Air ejector having discharge pressure-limiting and noise-suppressing nozzle means is provided with valving means actuated by dead-ending said nozzle means against a surface to thereby reduce the downstream pressure of the air at the outlet of said nozzle means for all static conditions.
DEAD-ENDABLE SELF-PRESSURE REGULATING AIR NOZZLE

This invention relates to an improvement on the "Self-Pressure Regulating Air Ejector" disclosed in my co-pending application, Ser. No. 162,784, filed July 15, 1971, of which this application is a continuation-in-part, and, more particularly, to such an air ejector nozzle which not only will suppress the noise of pneumatic cleaning lances or blow-guns to occupationally safe sound-levels and limit the dynamic force of air blasts to safe operating levels despite higher and fluctuating line pressures but, further, more than meet governmental regulations for maximum downstream pressure at the outlet of the cleaning device when the device is "dead-ended", i.e., when the discharge outlet is pressed against an obstructing surface. Indeed, under such static conditions the down-stream pressure at the discharge outlet may be reduced to zero in air ejector nozzles made according to this invention.

As pointed out in my above-entitled co-pending application, the normal line pressure of the air supply required in shops for operation of paint sprayers, pneumatic tools, cylinders, valves, and the like, is in the order of 90 p.s.i., whereas for removing small parts from forming dies, for moving parts along conveyor chutes, and the like, by means of air-ejector nozzles, the maximum outlet discharge pressure now permitted by occupational safety and health administrative ("OSHA") regulations is 30 p.s.i. The multi-jet air-ejector disclosed in my above co-pending application provides ample air for such operations, despite wide fluctuations in the available shop-air over normal line pressure at a much lower sound level, due to the use of a multi-jet plug as disclosed in my U.S. Pat. No. 3,537,543 to which air is supplied through the orifice of an adjacent internal disk, the orifice being centrally located with respect to the plurality of concentrically-located nozzle ports. This device thereby eliminates the need for expensive pressure regulators in the line to the ejector from the high-pressure shop air line and provides a relatively silent blast of air, free from malfunctioning of internal check valves or pressure reduction by very noisy aspirating devices which are also subject to tampering and abuse.

Air ejectors, as such, are also used as "blow-guns" or "cleaning lances" attached to the end of a flexible line. They can then be moved by an operator for cleaning residual chips and lubricants or cutting oils from dies and/or cutting tools, for cleaning parts, and to allow selective removal of formed parts from dies and molds. Such mobility, unfortunately, also permits the accidental or intentional dead-ending of their outlets.

The same governmental (OSHA) regulations which limited the dynamic air-stream from an air ejector nozzle also set the same limit on the permissible downstream pressure when the air at the discharge outlet is static, as when the outlet is dead-ended. To meet this standard, two expedients are suggested by the regulations, (a) inserting a pressure-limiting valve in each line between the ejector and the supply of high-pressure shop-air, i.e., installing expensive pieces of equipment which my self-pressure regulating ejector is intended to eliminate or (b) surrounding the outlet of the discharge nozzle with a protruding porous cone, sleeve, or screen which prevents the outlet from being dead-ended and subjected to static pressure and also intended to catch chips or other small objects which may be sent flying in haphazard directions when such a protruding and surrounding guard prevents the outlet from being precisely aimed. This latter alternative was no solution to the problem of preventing self-pressure regulating multi-jet air ejectors as disclosed in my above application from being dead-ended and developing the full shop-line pressure at the nozzle outlets; this is due to the absence, under static conditions, of the back-turbulence within my ejector which, under dynamic flow through it, self-limits the outlet pressures to levels meeting or exceeding safety standards. For some causes not fully understood, any apertured sleeve or cone surrounding the multi-jet nozzles of my ejector and extending beyond them a distance sufficient to allow a flow sufficient to allow the limiting internal back-turbulence to develop also interferes with the multiplicity of jets so that they are inoperative, or nearly so, to eject or move the parts or substances the ejector is intended to act on.

