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[54] **ABRADING APPARATUS**

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[52] **U.S. Cl.** **51/12**

[51] **Int. Cl.** **B24c 9/00,** B24c 3/00

[58] **Field of Search** ..... 51/8 R, 12

[56] **References Cited**

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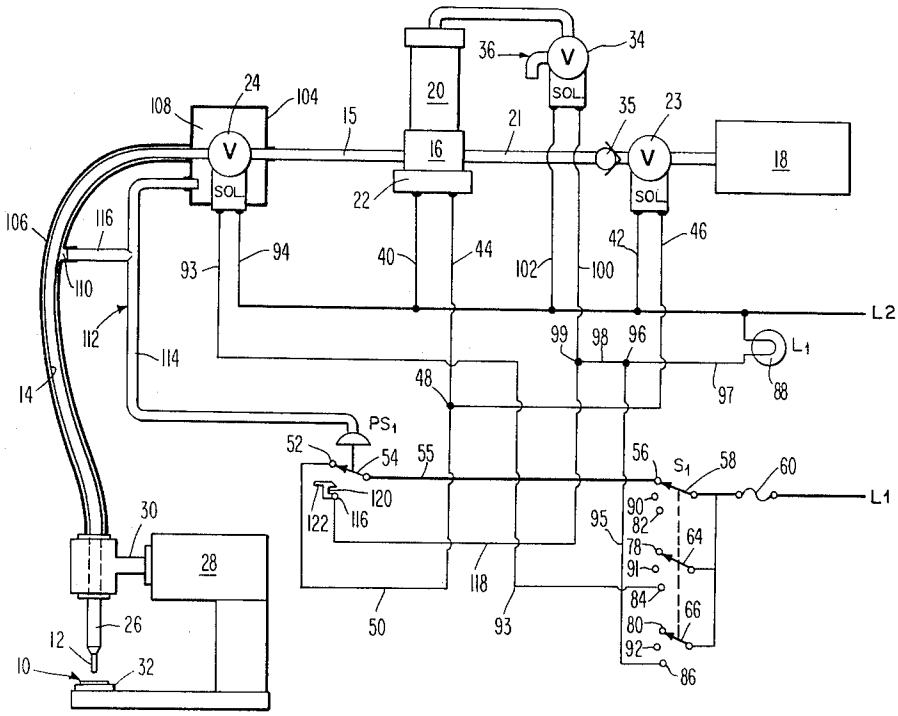
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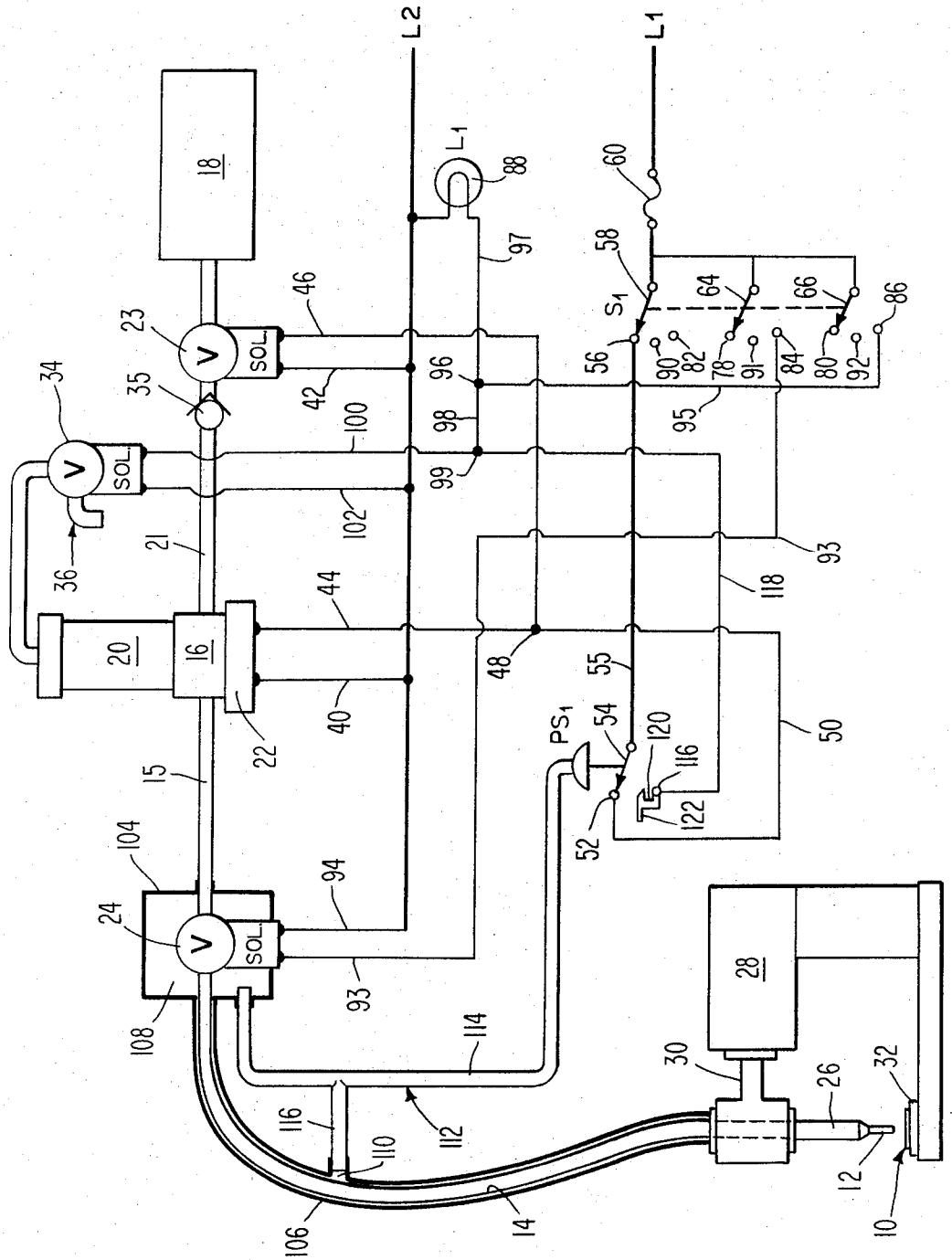
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[57] **ABSTRACT**

