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Baumann

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[54] **ADJUSTABLE FLUID RESTRICTOR METHOD AND APPARATUS**

[76] Inventor: **Hans D. Baumann,** 29 Villa Drive, Foxboro, Mass. 02035

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[51] **Int. Cl.**.....**F16k 47/00**

[58] **Field of Search**.....251/120, 121, 122, 127

[56] **References Cited**

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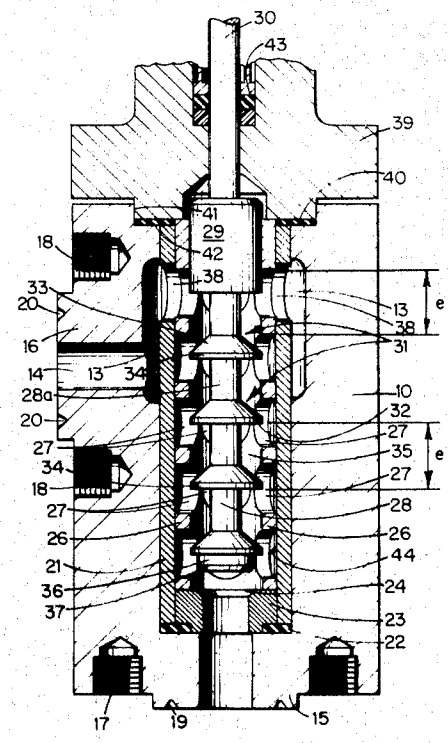
Primary Examiner—Henry T. Klinksiek

Attorney—Chittick, Pfund, Birch, Samuels & Gauthier

[57] **ABSTRACT**

The present invention constitutes an adjustable fluid restrictor providing throttling means to reduce pressure of liquid or gaseous media through a process of adiabatic flow with friction in contrast to conventional orifice type throttling devices which utilize rapid acceleration and deceleration as primary means of energy conversion. Said adjustable fluid restrictor containing labyrinth-type restrictions which are adjusted by conventional actuating means and provide constant enthalpy pressure reduction at substantially constant velocity regardless of variations in flow area.

15 Claims, 3 Drawing Figures



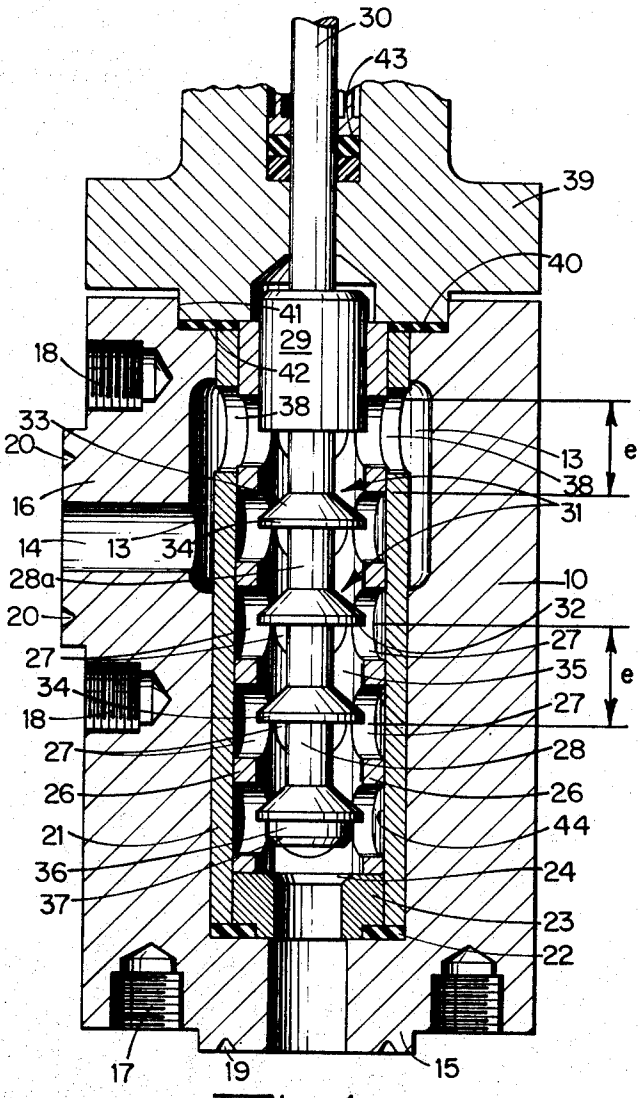


Fig. 1.

