

United States Patent

[11] 3,620,248

[72] Inventor **Francis H. Cary**
Hope, R.I.
 [21] Appl. No. **56,620**
 [22] Filed **July 20, 1970**
 [45] Patented **Nov. 16, 1971**
 [73] Assignee **General Signal Corporation**

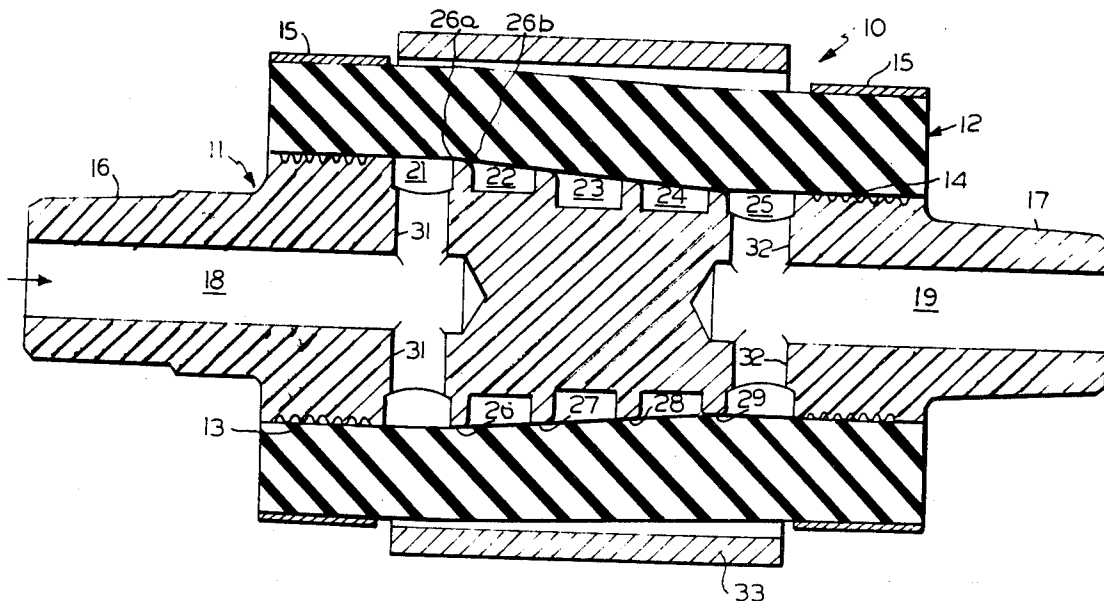
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Primary Examiner—M. Cary Nelson
Assistant Examiner—Robert J. Miller
Attorney—Dodge & Ostmann

[54] **BACKPRESSURE DEVICE**
6 Claims, 2 Drawing Figs.

[52] U.S. Cl. **137/493,**
137/516.25
 [51] Int. Cl. **F16k 17/18**
 [50] Field of Search **137/493,**
493.9, 510, 516.29, 516.25; 251/122, 127, 125,
118

ABSTRACT: The disclosure concerns a device for imposing a back pressure on hydraulic metering pumps. The device includes a plurality of serially arranged, annular orifices defined by peripheral, axially spaced lands on a rigid mandrel, and an encircling, stretched elastomeric sleeve. The preload in the sleeve at each land determines the upstream pressure required to open the orifice and allow flow across the land, and the preloads are controlled by design so that none of the orifices creates a pressure differential which results in damaging cavitation.