Abrading apparatus, including a conduit for conducting a mixture of pressurized gas and abrasive powder, is provided with a pressure-tight enclosure for containing leaks from the conduit, also a pressure-responsive switch for detecting leaks into the enclosure and for closing the valve which controls the flow of compressed gas from its source. The same pressure-responsive switch preferably de-energizes a vibrator in the abrasive mixture supply system; and it simultaneously lights a warning lamp and depressurizes the compressed gas supply line.

4 Claims, 1 Drawing Figure




L2
L1
L1
18
88
97
60
58
S1
64
66
86
46
23
SOL
56
90
82
78
91
84
80
92
34
35
42
96
100
98
95
SOL
99
102
21
36
93
118
44
20
16
48
55
40
22
PS1
54
120
116
50
15
52
122
104
94
24
SOL
93
28
108
114
30
26
32
116
110
112
12
106
14
10

ABRADING APPARATUS

BACKGROUND OF THE INVENTION

Abrading apparatus is now in common use for a variety of applications, including manual abrading operations with a hand-held nozzle issuing a jet of airborne abrasive particles. Also included are fully automated operations wherein printed resistors and other kinds of workpieces are automatically trimmed to desired value with automatic abrading equipment requiring only bulk loading of workpieces and bulk unloading of finished goods by an operator.

The basic abrading apparatus comprises an air supply, a powder reservoir with vibrator and mixing chamber, and a supply conduit fitted with an appropriate nozzle. Under pulsation from the vibrator abrasive powder trickles into the pressurized airstream, the amount depending on the amplitude of vibration. A rheostat may be employed to regulate the amplitude of vibration and, consequently, the intensity of abrasive cutting action.

Leaks in the hoses or supply conduit and the flow valve conducting the pressurized abrasive mixture can cause damage to surrounding components and auxilliary equipment, especially if the abrasive powder deposits on the surfaces of moving parts. The early detection and containment of such leaks is therefore highly desirable.

SUMMARY OF THE INVENTION

According to the invention, the supply conduit and the pinch valve controlling flow through the supply conduit are respectively enclosed in a pressure-tight tube and a pressure-tight housing. Both pressure-tight encasements are maintained at low or atmospheric pressure; and they are connected to a pressure-responsive switch. If a leak occurs in the supply conduit or in the pinch valve, the leak will be contained by the encasements; and the increased pressure resulting from the leak of pressurized gas will be sensed by the pressure-responsive switch which is then activated. Activation of the pressure-responsive switch de-energizes the vibrator and the solenoid of the delivery valve for compressed air, thus shutting off the compressed air supply. Activation of the pressure-responsive switch also energizes the solenoid of a bleed or relief valve in order to depressurize the upstream supply lines for compressed air, and at the same time lights up a signal lamp in order to indicate that a leak has occurred.

BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE of the drawing is a diagramatic view of abrading apparatus embodying the invention.

DETAILED DESCRIPTION OF THE INVENTION

The illustrated abrading apparatus will now be described as applied to the trimming of a thick-film resistor or other workpiece designated generally by the numeral **10,** utilizing a high velocity abrasive stream issuing from a nozzle **12.** The latter is supplied through a supply conduit **14** and a connecting tube **15** by a mixing chamber **16** where dry, filtered, pressurized air at about 85 p.s.i. from a compressor **18** is uniformly mixed in the desired proportions with abrasive powder from a reservoir **20.** By means of a unique arrangement more fully described in U.S. Pat. No. 3,344,524, granted Oct. 3, 1967, a vibrator **22** is employed to apply vibrations to the chamber **16.** This arrangement can produce an automatically replenished trickle of about 3 to 5 grams per minute of aluminum oxide or other abrasive powder having an average particle size of 27 microns, from the reservoir **20** through a passageway (not shown) to the mixing chamber **16** for combining with the pressurized air.

The invention may be practiced by substituting another source of compressed gas for the air compressor **18.** In the illustrated embodiment, pressurized air is delivered from the compressor **18** to the chamber **16** by means of a tubular delivery line **21.** A normally closed, solenoid operated, delivery valve **23** is installed in the delivery line **21,** the latter being opened for flow of compressed air from the compressor **18** by energization of the solenoid of delivery valve **23.**

Airborne abrasive particles will flow from the mixing chamber **16** to and out the nozzle **12** so long as the normally open, solenoid operated pinch valve **24** remains de-energized. Valve **24** is at the upstream end of the supply conduit **14,** that is, at the outlet of the connecting tube **15,** downstream of the mixing chamber **16.** The nozzle **12** will have a restricted orifice, e.g. 0.018 inch diameter, of much smaller cross-sectional flow area than the supply conduit **14,** and thus the entire system is pressurized. In order to achieve uniform cutting action the apparatus is arranged to provide a uniform concentration of particles in a constant airstream issuing from the nozzle at about 40 to 80 p.s.i.

The supply conduit **14** may be a flexible hose of abrasion resistant material and it is preferred that the terminal or end portion adjacent the nozzle **12** be of rigid tubular construction so that it can serve as nozzle holder **26** capable of having its movements accurately controlled by a traversing mechanism **28** connected thereto by a rigidly constructed arm **30.** The nozzle holder **26** is suitable journaled in the extended free end of the arm **30,** in upright position above a holder **32** for the workpiece **10.** The traversing mechanism **28** serves to move the nozzle **12** by its holder **26** transverse to the longitudinal extent of the holder, whereby the abrasive stream is traversed along the length of the workpiece to cut or abrade along the line of travel. The traversing mechanism **28** responds to signals received from a control (not shown) to move a controlled distance first in one direction and then usually in opposite or reverse direction upon completion of an abrading operation. As is well known in in the art, such control may incorporate a four-wire resistance limit bridge, integral to the electrical control system, for monitoring the resistor as it is being trimmed and sending a signal to the pinch valve **24** and to the traversing mechanism **28.**

The traversing mechanism **28** may be of the type described in U.S. application Ser. No. 360,496, filed Mar. 15, 1974.

In order to relieve reservoir **20** of air pressure in certain situations, a normally closed, solenoid operated relief valve **34** is connected thereto by a tube, and made connectable to atmosphere via a spout **36** when valve **34** is opened. Valve **34** is opened by energization of its solenoid. A check valve **35,** installed in delivery line **24** immediately downstream of valve **23,** is in open position so long as the pressure is greater on the upstream side thereof.

In the positions as illustrated, main switch S1 connects L2 through vibrator **22** and the solenoid of deliv-

ery valve 23 to L1 via pressure switch PS1. This is the normal operating position of the circuit now to be described, since in such position, the vibrator 22 is energized, the valve 23 is open to compressed air flow, while the pinch valve 24 remains normally open and the pressure relief valve remains normally closed. As shown, conductor 40 connects vibrator 22 to L2 and line 42 connects the solenoid of delivery valve 23 to L2. Conductor 44 from vibrator 22 and line 46 from the solenoid of valve 23 are connected at junction 48. From junction 48 line 50 leads to terminal 52 engaged by the blade 54 of pressure switch PS1. The blade 54 is connected by conductor 55 to terminal 56, thence through blade 58 of main switch S1 and via fuse 60 to L1.

