure gauge 68 is provided for determining the pressure in the conduit 59. The jet-receiving pipes 63 are connected to separate air chambers 69 and 70, each of which has a thin flexible membrane or diaphragm wall 71 which is connected to a stem 72 for operating the switches S2 or S3. The pressure-responsive switch devices which include diaphragm 71 are sensitive to the minute pressure change which occurs when the air jets from nozzle orifices 62 enter the jet-receiving pipe 63 for operating the switches.

The pipes 63 are periodically cleaned by air under pressure supplied through exhaust conduits 73a and 73b, each of which includes a check valve 74 to prevent air flow from the conduit 63 and to conduit 73a or 73b. Air is periodically supplied to the conduits 73a and 73b as hereinafter more fully explained.

Another air pressure-responsive switch S1 is operated by movement of a diaphragm 75 which comprises one side of an air chamber 76 which is connected to the main supply conduit 58.

The main air supply conduit is connected through a pressure regulator 77 to an air conduit 78 for supplying air to the belt-steering, double-acting pneumatic cylinder 54. The conduit 78 is connected to the inlet port of a two-position, four-way air valve 79 which also is connected to an exhaust conduit 80. The valve 79 is of a conventional construction so that when moved in one position or another position, the inlet conduit 78 and the exhaust conduit 80 are individually and alternately connected to the air conduits 81 and 82 respectively for supplying and exhausting air from the opposite ends of steering cylinder 54. A pair of electric solenoids SOL3 and SOL4 have their movable armatures connected to the valve plungers for operating the plunger. When one of the solenoids is energized, the valve stem is pulled in one direction so as to connect the air inlet conduit 78 with one of the conduits 81 or 82 and to connect the exhaust conduit 80 to the other air conduits 81 and 82. When the first solenoid is deenergized and the other solenoid is energized, the connections in the valve are reversed so as to operate the cylinder 54. It will be remembered that movement of the piston rod of cylinder 54 rotates the shaft 49 and causes reversal of the direction of steering of the belt 24.

A pressure regulator 83 supplies air to the inlet conduit 84 which supplies air for the belt-tensioning cylinder 37. The air inlet conduit 84 is connected to the inlet port of a two-position, air valve 85 to which the pair of exhaust conduits 73a and 73b are individually connected. Valve 85 is also connected to opposite ends of cylinder 37 by air conduits 86 and 87. The valve 85 is of a conventional construction with a two-position valve stem, movable by one or the other of solenoids SOL1 or SOL2 so as to connect the inlet conduit 84 to one of the air conduits 86 or 87, while the other of the conduits 86 or 87 is connected to one of the exhaust conduits 73a or 73b. When the position of the valve is reversed, the other exhaust conduit 73a or 73b is connected to the appropriate air conduit 86 or 87 and the other air conduit 86 or 87 is connected to the inlet conduit 84. It will therefore be seen that as the valve is operated, one end of the cylinder will be exhausted through one of the conduits 73a or 73b and the other end of the cylinder is exhausted through the other conduit 73a or 73b so as to discharge blasts of air through the open end of the corresponding jet-receiving pipe 63. The connection between conduits 73a and 73b and 63 is disposed well away from the open ends of conduits 63 so as to be sure to sweep all of the dust particles from the conduit 63 when air is exhausted from the conduits 73. It will further be noted that the air for cleaning the conduits 63 is supplied from the exhaust side of the abrading belt tensioning cylinder 37 so that one of the conduits 63 is cleaned when the abrading belt is tensioned and the other conduit 63 is cleaned when the tension on abrading belt 24 is released. Therefore, in the normal operation of the machine, the air jet-receiving conduits 63 are cleaned each time the tension on the abrading belt is released and applied. Of course this occurs when the abrading belt 24 is being changed.

As seen in FIG. 9 wherein all of the circuitry is shown in deenergized condition, the main power buses B1, B2 and B3 are connected through main switch M to a three-phase source of power which may be 220 volts. One phase of the three-phase source is connected through an appropriate terminal box T to the primary windings of transformers T2 and T3. The connections in the terminal box T will vary according to the voltage on the three-phase source. In one instance the transformer primaries will be connected in series and in the form shown, the transformer primaries are connected in parallel. The parallel connected transformer secondaries supply low voltage power to the buses B4 and B5 and also supply power to the primary windings of transformer T1, the secondary of which is connected through a manual switch S5 to a rectifier Q, the output of which provides low voltage D.C. current having the polarity shown applied to buses B6 and B7.