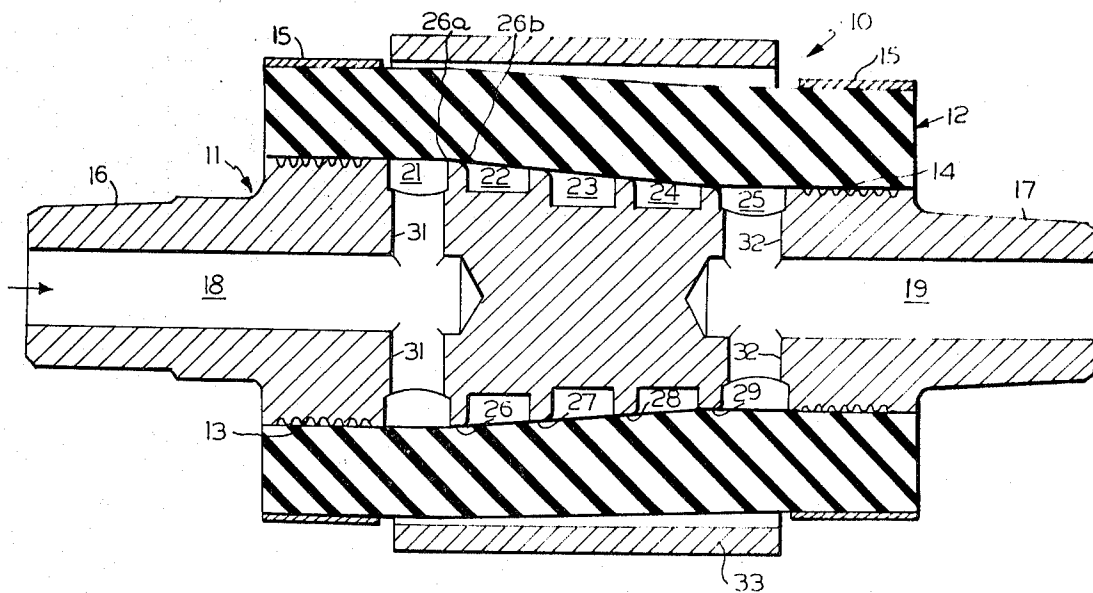


FIG. 1

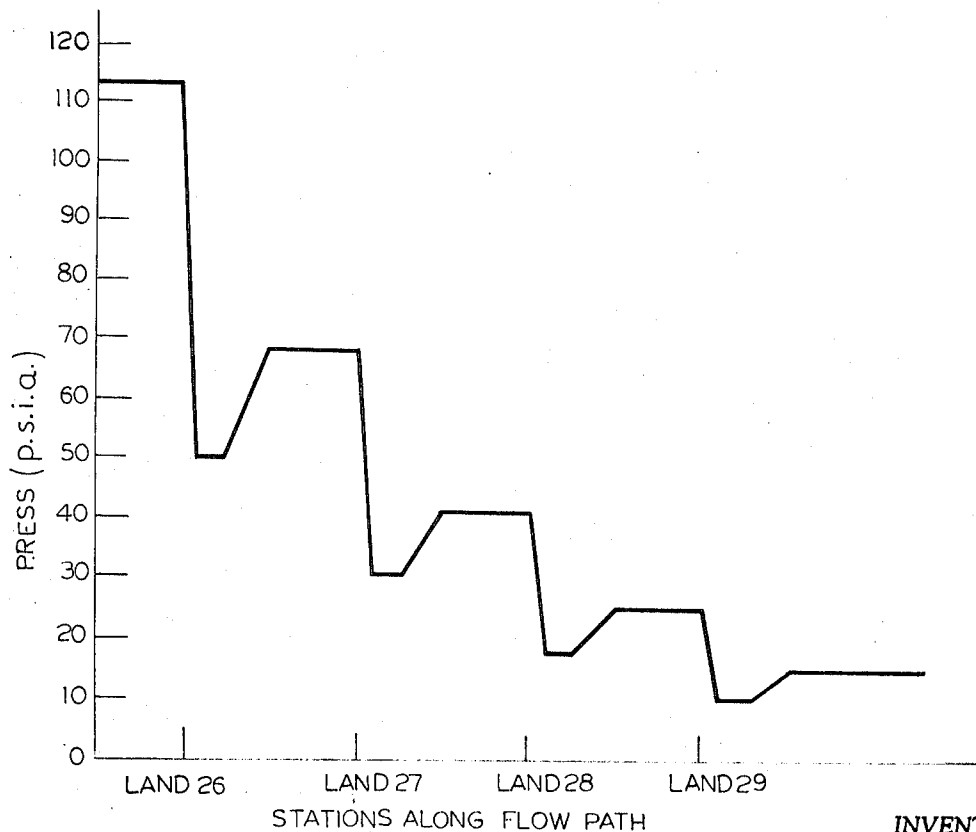


FIG. 2

INVENTOR
FRANCIS H. CARY

BY *Dodge & Ostermann*

ATTORNEYS

BACKPRESSURE DEVICE

BACKGROUND AND SUMMARY OF THE INVENTION

Many industrial and water treatment processes employ pulsed diaphragm or reciprocating plunger metering pumps for feeding liquids and slurries at accurate, controlled rates of flow. The pumping elements of these devices are driven harmonically at relatively high stroking rates, so substantial momentum heads are developed by the liquid streams drawn into and expelled from the pumping chamber on the suction and discharge strokes, respectively. If the system being fed imposes only a low back pressure on the pump, the energy imparted to the liquid column during the acceleration phase of a suction or discharge stroke will not be dissipated quickly enough to cause the column to decelerate at the same rate as the pumping element during the final phase of the stroke. As a result, the stream will continue to move after the stroke is completed, and an uncontrolled, excess quantity of liquid will be delivered to the system. In some cases, the overfeed can be as great as the displacement of the pump itself.

In order to eliminate the overfeed problem, the discharge lines of metering pumps used in low pressure systems are provided with spring-loaded throttling valves. The back pressure produced by the valve supplements the friction pressure losses of the discharge piping and is sized to insure that the liquid columns set in motion during the suction and discharge strokes will come to rest at the completion of each stroke. These throttling valves, however, frequently have very short service lives. As those skilled in the art know, a flowing aqueous solution at ambient temperature will begin to cavitate when the ratio of the absolute pressure at the downstream side of a restriction to the absolute pressure at the upstream side is 0.715, and will be subjected to a fully developed cavitation condition when that ratio decreases to 0.333. Thus, if the system being supplied is at