It is an object and advantage of this invention to modify a multi-jet air ejector, as disclosed and claimed in my above pending application to permit its use on flexible lines as a "blow-gun" or cleaning lance without interference with its effectiveness due to guard covers or sleeves. Another object and advantage of this invention is that when such an air ejector commences to be dead-ended, it reduces the flow of emitted air and, when fully dead-ended, the static pressure at the outlet is preferably reduced to zero, thereby eliminating the recoil which could be produced if the outlet were under a static full line pressure when dead-ended.

Other objects and advantages of this invention will be apparent from the following specification, claims, and drawings, in which:

FIG. 1 is an end-view of an ejector made according to this invention.
FIG. 2 is a side view, partly in section along the line 2—2 of FIG. 1, of the ejector shown in FIG. 1.
FIG. 3 is an end view of another embodiment of this invention.
FIG. 4 is a side view of the embodiment shown in FIG. 3, being partly in section along the line 4—4 of FIG. 3.
FIG. 5 is a fragmentary view showing a variation of the embodiment shown in FIG. 4.
FIG. 6 is a fragmentary view showing another variation of the embodiment shown in FIG. 4.
FIG. 7 is a fragmentary view showing still another variation of the embodiment shown in FIG. 4.
FIG. 8 is a fragmentary view corresponding to FIG. 7 but showing a modification thereof.
FIG. 9 is a fragmentary view corresponding to FIG. 7 but showing another modification thereof.

Referring to the drawings, FIGS. 1 and 2 illustrate a self-pressure regulating, relatively silent air ejector which, but for one relatively minor and one major difference, corresponds to the device shown in FIGS. 1 and 2 of my co-pending application Ser. No. 162,784. That is, the device 10 comprises a casing or sleeve 11 having a pipe-threaded fitting 12 permitting attachment by the nut faces 14 to a conventional coupling connecting the device 10 to a flexible hose leading to a high-pressure shop air line; such a coupling is usually a hand-held, button-operated, quick-opening shut-off valve. The device 10 may thus be manually aimed at the object or material to be moved by the blast of air discharged when the normally-closed shut-off valve is
opened. The end of the casing 11 opposite the fitting 12 is counter-bored to receive a disk 15 and a plug 20. The plug 20 is provided with a dished inlet face 22 and three or more outer concentrically-arranged, equally-spaced holes 25 tapered to function as nozzles; the size, form, and number of such nozzle passageway with respect to the length of the plug are preferably according to the proportions of the similar sound-reducing plug 20 shown in my U.S. Pat. No. 3,537,543. The disk 15 has a central orifice 16; the dishing of the plug 20 and size of the orifice 16 with respect to the nozzle holes 25 are preferably according to the proportions disclosed in my co-pending application Ser. No. 162,784.

As described so far, the device shown in FIGS. 1 and 2 of this application is the same as shown in my said application, with one relatively minor difference. To secure the plug 20 and disk 15 within the casing 11, if the protruding end of the thinner counter-bored wall of the casing 11 is spun in to reversely fold it against the discharge face 21 of the plug 20, the plug and disk 15 will be securely locked by a ring or rim thus formed but which thereby produces an appreciable distance beyond the discharge face 21 of the plug 20. In solving the problems met by this present invention, it has been discovered that the effect of the parallel multiple jets of air emitted by the nozzle 25 is enhanced if there is a minimal external ring or sleeve protruding beyond the discharge face 21. Accordingly, the end of the thin casing wall is now spun in to provide an internal retaining ring 17 of no greater length than the thickness of the counter-bored portion of the casing 11.

The major difference between the device 10 as shown in FIGS. 1 and 2 of the drawings and that shown in my said co-pending application is that the center of the plug 20 is drilled to receive the stem 31 of a valve 30, and the center of the dished inner surface 22 of the plug 20 is counter-bored to receive the head 32 of the valve so that it is substantially flush with the center of the dished surface 22. The end of the stem 30 protrudes from the plug face 21 only a distance sufficient to insure that just before the retaining ring 17 can be pressed against a surface, the valve-head 32, slightly larger than the orifice 16, will be firmly seated on the orifice.