The control circuitry includes previously mentioned electric solenoids SOL1, SOL2, SOL3 and SOL4, and also includes the motor starter windings L, the contacts of which are in the three-phase line supplying drive motor 33. The circuit controls also include relays X1, which has three sets of contacts X1–1, X1–2 and X1–3; relay X2 which has three sets of contacts X2–1, X2–2 and X2–3; relay X3 having two sets of contacts X3–1 and X3–2; relay X4 having two sets of contacts X4–1 and X4–2; and relay X5 having two sets of contacts X5–1 and X5–2.

Two of the power lines for conveyor motor 14 include relay contacts X5–1 and X5–2 respectively. Solenoid SOL1 is connected directly to bus B5 and is connectible to but B4 through the parallel connected contacts X3–1 and X3–2. Solenoid SOL2 is connected directly to bus B5 and is normally connected to bus B4 through parallel connected contacts X3–1 and X3–2. The tension applying and releasing solenoids SOL1 and SOL2 are alternately energized and deenergized as relay X3 is operated and released.

Steering solenoid SOL3 is directly connected to bus B5 and is connectible to bus B4 through contact X2–3. Solenoid SOL4 is connected directly to bus B5 and is connectible through contacts X1–3 to bus B4. The motor starter L is connected at one side to bus B5 and may be connected at the other side to bus B4 through parallel contacts X4–1 and X4–2.

Condenser C1 is connected between buses B6 and B7. The coil or relay X1 is connected directly to bus B7 and is connectible to bus B6 through pressure-responsive switch S2, or is connectible to bus B6 through normally open holding contacts X1–1, removable wire jumper A1 and normally closed contacts X2–2. Relay X2 is connected directly to bus B7 and is normally connected to bus B6 through pressure-responsive switch S3, or on the alternative is connected to bus B6 through normally open holding contact X2–1, removable wire jumper A3 and normally closed contacts X1–2.

Relay X3 is connected directly to bus B7 and is connectible to bus B6 through manual switch S6. Relay X4 is connected directly to bus B7 and is connectible through pressure-responsive switch S1 and manual switch S7 to

bus B6. Relay X5 is connected directly to bus B7 and is connectible to bus B6 through manual switch S4.

Operation

In the operation of the machine the main switch M is closed and air is supplied to the air conduit 58. It will be understood that when the air is supplied, pressure-responsive switch S1 is closed, air under pressure is applied through air conduit 87 to the upper end of tensioning cylinder 37 which is thereby held in retracted condition, and air is also supplied to one end of the steering cylinder 54, and further, air is supplied to the nozzle orifice 62 is the sensing devices. Power is supplied to the transformers T1, T2 and T3. A belt is applied onto the rolls 18, 19 and 20 and tension is applied on the belt by operating manual switch S6 which operates relay X3, the contacts of which shift to cause energization of solenoid SOL1, which causes operation of valve 85 and projection of the piston rod 37*a* of tensioning cylinder 37 and outward swinging of roll 20. It will be noted that when the valve 85 is operated to apply air pressure in the conduit 86 and exhaust through conduit 87, the exhaust air is directed outwardly through one of the pipes 63 and thereby sweeps out any dust that may have accumulated.

When the abrading belt 24 has been tensioned, the main drive motor 33 is operated by closing manual switch S7 which energizes relay X4, causing the contacts thereof to shift and energize the motor starter L, the contacts of which close to connect the drive motor to the main power buses. The workpiece conveyor 13 is started by closing manual switch S4 which energizes relay X5, the contacts of which close to connect the motor 14 to the main power buses.

The air, having been supplied to the conduit 58, is supplied to one end of steering cylinder 54 and to the nozzle orifices 62. With the belt 24 in the position shown in FIG. 8, atmospheric pressure remains in chamber 69 to allow switch S2 to remain in its normally open position; and air pressure is normally applied in chamber 70 by the jet directed into the corresponding jet-receiving pipe 63 of sensing device 56 so as to shift or open the pressure-responsive switch S3. Opening of switch S3 permits relay X2 to remain deenergized. When the edge of the belt moves into obstructing relation with the air jet of sensing device 56 the pressure in chamber 70 is reduced and diaphragm 71 returns to normal position to close pressure-responsive switch S3 which causes the contacts thereof to shift. Contacts X2–1 close to provide a holding circuit for the coil of relay X2. Contacts X2–2 open. Contact X2–3 closes to engergize solenoid SOL3 which operates air valve 79 to operate steering cylinder 55 and cause rotation of shaft 49 and shifting of the opposite ends of roll 19 so as to cause the belt to steer away from the sensing device 56 so that the edge of the belt as seen in FIG. 8, moves toward the sensing device 57.