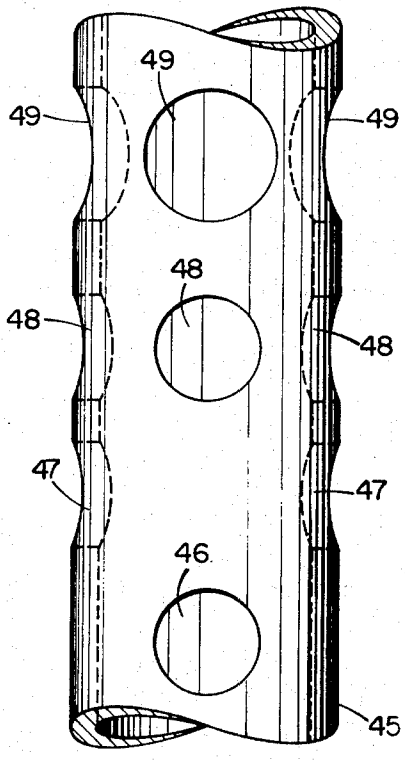


Fig. 3.

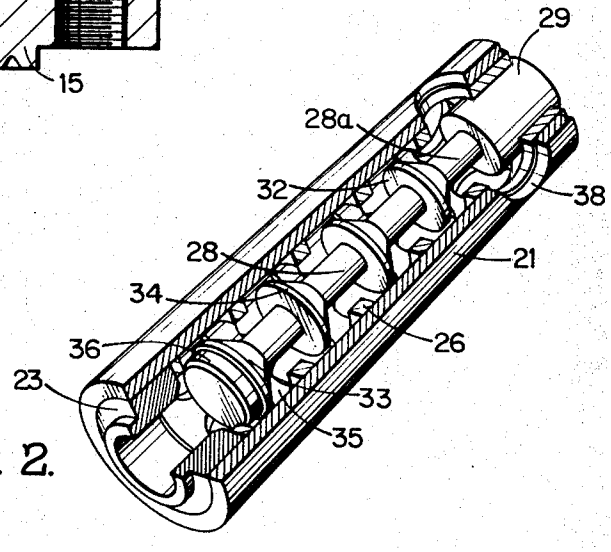


Fig. 2.

ADJUSTABLE FLUID RESTRICTOR METHOD AND APPARATUS

Background of the Invention

Energy transported in fluid form has to be transformed quite frequently into a lower form of state (increased entropy) to suit process requirements. Such energy conversion is most common in the form of fluid pressure reduction. In a so-called "throttling process" potential energy of the fluid is transformed into kinetic energy (high velocity), then by a process of rapid deceleration (turbulence) into heat through friction. However, not all of the kinetic energy is converted into heat. A certain amount of it produces sound power, more commonly known as throttling noise. The amount of sound power produced in a fluid system is generally a function of the fluid velocity. It has been determined, for instance, that the sound level of a free jet increases to the eighth power of the velocity below Mach 1 (sonic velocity) and to the 6.5th power above Mach 1. In practice this means that the sound power produced by a single throttling orifice will increase 256 times, if the throttling velocity across it is doubled. Now, since the velocity in an orifice is a function of $\sqrt{2gh}$ where h is the created pressure drop, one can state that a four-time increase in pressure drop could produce 256 times more noise. This simple arithmetic explains why high pressure reduction necessary in today's power plants can create intolerable noise levels in residential neighborhoods. Such noise can not only be annoying but also a vital factor in the successful operation of submarines. Noise produced through pressure reduction in the ship's power plant can lead to sonar detection with diastrous consequences. In addition, sound vibrations can cause structural damage to adjacent piping and pressure vessels.

From the foregoing it is obvious that a significant reduction in velocity is necessary to achieve a tolerable low noise level. With conventional plug and orifice valves such velocity reduction is only possible by employing a lower pressure drop, thereby seriously limiting the usefulness of such a device.

Besides the obvious high throttling noise level, there is the added effect of wear. Conventional throttling orifice valves, for instance, show substantial effects of erosion at or near the plug and orifice, when subjected to high pressure drop. Again, the higher the pressure drop the more pronounced the wear and the shorter the lifetime of the valve.

Field of the Invention

This invention relates to adjustable fluid restrictor devices such as shown and described in my prior U.S. Pat. No. 3,485,474, and providing a throttling series affording successive friction losses primarily through tortuous turns of a fluid under pressure, so as to limit the speed of throttling of that fluid to a value assuring a low and, in any case, acceptable level of the throttling noise; and also preventing quick wear, by the effects of cavitation, of the throttling elements of the device.