In normal operation, air passing through the orifice 16 will impinge on the valve head 32 and seat it in the dished plug surface 22; this air is then discharged through the nozzles 25 to issue as a multi-jet discharge from the plug face 21 with no significant diminution of the moving force of a similar quantity of air emitted from a single discharge outlet, but with very noticeably less noise. And if the full line pressure on the upstream side of the disk 15 should substantially increase, the outlet pressure of the jets from the nozzles 25 will increase only slightly and remain within acceptable operating limits due, apparently, to the back-turbulence created by the inner plug face 22 which thereby automatically throttles the flow which would be expected to increase through the orifice 16.

The ejector shown in FIGS. 1 and 2 permits close and accurate aiming of the device 10, without interference by the stem 31; this protruding stem does not interfere with the action of the multiple jets, as has been found with a surrounding collar or wall. If, however, the operator commences to dead-end the face 21, the valve head 32 will be raised from its seat, throttling flow through the orifice 16 and shutting off the flow entirely if the device 10 is fully dead-ended, thereby reducing the static outlet pressure to zero under such conditions. If the device 10 were not equipped with the valve 30, the dead-ending of it to create a static condition at the discharge face 21 of the plug would terminate the throttling back-turbulence between the disk 15 and face 22 and create a downstream pressure at the face 21 equal to the full line pressure on the upstream side of the disk 15. This would exceed permissible regulatory standards and create possibly dangerous recoil conditions if the operator did not release the normally closed, manually-operated shut-off valve.

To eliminate the appearance of the valve stem 31 as shown in FIGS. 1 and 2 and the possibility of its being accidentally or intentionally bent or broken so as to interfere with the operation of the valve 30, FIGS. 3 to 7 show a variety of modifications wherein the nozzle plug protrudes from the casing 11 but is slideably mounted to permit retraction into it.

Thus, referring to FIGS. 3 and 4, the device 110 corresponds to the device 10 as shown in FIGS. 1 and 2, except that the corresponding disk 115 is force-fitted to be retained at the seat provided by the deeper counter-bored portion of the casing 111, the end of which is spun in to provide a retaining ring 117. A slightly longer plug 120 is provided with a shouldered outer end normally held against the ring 117 by the pressure of air discharged through the orifice 116 and acting on the dished plug face 122, leaving an internal chamber 133 between the disk and plug. The plug 120 is provided with parallel tapered nozzle holes 125 corresponding to the nozzle holes 25 shown in FIG. 1. The plug 120 carries a fixed protruding valve head 132 aligned with the orifice 116. The nozzles 125 provide a silenced multi-jet discharge from the discharge face 121 and the back-turbulence within the chamber 133 created by air from the orifice impinging on the valve head 132 regulates the normal dynamic discharge pressure. If the device is dead-ended, however, the valve head 132 throttles the downstream static pressure at the face 121 to zero as the plug 125 is retracted in the casing 111.

FIG. 5 shows a variation functioning in the same manner as the retractable plug construction shown in FIG. 4. The disk 215, however, carries a central tubular orifice 216 extending into the chamber 233. The plug 220, provided with nozzles 225, is slidable in the counter bore of the casing 211 and carries a short valve plug 232, which may be of relatively softer material, such as nylon, to insure closure of the orifice 216.

FIG. 6 shows a variation substantially identical to that in FIG. 5 with a corresponding casing 311, disk 315, orifice 316, plug 320, nozzles 325 and chamber 333. Rather than a valve stem, however, the plug 320 carries an inserted seat 322 against which the tubular orifice 316 seats when the plug is retracted in the casing.

FIG. 7 shows a modification corresponding in some respects more nearly to that shown in FIG. 4, having a corresponding casing 411, a disk 415 having a central orifice 416 and a slidable plug 420 with multi-jet nozzles 425. To secure self-pressure regulation similar to that achieved by the embodiment shown in FIGS. 1 and 2, the plug 420 carries a disk 435 having lateral orifices 436, which are shown for purposes of illustration as substantially aligned with the nozzles 425, but are preferrably offset to create greater back turbulence between
the disk 435 and the dished face of the plug 426. The disk 435 carries a stem 437 aligned with the orifice 416 so as to close it when the plug is fully retracted.