atmospheric pressure (i.e., 14.7 p.s.i.a.), cavitation will commence when the pressure upstream of the throttling valve reaches 20.6 p.s.i.a. and will be fully developed when that pressure reaches 44 p.s.i.a. Since the back pressure needed to prevent overfeeding is on the order of 50 to 150 p.s.i.a., it is evident that the throttling valve can be subjected to severe cavitation and will deteriorate rather quickly. In cases where the medium being pumped is a slurry, wear occurs even more rapidly because of the abrasive action of the particles in the slurry. In some situations, the throttling valve has a service life of only a few hours.

The object of this invention is to provide an economical back pressure device which is capable of dissipating the required amounts of kinetic fluid energy without producing damaging levels of cavitation, and which may be used in slurry-metering systems. According to the invention, the required back pressure is developed in steps by a series of flow restrictors. The restrictors are annular orifices defined by peripheral lands on a rigid mandrel which are spaced axially from each other by intervening grooves, and an encircling, stretched elastomeric sleeve. The elastic preload in the sleeve at each land determines the static pressure in the upstream groove required to lift the sleeve from the land and allow flow to the next restrictor in the series, and these loadings are so sized that each annular orifice creates the largest pressure differential which cavitation considerations permit. As a result, the required back pressure is produced with the minimum number of restrictors and without risk of incurring cavitation damage. Moreover, since the grooves between lands are self-scouring, and abrasion has only a minimal adverse effect upon the mandrel and the sleeve, the new back pressure device may be used in systems which handle slurries.

BRIEF DESCRIPTION OF THE DRAWINGS

The preferred embodiment of the invention is described herein with reference to the accompanying drawing in which:

FIG. 1 is an axial sectional view of the improved back pressure device.