In general, a fluid restrictor, or throttling device such as here concerned, has comprised:

A housing internally provided with concentric rings axially spaced from one another;

A moving stem, mounted coaxially in regard of said rings and presenting radially projecting circular discs, arranged or spaced intermediate or in alternation with the rings, and so as to cooperate therewith; and

Some means of axial adjustment of the stem whereby to regulate the spacing between the rings and the discs.

The rings and discs of such throttling device provide radially spaced, axially directed passages for fluid flow, and radial flow passages connecting said axially directed passages in an annular labyrinth presenting adjustable restrictions by which is accomplished, through successive throttlings, expansion of fluid under pressure.

Such fluid restrictor additionally affords successive throttlings independently of the flow variations of the fluid under pressure, and requires only relatively small movements of the stem discs in relation to the cage rings, to accomplish the needed adjustment of the restrictions of the labyrinth.

BRIEF SUMMARY OF INVENTION

In accordance with the present invention, there are provided for the throttling means a moving stem mounting discs, and in combination therewith a cage formed opposite each of said discs with at least one radially extending, internally open faced port.

Each said port is preferably formed as a blind hole about a radial axis; and the one or more ports of the group cooperating with one of the stem discs are arranged in the same transverse plane. Also, the corresponding ports of the several groups are vertically aligned, or correspondingly oriented about the longitudinal axis of the device.

It will be understood that each such disc, and the ports of the group cooperating with the disc, provide, for a fluid under pressure, flow passages corresponding to the annular grooves defined by two adjacent rings of my prior apparatus.

The invention embraces apparatus adapted for the pressure reduction either of a liquid or of a gaseous fluid. In a form adapted particularly to liquid reduction, the annular discs are all of the same, identical proportion or diameter, and the cage is embodied as an annular sleeve or cylinder whose internal diameter is so correlated with the external diameter of the discs as to afford a freely sliding relation between the relatively moving cage and stem parts.

Where the invention apparatus is used for gaseous media, the number of ports may be varied between successive stages, to compensate for changes in density of the fluid accompanying pressure reduction. Furthermore, the diameter of the ports and/or the spacing between the discs may be increased to accomplish the same purpose.

The present invention provides also a method of forming an annular, cage and stem flow restrictor, or throttling device, that enables simple, fast assembly and disassembly of the device.

BRIEF DESCRIPTION OF THE DRAWINGS

In the annexed drawings:

FIG. 1 is a vertical section of a preferred embodiment of the invention throttling device;

FIG. 2 is a perspective view of the same, cut away to show the internal parts; and

FIG. 3 is a fragmentary vertical section of the inner cage tube of another embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The adjustable fluid restrictor hereof if seen to comprise a herein vertical valve block or body **10** formed from its one or upper end with an annular recess **11** receiving the invention cage means, and provided at the other or bottom end with a reduced opening or inlet port **12** admitting to said recess **11**. Proximate the upper end of the block **10** the recess **11** is enlarged by an annular chamber **13**. Communicating therewith is a lateral passage or outlet port **14** opening through a side wall of the body **10**.

The inlet and outlet ports **12, 14** are provided as conventionally with flanges **15, 16**, threaded holes **17, 18** and locator pin recesses **19, 20**, for connecting the valve body as conventionally in and between mating flanges of a pressure fluid flow line.

The invention cage means comprises an outer sleeve or tube **21** interfitting body recess **11** and inserted therein against gasket **22** sealing the internal shoulder defined by reduced inlet **12**. Also received over the gasket **22** is an annular valve seat **23** having a tapered face **24**, and an annular flange **25** projecting within said gasket **22** to engage said internal shoulder, as shown.

Press fitted within said tube **21**, and engaging also said seat **23**, is an inner cage means sleeve or tube **26**. Said tube **26** is radially apertured by circular ports **27** which are seen as closed over by the outer tube **21** to form blind openings.

There are provided a series of plurality of sets or groups of such ports **27**, each such group comprising one or more herein four of the ports, uniformly distributed about the circumference of the tube **26**, and located on the same transverse axes, whereby the corresponding ports of the said several groups thereof are vertically or longitudinally aligned, as shown, FIG. **1**.

The valve stem hereof comprises a shaft or post **28** comprising a sleeve **29** having a sliding, centering fit within inner tube **26**, and threaded over or otherwise interfitting usual valve stem **30**, as adapted for reciprocation or adjusted positioning in the longitudinal direction or axis of the device by external actuator means.

Further to the invention, the post **28** mounts a series of annular discs **31** defined by flat transverse under faces **32**, conical or tapered upper faces **33**, and relatively short, straight or vertical sided annular peripheral portions **34** intermediate said transverse and tapered, lower and upper portions **32, 33**.