The modification shown in FIG. 8 corresponds to that shown in FIG. 7, except for a reversal of the centrally and laterally orificed disks. That is, the casing 511 carries a slidable plug 520 having multi-jet nozzles 525, the plug, in turn, carrying a disk 515 having a central orifice 516 opening onto the dished face of the plug 520. The bottom of the counter-bore carries a disk 535 having lateral orifices 536 and a central valve stem 537 which throttles the orifice 516 when the plug is retracted.

The modification shown in FIG. 9 functions to throttle the ejector when it is dead-ended but provides a plurality of chambers both to increase the silencing and self-pressure regulating effects. That is, the casing 611 carries a slidable plug 620 having multi-jet nozzles 625. A fixed disk 615 at the bottom of the deep counter-bore has a central orifice 616. Intermediate the disk 615 is a disk 635 having a plurality of lateral orifices 636 and also serving as a guide for a valve 637 carried by the plug 620, the valve throttling the orifice 616 when the plug is retracted by dead-ending.

Still other modifications and variations may be made by those skilled in the art without departing from the spirit and scope of this invention as defined in the following claims.

What is claimed is:

1. An air ejector comprising a casing having one end adapted to be coupled to a high-pressure air supply, a disk within said casing and having a central orifice therein, a plug member within the opposite discharge end of said casing, said plug member having three or more parallel and axially-extending passageways therethrough providing outlet ports at its discharge end, said passageways being substantially equally spaced from each other and the longitudinal center line of said plug member and connecting their outlet ports to inlet ports in an inlet surface of said plug member, whereby air passing through said disk orifice enters said inlet ports and is emitted from said outlet ports as parallel multiple jets, and valve means actuated as said outlet ports commence to be dead-ended against a surface to which said outlet ports are directed to throttle air passing through said central orifice.

2. An air ejector as defined in claim 1 in which said valving means comprises a valve stem slidably and centrally mounted in said plug member and extending beyond said outlet ports, said valve stem having a valve head centrally located at said inlet surface of said plug, whereby the commencement of dead-ending of said outlet ports and engagement of the protruding valve stem will push said valve head toward said central orifice to throttle the same.

3. An air ejector as defined in claim 1 wherein said plug member is slidably mounted in said casing and normally pushed in the downstream direction of the movement of air through said ejector by the pressure of air moving through said central orifice, whereby the pressure exerted on the slidable plug member when dead-ending the ejector actuates the valving means to throttle said central orifice.

4. An air ejector as defined in claim 3 in which said valving means comprises a headed valve stem member protruding upstream from the inlet surface of said plug member and normally spaced from said orifice, whereby the retraction of said plug member upon the commencement of dead-ending causes said stem to throttle said orifice.

5. An air ejector as defined in claim 4 wherein a second disk is interposed between said centrally orificed disk, said second disk having a plurality of lateral orifices and a central opening to guide said valve stem whereby a plurality of sound-deadening and back-turbulence creating chambers are provided between said orificed disk and the inlet surface of said plug member.

6. An air ejector as defined in claim 3 wherein said central orifice in said disk is a short tubular portion extending downstream and the inlet surface of said plug member is dished downstream, whereby retraction of said plug member upon the commencement of dead-ending moves the inlet surface of said plug member toward said central orifice to throttle the same.

7. An air ejector as defined in claim 6 wherein the central dished portion of said inlet surface carries a valve head member protruding toward said orifice tube.

8. An air ejector as defined in claim 3 in which said centrally-orificed disk is carried by said plug member over a dished inlet surface of said plug member to provide a sound-deadening and back-turbulence creating chamber between said dished inlet surface and said disk, a fixed second disk member is carried in said casing upstream of said first disk, and a centrally located downstream-extending valve stem carried by said secured disk, said second disk having laterally located orifices to permit the passage of air around its central valve stem, whereby retraction of said plug member into said casing upon the commencement of dead-ending pushes said first disk toward said valve stem to throttle the orifice in said first disk.

9. An air ejector as defined in claim 3, in which a first disk having a central orifice is fixed upstream and normally spaced from said plug member, said plug member has a dished inlet surface covered by a second disk having lateral orifices therethrough to form a back-turbulence creating chamber between said plug and said second disk, a valve member located centrally on said second disk and extending upstream toward the said central orifice to throttle the same when said plug member is retracted into said casing upon the commencement of dead-ending the ejector.