When the edge of belt 24 again permits the air jet in sensing device 56 to be directed into the corresponding jet-receiving pipe 63 and thereby increase the pressure in chamber 70, switch S3 is opened, however, relay X2 remains energized through the holding contacts X2–1 and the steering solenoid SOL3 remains energized. As the belt 24 steers away from sensing device 56, the jet from sensing device 57 becomes unobstructed so that the pressure in the corresponding jet-receiving pipe 63 and air chamber 69 is increased to operate pressure-responsive switch S2. When the pressure-responsive switch S2 operates the contacts thereof are caused to energize relay X1 and thereby operate the contacts thereof. Holding contacts X1–1 close; contacts X1–3 close to energize SOL4; contacts X1–2 opens to break the holding circuit and thereby deenergize relay X2, the contacts of which return to normal position as shown. Holding contacts X2–1 open; contacts X2–2 close to establish the holding circuit of relay X1; and contacts X2–3 open to deenergize solenoid SOL3 substantially simultaneously with the energization of solenoid SOL4 so as to cause solenoid SOL4 to operate air valve 79 and thereby reverse the air pressure and exhaust connections to the opposite ends of steering cylinder 54. When this occurs, the shaft 49 is rotated to shift the ends of roll 19 and cause the belt to be steered in the opposite direction again, whereupon belt 24 steers into obstructing relation with the air jet of sensing device 57 and moves progressively toward the air jet of sensing device 56.

As the air jet of sensing device 57 is again obstructed, the pressure in chamber 69 returns to atmospheric to allow the pressure responsive switch S2 to return to normal position and to thereby open. Relay X1 is maintained in energized condition through the holding contacts X1–1 thereof. The belt continues to steer toward the sensing device 56 until the air jet thereof is obstructed, whereupon the pressure in chamber 70 returns to atmospheric and allows switch S3 to reclose so as to energize relay X2 and operate the contacts thereof. Holding contact X2–1 closes; contact X2–3 closes to energize solenoid SOL3 which in turn operates the air valve 79 for reversing air connections to cylinder 54 and causing reversal of direction of steering of abrading belt 24; and contact X2–2 opens to break the holding circuit of relay X1, the contacts of which return to normal. Holding contact X1–1 opens; contact X1–2 closes to establish the holding circuit for relay X2 and contact X1–3 reopens to drop out solenoid SOL4 substantially simultaneously with the energization of solenoid SOL3.

It will be seen that as the jets of air in the sensing device are alternately obstructed and unobstructed, the abrading belt 24 is steered back and forth within a limited range depending upon the physical spacing between the nozzle orifices 62 of the sensing devices 56 and 57 in a direction transversely of the abrading belt. As previously indicated, the steering cycle may be extremely short and the belt may steer back and forth within its limits approximately five times per second, depending upon the magnitude of steering and speed of the belt, which may be in the range of two hundred to five thousand feet per minute. The steering or oscillation of the belt is sufficiently fast so as to cause the self-cleaning of the abrading belt without causing objectionable score marks on the workpiece which may be extremely delicate.

The steering is accomplished by movement of the steering roll 19 in a direction that has the minimum effect on the overall tension of the belt and on the tension of the belt at either side thereof because the bearing mounts 45*a* and 45*b* on the corresponding ends of the roll move substantially normal to the bisector of the angle between the adjacent legs 24*a* and 24*b* of the abrading belt. The minimizing of the tension differential across the width of the belt causes all areas of the belt from one side or the other to engage the workpiece on conveyor 13 with uniform pressure even though the contact idler roll 18 is extremely soft and has only a very few ribs on its periphery.