Main switch S1 is a three position, double throw switch, having switch blades 62 and 64 in addition to blade 58 arranged for gang operation. While in the upper position previously described, with blade 58 engaging terminal 56, blades 64 and 66 respectively engage terminals 78 and 80. In the lowermost position of switch S1, blades 58, 64 and 66 respectively engage terminals 82, 84 and 86 to provide a momentary bleed position. In the momentary bleed position, the disengagement of blade 58 from terminal 56 de-energizes the vibrator 22 and the solenoid of delivery valve 23, thereby interrupting the flow of the air-powder mixture. Simultaneously, in the momentary bleed position, the engagement of blade 64 with terminal 84 energizes the solenoid of pinch valve 24 and thereby closes it, while at the same time the engagement of blade 66 with terminal 86 energizes the signal lamp 88 and also energizes the solenoid of relief valve 34 to open it and thereby connect reservoir 20 to atmosphere. Upon release of main switch S1, the blades 58, 64 and 66 move to a neutral position, respectively engaging terminals 90, 91 and 92 until manually reset, e.g. to uppermost position. The apparatus is conditioned to be inoperative with the blades of switch S1 in neutral position.

Tracing the circuit in the momentary bleed position of switch S1, it is first established that the blades 64 and 66 are connected to L1. Upon engagement of blade 64 with terminal 84, the latter is connected by conductor 93 with the solenoid of pinch valve 24, and from there conductor 94 connects to L2. With blade 66 engaging terminal 86 current flows via conductor 95 to junction 96, and thence via line 97 through lamp 88 to L2, and also from junction 96 via line 98, junction 99 and conductor 100 to the solenoid of valve 34. The solenoid of valve 34 is connected to L2 by conductor 102.

According to the invention, the pinch valve 24 is enclosed in a pressure-tight housing 104 through which supply conduit 14 passes. In addition, a pressure-tight tube 106 encloses supply conduit 14 for the full length thereof. Preferably, the tube 106 is flexible to enable it to flex with the conduit 14. The pressure-tight housing 104 defines a closed chamber 108 about pinch valve 24 which is maintained at a pressure level below that of the pressure within the supply conduit 14 and the pinch valve 24, and preferably at atmospheric pressure. Likewise, there is an elongated chamber 110 of generally annular cros-sectional configuration between the conduit 14 and the tube 106 which is maintained at the same pressure as the chamber 108. Preferably, the chambers 108 and 110 are in communication with one another as shown. Further provided is a pressure sensing tube 112, the main portion 114 of which extends between the pressure switch PS1 and the housing 104; and a branch portion 116 of which is connected between the pressure-tight tube 106 and the main portion 114 of the pressure sensing tube 112.

With the proposed arrangement in the normal operating position, any leak of compressed air or gas from the supply conduit 14 or pinch valve 24 will pressurize the chambers 108 and 110, the interior of the pressure sensing tube 112, and the pressure switch PS1, thereby disengaging the blade 54 from terminal 52 and moving it into engagement with terminal 116. Such action immediately disconnects L1 from junction 48 and de-energizes the vibrator 22 and the solenoid of delivery valve 23, and then connects L1 through blade 54, terminal 116, and conductor 118 with junction 99. The connection of L1 with junction 99 results in the energization of the solenoid of relief valve 34 via conductor 102 and of the signal lamp 88 via line 98, junction 96 and line 97. Thus, the opening of valve 34 discharges compressed air from reservoir 20 through the spout 36 to atmosphere. The lighting of the signal lamp 88 while switch S1 is in uppermost or operating position is a visual indication to the operator of a leak, also that the operation of the apparatus has been interrupted by the de-energization of the vibrator 22 and of the solenoid of delivery valve 23.

Other electrically operated signal means may be employed instead of, or in addition to, the signal lamp 88.