FIG. 2 is a graph showing the manner in which static pressure changes as fluid flows through the FIG. 1 device.

DESCRIPTION OF PREFERRED EMBODIMENT

As shown in FIG. 1, the improved back pressure producer 10 comprises a rigid mandrel 11 of circular cross section, and an encircling, stretched elastomeric sleeve 12 which is held tightly against the serrated end sections 13 and 14 of the mandrel by a pair of hose clamps 15. Mandrel 11 may be molded from (polyvinylchloride plastic) or made from a corrosion-resistant metal, whereas sleeve 12 may be made from (neoprene, HYPALON chlorosulfonated polyethylene or VITON fluorocarbon rubber.) Mandrel 11 is provided with axial extensions 16 and 17 which contain inlet and discharge passages 18 and 19, respectively, and which can be formed to connect unit 10 with the system piping through welded, bolted flange or screw-threaded joints.

The periphery of mandrel 11 is formed with a plurality of axially spaced annular grooves 21-25 which define a series of lands 26-29 which engage sleeve 12. The end grooves 21 and 25 are connected with passages 18 and 19, respectively, by transverse passages 31 and 32, so it will be understood that the fluid being handled passes serially through the grooves. The lands 26-29 cooperate with sleeve 12 to define a plurality of annular orifices, and therefore their upstream edges (see edge 26a of land 26) preferably are sharp. The downstream edges (e.g., the edge 26b and land 26), on the other hand, are rounded in order to facilitate insertion of the mandrel into the sleeve. Since the purpose of unit 10 is to dissipate energy, the grooves 22-25 at the downstream sides of the four lands should have an axial length sufficient to insure formation therein of substantial eddy currents, and a radial width which allows for expansion of the fluid jet issuing from the upstream orifice. In other words, the annular orifices should afford, as closely as practicable, the poor head recovery performance of a conventional thin plate orifice.

The pressure drop across each of the lands 26-29 depends upon the preload in sleeve 12 at the land, and this, in turn, depends upon the difference between the diameter of the land and the relaxed internal diameter of sleeve 12 at that location. The preload decreases from land-to-land in the direction of flow so that the ratios of the absolute pressures at opposite sides of the lands 26-29 are substantially equal. This gradation of preload is effected in the illustrated embodiment by using land of different diameters and sleeve 12 which, in the relaxed state, has a cylindrical inner periphery. However, the same effect can be achieved by using lands of uniform diameter, and a sleeve 12 whose relaxed inside diameter increases from the upstream to the downstream end. The illustrated scheme is preferred because it requires less stringent manufacturing controls.

The number of lands used in a particular back pressure device is determined from the equation

$$\Sigma \Delta P = P_d / K^n$$

where:

$\Sigma \Delta P$ is the differential between the pressures in passages 18 and 19 which the device

is intended to produce

P_d is the discharge pressure in passage 19, in p.s.i.a.

n is the number of lands

K is the ratio of the absolute downstream to the absolute upstream pressure at each land

The value of K is selected to avoid damaging cavitation, and experience shows that a value above 0.55 is satisfactory for aqueous solutions at temperatures between 30° and 100° F. The illustrated embodiment is intended for service in a system wherein the discharge pressure in passage 19 is 14.7 p.s.i.a., and which requires a back pressure in passage 18 of 113 p.s.i.a. Therefore, using a K value of 0.6, the foregoing equation shows that the unit 10 requires the four lands 26-29. With this arrangement, the static pressure of the flowing stream should decrease in steps in the manner shown in FIG. 2 and tabulated below.

	Upstream pressure p.s.i.a.	Down- stream pressure p.s.i.a.	Pressure drop. p.s.i.
Station along flow path:			
Land 26	113.3	68.0	45.3
Land 27	68.0	40.8	27.2
Land 28	40.8	24.5	16.3
Land 29	24.5	14.7	9.8
Total, EAP=			98.6

The grade line of FIG. 2 shows that the final pressure in each of the grooves 22-25 is higher than the minimum pressure therein because of the normal static pressure recovery which characterizes flow through any orifice.