In the operation described, the magnitude of steering may, in a typical instance, be one-quarter to one-half inch or more. The magnitude of steering may be adjusted by moving the bars 61 endwise to vary the spacing between the sensing devices 56 and 57. When the abrading machine is to be shut down, the conveyor 13 will be stopped by opening manual switch S4 which releases relay X5 to open the line to the conveyor motor 14. The main drive motor 33 is shut down by opening manual switch S7 which causes relay X4 to drop out and its contacts open the coil L, the contacts of which open the main power connections to the motor 33. When the motor has stopped and the belt 24 has stopped, the tension on the belt may be released by opening manual switch S6 which drops out relay X3 and allows the contacts thereof to return to normal to deenergize solenoid SOL1 and energize solenoid SOL2 which cause the valve 85 to shift so as to apply air to the upper end of cylinder 37

and retract the piston rod thereof. Simultaneously the lower end of cylinder **37** containing air under pressure, is exhausted through valve **85** and through the appropriate exhaust conduit **73***a* or **73***b* so as to sweep out collected dust in the appropriate jet-receiving pipe **63**. It will therefore be seen that one of the jet-receiving pipes **63** is cleaned when tension is applied on the belt **24** and the other jet-receiving pipe **63** is cleaned when tension on belt **24** is released. It has been found that in the normal operation of the abrading machine, no dust has been found in the jet-receiving pipes **63** further than three inches from the open end thereof. The exhaust conduits **73** are connected into the jet-receiving pipe at approximately twenty-four inches from their open ends so as to assure thorough cleaning.

It should also be pointed out that if at any time the supply of air fails, the pressure-sensitive switch **S1** will open so as to immediately shut down the motor **33** by dropping out relay **X4** and the control coil L and the contacts thereof in the main power fuses for driving motor **33**.

If it is desired to steer in a substantially straight line or with a minimum of side-to-side movement of the belt, one of the jumpers **A1** or **A3**, shown in the holding circuits of relays **X1** and **X2**, may be removed. For instance, if jumper **A1** is removed a coil tension spring **90** is also applied as seen in FIG. 10 between the arm **53** and the bracket of the steering cylinder **54**. It will therefore be seen that where pressure in the bottom of cylinder **54** tends to project the piston rod of cylinder **54** to cause swinging of farm **53** upwardly it effects steering of belt **24** in the direction of arrow *a* (see FIGS. 7 and 8). When air pressure in the bottom of cylinder **54** is released spring **90** swings the arm downwardly to rotate shaft **49** and move roll **19** so as to steer the belt forwardly or in the direction of arrow *b*.

With jumper **A1** removed from the circuit, the holding circuit for relay **X1** is broken. As previously indicated, the air jet of sensing device **57** is normally obstructed which allows pressure-responsive switch **S2** to remain open, in which case relay **X1** is deenergized and the contacts thereof are in normal condition so that solenoid **4** is deenergized. All of the solenoids **SOL1–SOL6** have built-in spring returns to neutral position. Because solenoid **SOL4** is deenergized and solenoid **SOL3** is also deenergized, the valve **79** is at a neutral position wherein the line air pressure is removed from the bottom end of cylinder **54** and the top end of cylinder **54** is not open to exhaust. Spring **90** will then pull the piston rod down and swing arm **53** down so as to steer the belt toward the front or in the direction of arrow *b*. The air jet of sensing device **57** then becomes unobstructed so as to cause the pressure in chamber **69** to be raised, whereupon pressure-sensitive switch **S2** is closed and relay **X1** operates. The contact **X1–3** closes to energize solenoid **SOL4** which operates valve **79** to apply pressure to the bottom of cylinder **54** and cause upward movement of piston rod in arm **53** so as to steer the belt in the direction of arrow *a* whereby the air jet of sensing device **57** is obstructed. Pressure switch **S2** returns to normal and opens so as to drop out relay **X1** and solenoid **SOL4** to permit the spring **90** to again operate and cause steering of the belt in a direction of arrow *b*.

In this mode of operation employing springs **90** with jumper **A1** removed, the belt is controlled but steering thereof is at a minimum. At low speeds the magnitude of steering side-to-side movement of the abrading belt is at an absolute minimum and at high speeds the magnitude of steering of the belt **24** is minimized but will be somewhat greater than at low speeds.

It will be seen that I have provided a new and novel steering mechanism for a high speed belt-type abrading machine wherein the steering of the abrading belt is accomplished with only a minimum of change in the tension on the belt because the steering roll **19** is moved in directions substantially normal to the bisector of the angle between the adjacent legs or runs **24***a* and **24***b* of the abrading belt. Furthermore, rapid oscillation of the roll is permitted because only a minimum number of components is moved to effect the steering and all of these components are light in nature and not massive in any sense.