The disc peripheries **34** are proportioned for a smooth sliding fit with the inner face **35** of inner tube **26**, whereby the discs **31** in their movement relative thereto will wipe cleanly across the ports **27**.

Intermediate the discs **31** the post **28** is seen as defining axial portions or surfaces **28***a* reduced or spaced from the opposing surfaces of inner tube inner wall **35**.

In accordance with the invention, the discs **31**, which may be integral with the post **28**, are identically spaced one from the other, and are spaced in their corresponding parts the same distance apart as are corresponding parts of the ports **27**, as shown by the arrows *e* and *e* having the same length.

At its lower or inlet facing end the post **28** mounts a reduced plug **36** having a tapered face **37** interfitting seat face **24**, and defining thereby the inlet closing, lower limit of travel of the stem **30**, the stem-carried post **28**, and the post-mounted discs **31**.

With the plug in the open or FIG. **1** position, the pressure fluid flow is seen to proceed from the inlet **12** through the valve seat **23** to the chamber defined within inner tube inner wall **35**, and thence to continue past the ports **27** and discs **31** to the ports **27** above the uppermost disc **31**, and with which communicate outer tube openings **38**, whereby the fluid passes to chamber **13** and therefrom through outlet **14**.

A bonnet **39** is received over the valve body **10** and presses a gasket **40** in valve body recess **41** wherein the gasket **40** overlies outer sleeve **21** and annular body portion **42**, and the bonnet **39** overlies also inner tube **26**. Bonnet **39** is recessed in turn to receive the usual packing **43** sealing stem **30**.

It will be understood that the proportioning and spacing of the valve ports and discs is such that when the seat **23** is closed by the plug **36**, each disc **31** is positioned opposite and so as to seal the lowermost portion or inlet side of the port or ports **27** cooperating therewith. In moving the post **28** from that closed position to the full open position of FIG. **1**, there are opened the series or succession of annular throttling stages, or reversing flow passages, defined by the axial surfaces of post **28**, the transverse, axial, and tapered portions of the discs **31**, the radially extending surfaces of the ports **27**, and the port closing, blind hole completing inner surface **44** of outer tube **21**.

In the operating position of the fluid restrictor, or throttling device, the pressure fluid flow, between the axial passages defined between the axial post surfaces **28***a* and inner tube wall **25**, is reversely through the radial passages defined by and between the transverse, axial and conical surfaces **32, 34, 33** of the discs **31**, and the thereto juxtaposed radial and axial surfaces of the disc overlapping ports or cage means recessing **27**, said ports surfaces comprising more particularly the radial bores **27** in inner tube **26**, and the bore closing portions of axial inner wall **44** of outer tube **21**.

It will be appreciated also that when the plug **36** is lowered to approach seat **23** the discs **31** are exposing small portions of the circular openings or bore passages **27**. In this way, by a small movement of stem **28** from the closed position, the discs **31** are made to uncover or expose small areas or segments of the circular ports **27**, defining very small or restrictive areas for the passage of fluid. This insures, of course, a very good expansion of small flows of fluids.

From the foregoing it will be apparaent that the described annular flow passages define a series or succession of throttling stages wherein is accomplished successive drops of the pressure of the fluid, or liquid, in accordance with the positioning of the stem **38** and post **28**, and wherein is avoided excessive throttling noise, and accelerated wear by cavitation of the flow restricting elements. It will be understood also that the number of throttling stages needed to be employed may be readily calculated from the pressure drop which the device is designed to achieve.

Among the invention advantages are that the discs **31** can be formed by conventional methods of turning.

Also that the ports **27** need merely be drilled in the inner tube **26**. Additionally that the closing over the ports **27** as blind holes can readily be accomplished by force fitting of the sleeves **21**, **26** in conventional manner, as by heating outer cage or tube **21**, or cooling the inner cage tube **26**. Finally, that through the cylindrical sliding configuration and interrelation of the discs **31** and inner cage wall **35**, the assembly and disassembly therewithin of the post **28** may be readily accomplished.

In embodiments adapted particularly to the reduction of gaseous media, as having exemplary illustration in FIG. **3**, the inner tube **45** may be provided in one stage with a single port **46**, in the next stage with a pair of ports **47**, and in the next succeeding stage with three ports **48**.

In the following stage the tube **45** is shown as provided with the same number, that is, three, of the ports **49**, but the said following ports **49** are seen as of a larger diameter than the ports **48** of the preceding stage. The ports **49** are also shown as located at a greater spacing from the ports **48** than said ports **48** have from the ports **47**, and the ports **47** in turn from the port **46**.