After the number of lands and the schedule of pressures for the grooves of a particular device 10 have been determined, the lands and sleeve 12 must be dimensioned to provide the preloads necessary to produce the desired stepwise reduction in pressure. This, however, cannot be done by calculation because the spring rate of the elastomeric material used in the sleeve usually is not known with certainty and, in any event, is nonlinear. Therefore, the specific dimensions of the parts are ascertained by an empirical procedure wherein a sample sleeve made of the same elastomeric material and having the same wall thickness as the sleeve 12 to be used in unit 10 is fitted over sample lands of different diameters and tested to determine, for each configuration, the upstream pressure at which the sleeve will lift from the land and permit flow through the annular orifice. The test results provide a curve of cracking or opening pressure versus land diameter for this specific sleeve, and from this data the diameters of the lands 26-29 needed to produce the pressure steps shown in FIG. 2 can be selected.

In some installations, the discharge pressure in passage 19 is a variable and may reach levels which will cause sleeve 12 to rupture. In these cases, unit 10 is equipped with a rigid tube 33 which serves to limit the outward deflection of elastomeric sleeve 12. Tube 33 fits loosely around sleeve 12, so that the latter can lift or deflect sufficiently to permit flow across lands 26-29, and is retained in place by the ears (not shown) of the hose clamps 15.

It is of interest to note that, unlike the conventional throttling valve, back pressure device 10 is not a check valve and will allow flow in the reverse direction if passage 19 is subjected to a pressure sufficient to overcome the back pressure which the unit is designed to produce. While reverse flow is not contemplated, and would, in fact, result in cavitation damage, nevertheless this feature is desirable in applications where the system being supplied sometimes operates at a pres-

sure level high enough to prevent overfeeding. At those times, system pressure will maintain the annular orifices of unit 10 open, and consequently the unit itself will produce only a relatively small differential between the pressures in passages 18 and 19. As a result, energy is conserved.

I claim:

1. Apparatus for producing a back pressure in a fluid stream comprising

- a. a rigid mandrel (11) formed with a series of axially spaced, annular grooves (21-25) which define a plurality of peripheral lands (26-29);
 - b. an inlet passage (18) for leading fluid into the first groove (21) of the series, and a discharge passage (19) for leading fluid from the last groove (25) of the series; and
 - c. an elastomeric sleeve (12) encircling mandrel (11) and having a stretched portion which overlies the grooves and is held by its internal stresses against the lands,
 - d. the stretched portion being free to lift away from the lands under the action of the pressures in the grooves so that fluid can flow serially through the grooves, and
 - e. the lands and sleeve being so dimensioned that the preload in the sleeve decreases from a maximum at the land (26) adjacent said first groove (21) to a minimum at the land (29) adjacent said last groove (25),
 - f. whereby as fluid flows from groove-to-groove its static pressure decreases in progressively smaller steps.
2. Apparatus as defined in claim 1 in which the preloads in the sleeve (12) at the lands (26-29) are sized to afford a constant ratio of the absolute pressure downstream of each land to the absolute pressure upstream of the land.
3. Apparatus as defined in claim 2 in which said ratio is greater than 0.55.
4. Apparatus as defined in claim 1 in which
- a. the diameters of the lands (26-29) decrease in the direction of flow; and
 - b. the inner peripheral surface of the stretched portion of the sleeve (12) is cylindrical when the sleeve is in the relaxed state.
5. Apparatus as defined in claim 4 in which
- a. the sleeve has portions at opposite ends of said stretched portion which are held in sealing engagement with seating portions (13, 14) on the mandrel (11) by clamps (15); and
 - b. the inlet and discharge passages (18, 19) extend into the mandrel (11) from its opposite ends.
6. Apparatus as defined in claim 1 which includes overpressure protection means (33) for limiting said lift of the stretched portion of the sleeve (12).

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