It will further be seen that I have provided a new and improved belt edge-positioning sensing apparatus for the steering mechanism, which is highly sensitive to steering movement of the belt. The sensitivity of the belt position-sensing apparatus is independent of the nature of the belt and is uneffected by the typical curved or curled edge portions which most abrading belts have during operation. Furthermore, the extremely sensitive belt-edge positioning detecting apparatus is virtually uneffected in its sensitivity by dust which is inherently present in the area of all abrading machines and is thoroughly and positively cleaned periodically during normal operation of the abrading machine, i.e., at each occurrence of applying or removing tension on the abrading belt.

It will, of course, be understood that various changes may be made in the form, detail, arrangement and proportion of the parts without departing from the scope of my invention which consists of the matter described herein and set forth in the appended claims.

What is claimed is:

1. An abrading machine comprising a frame, a work-piece support on the frame, an endless abrading belt having an edge, means mounting and moving the belt over the support and around a continuous path and including operable mechanism to effect steering of the belt, belt position-detecting means including an elongate air jet-receiving pipe having an end open to the atmosphere, an air supply conduit to be connected with a source of air under pressure and having a discharge end in spaced and aligned relation with the open end of the pipe for directing a jet of air thereinto and to thereby increase the air pressure in the pipe, means mounting the conduit and pipe ends adjacent the edge of the belt to permit the belt to be steered into and out of obstructing relation with the jet of air and to thereby cause a change of pressure in the pipe, air pressure-sensitive means connected with the pipe and producing indications of the sensed air pressure in the pipe, means responsive to said indications for operating the steering mechanism, a second air supply conduit connected into the pipe at a position remote from said open end, said second conduit being adapted for connection with a source of air under pressure and having on-off valve means therein to permit clean-out air to be directed through said pipe and outwardly through the open end thereof.

2. An abrading machine comprising a frame, a work-piece support on the frame, an endless abrading belt having an edge, means mounting and moving the belt over the support and around a continuous path and including operable mechanism to effect steering of the belt and also including operable apparatus for applying and releasing tension on the belt to permit removal of the belt, belt-position-detecting means including an elongate air jet-receiving pipe having an end open to the atmosphere, an air supply conduit to be connected with a source of air under pressure and having a discharge end in spaced and aligned relation with the open end of the pipe for directing a jet of air thereinto and to thereby increase the air pressure in the pipe, means mounting the conduit and pipe ends adjacent the edge of the belt to permit the belt to be steered into and out of obstructing relation with the jet of air and to thereby cause a change of pressure in the pipe, air pressure-sensitive means connected with the pipe and producing indications of the sensed air pressure in the pipe, means responsive to said indications for operating the steering mechanism, a second air supply conduit connected into the pipe at a position remote from said end of the pipe and said second conduit being

adapted for connection with a source of air under pressure, said second conduit having on-off valve means therein to permit cleanout air to be directed through said pipe and outwardly through the open end thereof, and means for substantially simultaneously operating the valve means and the tensioning apparatus whereby to effect cleaning of the pipe when the tension on the belt is changed.

3. An abrading machine comprising a frame, a workpiece support on the frame, an endless abrading belt having an edge, means mounting and moving the belt over the support and around a continuous path and including operable mechanism to effect steering of the belt and also including operable apparatus for applying and releasing tension on the belt to permit the belt to be removed, said apparatus including an air cylinder with a piston therein operable to apply tension on the belt, belt position-detecting means including an air jet-receiving pipe having an end open to the atmosphere, an air supply conduit to be connected to a source of air under pressure and having a discharge end in spaced and aligned relation with the open end of the pipe for directing a jet of air thereinto and to thereby increase the air pressure in the pipe, means mounting the conduit and pipe ends adjacent the edge of the belt to permit the belt to be steered into and out of obstructing relation with the jet of air and to thereby cause a change of pressure in the pipe, air pressure sensitive means connected with the pipe and producing indications of the sensed air pressure in the pipe, means responsive to said indications for operating the steering mechanism, a second air supply conduit connected into said pipe at a position remote from said open end of said pipe, a valve having an inlet port connected to a source of air under pressure and having a supply port connected to said air cylinder for operating the same to apply tension on the belt, said valve also having an exhaust port connected with said second air supply conduit for directing clean-out air through said pipe and outwardly through the open end thereof, said valve alternately connecting said supply port with said inlet and exhaust ports whereby to alternately receive air under pressure and to direct exhaust air outwardly through the pipe to clean dust and particles therefrom.