The pressure switch PS1 is a single pole, double throw switch which, although not shown in detail in the drawing, preferably has a conventional bellows connected through the sensing tube 112 to the pressure-tight tube 106 and enclosure 104 so that it is in communication with the chambers 108 and 110. The bellows is extendable in response to a substantial increase of pressure in the chambers 108 and 110. The bellows is operably associated with the switch blade 54 in such manner that extension of the bellows moves the blade 54 from its uppermost position in contact with the terminal 52 into engagement with the terminal 116. It is further preferred that the switch PS1 be manually resettable from its last-mentioned position in engagement with terminal 116 and, for this purpose, a latch-like retaining means or retainer 120 is provided. The retainer 120 may be a flexible member which is deflected out of position by the blade 54 as it moves toward the terminal 116, after which a detent portion captures the end of the blade 54 and holds the switch in this position against return to previous position even if the bellows is later depressurized. After depressurization of the bellows, the blade 54 may be manually reset by releasing it by manual deflection of the retainer 120, for example by depressing a tab 122. The use of a manually resettable, pressure-responsive switch PS1 is desirable because depressurization of the chambers 108 and 110 is a normal consequence of de-energizing the solenoid of the delivery valve 23 and allowing compressed air to bleed from reservoir 20 through relief valve 34. Unless switch PS1 is retained in a position with blade 54 held against terminal 116, upon depressurization of the chambers 108 and 110 the bellows will also be depressurized and the blade 54 will re-engage terminal 52 and thereby re-energize the solenoid valve 23 and vibrator 22.

The compressor 18, the delivery line 21, the mixing chamber 16, the reservoir 20 and the vibrator 22 are the primary components of a delivery system for pro-

viding a pressurized mixture of compressed gas and abrasive powder which is conducted to the supply conduit **14.** It is desirable to enclose the pinch valve **24** with enclosure **104,** as well as the main portion of the supply conduit **14,** because that portion of the supply conduit **14** which is pinched closed by the pinch valve **24** is a common location of leaks due to repeated flexing within the pinch valve **24.** The enclosures **104** and **106** are in at least partly spaced relationship with the supply conduit **14** and pinch valve **24** and they assist in containing at least partly within them much of the abrasive powder lost when a leak occurs.

With the foregoing arrangement, means have been provided for deactivating the apparatus when a leak occurs, thus reducing the chance of damage to sensitive parts, especially moving parts surrounding the supply conduit **14.**

What is claimed is:

1. In abrading apparatus having a nozzle, delivery means providing a pressurized mixture of compressed gas and abrasive powder, and a conduit for conducting said pressurized mixture from said delivery means to said nozzle, wherein said delivery means includes a solenoid valve which when energized activates said delivery means and which when de-energized deactivates said delivery means, that improvement comprising:

a. a pressure-tight enclosure enclosing said conduit in at least partly spaced relationship to define a chamber therebetween;

b. a pressure-responsive switch including

1. a bellows connected to said enclosure in communication with said chamber whereby said bellows is extendable in response to a substantial increase of pressure in said chamber,

2. a switch connected in an electrical circuit with said solenoid valve to energize said solenoid valve in a first position of said switch, said switch being operably associated with said bellows for movement thereby to a second position wherein said solenoid valve is de-energized when said bellows is extended,

3. retaining means holding said switch in second position against return to the first position when said bellows is depressurized, and

4. manual reset means operable for releasing said retaining means and returning said switch from second position to first position;

whereby a leak of said abrasive powder from said conduit is contained at least partly within said enclosure and said delivery means is deactivated when a leak occurs in said conduit.

2. Abrading apparatus according to claim **1** further including a relief valve having a solenoid connected between atmosphere and said delivery means, said relief valve being closed to atmosphere when its solenoid is de-energized and open to atmosphere when its solenoid is energized, said switch in first position effecting de-energization of said solenoid of said relief valve, and said switch in second position effecting energization of said solenoid valve of said relief valve, whereby said delivery means is depressurized when a leak occurs in said conduit and said bellows extends in response to a substantial increase in pressure in said chamber.

3. Abrading apparatus according to claim **1** further including a signal lamp connected in said circuit with said switch, said lamp being energized in second position of said switch and being de-energized in first position of said switch.

4. Abrading apparatus according to claim **1** wherein said delivery means includes structure defining a mixing chamber for mixing compressed gas and abrasive powder into a pressurized mixture for abrading; a source of compressed gas connected to said mixing chamber, and an electrically operated vibrator mounted to said structure, said vibrator being connected in said circuit to said switch for energization in first position of said switch and for de-energization in second position of said switch, whereby said vibrator is inoperative when a leak occurs in said conduit which extends said bellows by a substantial increase of pressure in said chamber.

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