It will be seen, then, that, to compensate for changes in density of the fluid, the invention embodiments adapted particularly for gaseous media may have variation between successive stages as to the number of the ports, as to the diameter of the ports, or as to the spacing between the ports (discs); or the variation may be as to any combination of these.

I claim:

1. An adjustable fluid restrictor, comprising

a. means providing a tubular cage;

b. a cylindrical chamber defined within said cage;

c. means defining an inlet end opening to said cylindrical chamber;

d. means defining an outlet side opening to said cylindrical chamber;

e. a cylindrical reciprocating stem extending within and coaxially with said cage means chamber, said stem comprising

e_1. a stem-centering cylindrical guide closing the opposite-to-inlet end of said cylindrical chamber,

e_2. a stem-terminating valve plug closing and opening said inlet opening upon the flow controlling axial adjustment of said stem, and

e_3. a series of annular discs spaced intermediate said guide and plug, said discs radially projecting within said cylindrical chamber to a sliding, sealing interfitting with said cage means;

said stem reduced from the wall of said cylindrical chamber intermediate said discs and defining thereat a series of axial passages sealed by said discs and wall in the inlet closing position of said stem and plug; and

f. a series of ports recessing the inner wall of said tubular cage means, at least one of said ports overlapping the periphery of each of said discs to define in the inlet-opening position of said stem and plug a series of throttling stages in which pressure fluid admitted through said inlet end opening is, between one and the next of said axial passages, reversely flowed in radial passages defined between the opposing faces of said discs and ports.

2. The apparatus of claim **1** wherein said ports comprise for each said disc a balanced plurality of uniformly distributed, radially oriented flow passages cut part way through said cage means.

3. The apparatus of claim **2**, wherein said cage means comprise concentric, sealingly interfitted cylinders, and wherein said passages aperture the inner of said cylinders.

4. The apparatus of claim **2** wherein said flow passages comprise a set of uniformly circumferentially distributed passages juxtaposed to each said disc, and wherein the passages of each said set have the same number and proportion and the same orientation circumferentially of said cage means chamber as have the passages of every other of said sets.

5. The apparatus of claim **1**, wherein said outlet side opening defining means comprise passage means in the outer of said cylinders communicating with the port passages at the outlet end of said inner cylinder.

6. The apparatus of claim **5**, and a valve body sealing enclosing said tubular cage means, said body having a chamber surrounding said cage means in communication with said outer cylinder passage means.

7. The apparatus of claim **1**, wherein said inlet end opening defines a valve seat adapted for sealing engagement by said plug.

8. The apparatus of claim **1**, wherein said cage means comprises an inner tube and an outer tube sealingly press fitted over said inner tube, and wherein said ports comprise wall apertures in said inner tube sealingly closed over and made into blind holes by said outer tube.

9. The apparatus of claim **1**, wherein said discs are defined at their inlet side by flat transverse faces, at their outlet side by conical faces, and intermediate said faces by cylindrical lengths having axial peripheries proportioned for snug sliding interfitting with said chamber wall and having thereby the capacity to wipe cleanly said ports recessing said wall.

10. The apparatus of claim **1**, and a valve body sealingly enclosing said tubular cage means.

11. The apparatus of claim **1**, wherein said ports are progressively larger in successive ones of said series of throttling stages, whereby to compensate for the fluid density changes accompanying the successive fluid pressure reductions in said throttling stages.

12. The apparatus of claim **1**, wherein said ports are progressively greater in number in successive ones of said series of throttling stages, whereby to compensate for the fluid density changes accompanying the successive fluid pressure reductions in said throttling stages.

13. The apparatus of claim **1**, wherein successive ones of said series of throttling stages are spaced progressively further apart, whereby to compensate for the fluid density changes accompanying the successive fluid pressure reductions in said throttling stages.

14. Cage and stem means for adjustable fluid restrictor comprising

a. a cylindrical stem, said stem having spaced annular reductions defining therebetween

b. a series of annular radially projecting discs;

c. an inner sleeve received over and sealingly interfitting said stem;

d. a series of ports aperturing said inner sleeve, at least one said port opposite each said disc; and

e. a concentric outer sleeve press fitted over said inner sleeve and having a solid wall closing over said ports.

15. The method of making adjustable fluid restrictor cage and stem means having a plurality of throttling stations which comprises the steps of

1. drilling a longitudinal series of radial holes in an inner sleeve;
2. press fitting an outer sleeve over said inner sleeve to close said openings and define the same as ports forming recessing of the inner surface of said cage means; and
3. assembling said stem with said sleeves to provide for controlled covering and uncovering of said ports by the relative axial adjustment of said cage and stem means.

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