4. An abrading machine comprising a frame, a workpiece support on the frame, an endless abrading belt having a pair of edges, means mounting and moving the belt over the support and around a continuous path and including operable mechanism to effect steering of the belt and also including operable apparatus for applying and releasing tension on the belt, said apparatus including a double-acting air cylinder and piston for applying and releasing tension on the belt, belt position-detection including a pair of air jet-receiving pipes each having an end open to the atmosphere, a pair of air supply conduits to be connected with a source of air under pressure and each of said conduits having a discharge end in spaced and aligned relation with the open end of an open pipe for directing a jet of air thereinto and to thereby increase the air pressure in the pipe, means mounting each of the conduit and pipe ends adjacent one of the edges of the belt to permit the belt to move into and out of obstructing relation with the jets of air from the conduits to change the air pressure in the pipes, said pipes being disposed in spaced relation with each other in a direction transversely of the belt, air pressure-sensitive means connected with each of the pipes and producing indications of the sensed air pressure in each of the pipes, means responsive to said indications for operating the steering mechanism and to cause the belt to be steered in one direction and then the other direction, a pair of second air supply conduits each connected into a respective jet-receiving pipe at a position remote from the end of said pipe, an air control valve having an inlet port connected to a source of air under pressure, having a pair of supply ports each respectively connected to opposite ends of the double-acting air cylinder, and having a pair of exhaust ports each connected to a respective second air supply conduit for exhausting air outwardly through the jet-receiving pipes to clean dust and particles therefrom, said air valve being constructed to alternately and individually connect each of said supply ports to a respective exhaust port and to said inlet port, whereby to cause clean-out air to be directed outwardly through said jet-receiving pipes each time the tension is applied and released on the abrading belt.

5. A workpiece abrading machine comprising a frame, a workpiece support on the frame, an endless abrading belt, means mounting and moving the belt at high speed over the support and around a continuous path and including a steering roll around which the belt is trained, the belt having a pair of linear runs extending to and from said roll at a predetermined angle with respect to each other, means movably mounting opposite ends of said roll on the frame for limited movement transversely of the bisector of said angle, oscillating means connected with opposite ends of said roll and oscillating the ends thereof transversely of the bisector of said angle, said oscillating means moving the opposite ends of the roll in opposite directions relative to each other to thereby steer the belt first toward one side and then toward the other side.

6. A workpiece abrading machine comprising a frame, a workpiece support on the frame, an endless abrading belt, means mounting and moving the belt at high speed over the support and around a continuous path and including a steering roll around which the belt is trained, the belt having a pair of linear runs extending to and from said roll at a predetermined angle with respect to each other, a pair of mountings each supporting a respective end of the roll, a pair of pivots each swingably supporting one of said mountings on the frame, the pivot axis and the rotation axis of the roll being parallel and disposed on the bisector of said angle, oscillating means connected with said mountings and oscillating said mountings and the corresponding ends of the roll in opposite directions with respect to each other about said pivot axis whereby to steer the belt first toward one side and then toward the other side.

7. An abrading machine as defined in claim 5 in which said limited transverse movement is in a direction substantially normal to said bisector.

8. An abrading machine as defined in claim 6 in which said oscillating means includes a shaft journaled on said frame for rotation about an axis generally parallel to the axis of said roll, a pair of eccentrics longitudinally spaced along and mounted on said shaft in alinement with the respective mounting, said eccentrics being phased apart about said shaft axis, a pair of links journaled at corresponding ends on said eccentrics and pivoted at the opposite ends on the respective mountings at points spaced from said pivots, and means for oscillating said shaft back and forth about its axis whereby said eccentrics reciprocate said links endwise back and forth to oscillate said mountings about said pivots.

References Cited in the file of this patent

UNITED STATES PATENTS

2,220,268	Olsen	Nov. 5, 1940
2,597,256	Murray	May 20, 1952
2,813,535	Markey	Nov. 19, 1957
2,860,840	Jacobsen et al.	Nov. 18, 1958