United States Patent

Baumann

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[54] **APPARATUS FOR REDUCING FLOWING FLUID PRESSURE WITH LOW NOISE GENERATION**

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[52] **U.S. Cl.** **138/42,** 181/46, 251/127, 181/56

[51] **Int. Cl.** **F15d 1/00**

[58] **Field of Search** 138/42; 181/46, 69, 33.9, 36.2, 181/56; 251/127; 285/49

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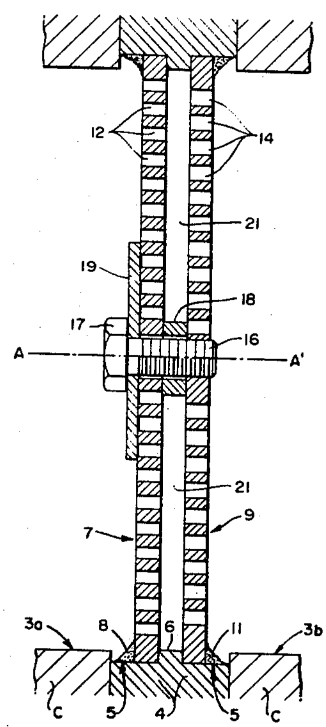
[57] **ABSTRACT**

Fluid pressure reducing apparatus presenting low noise throttling plates. The low noise fluid pressure throttling apparatus provides an assembly of a plurality of such plates, and which may comprise a segment of or be interposed in a fluid flow containing conduit. The low noise throttling plates are passaged by multiple small section orifices producing a high frequency pressure wave whose noise is more readily attenuated by the conduit. The spacing of the plates in the pressure reducing assembly defines with the intervening flow containing means a volume which is dimensioned to produce resonant damping of the noise pressure wave generated in the primary orifices. The pressure drop through the reducing apparatus is divided into nearly equal ratio drops across each plate, further minimizing noise generation.

12 Claims, 3 Drawing Figures



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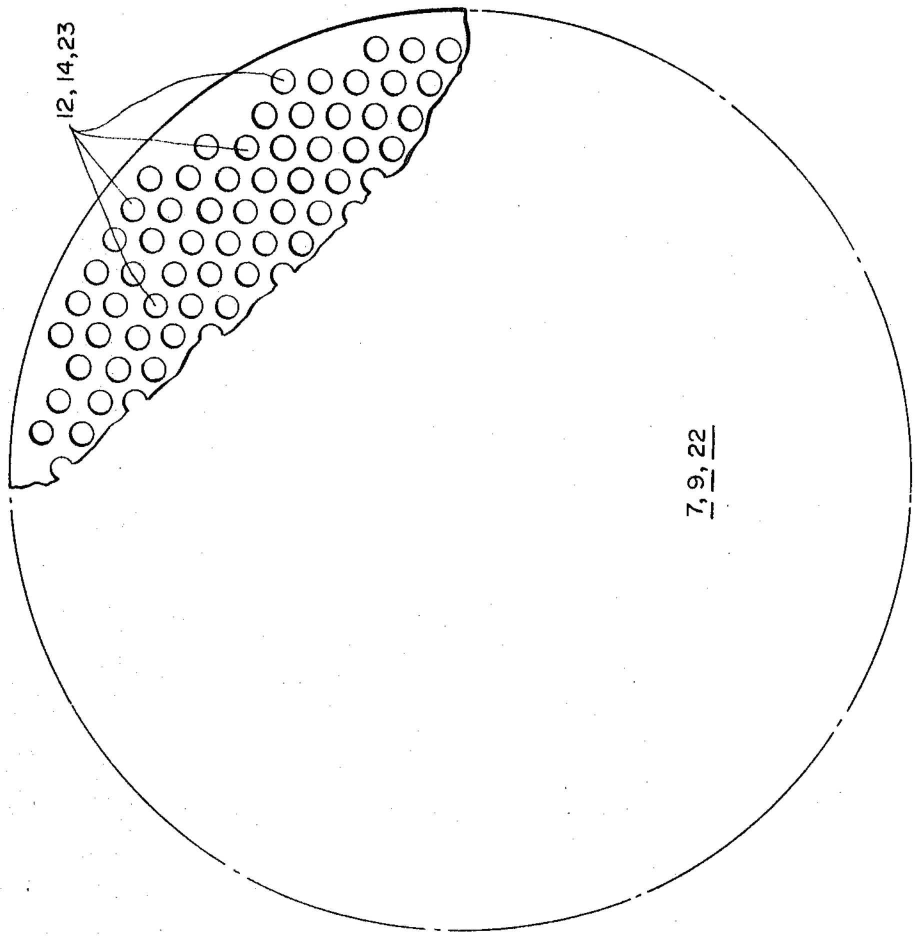

FIG. 1

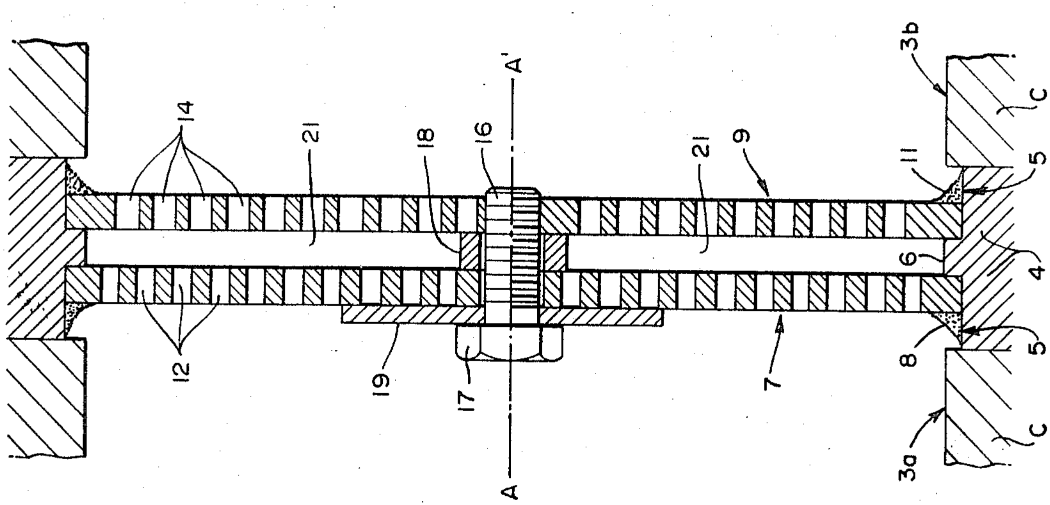

FIG. 2

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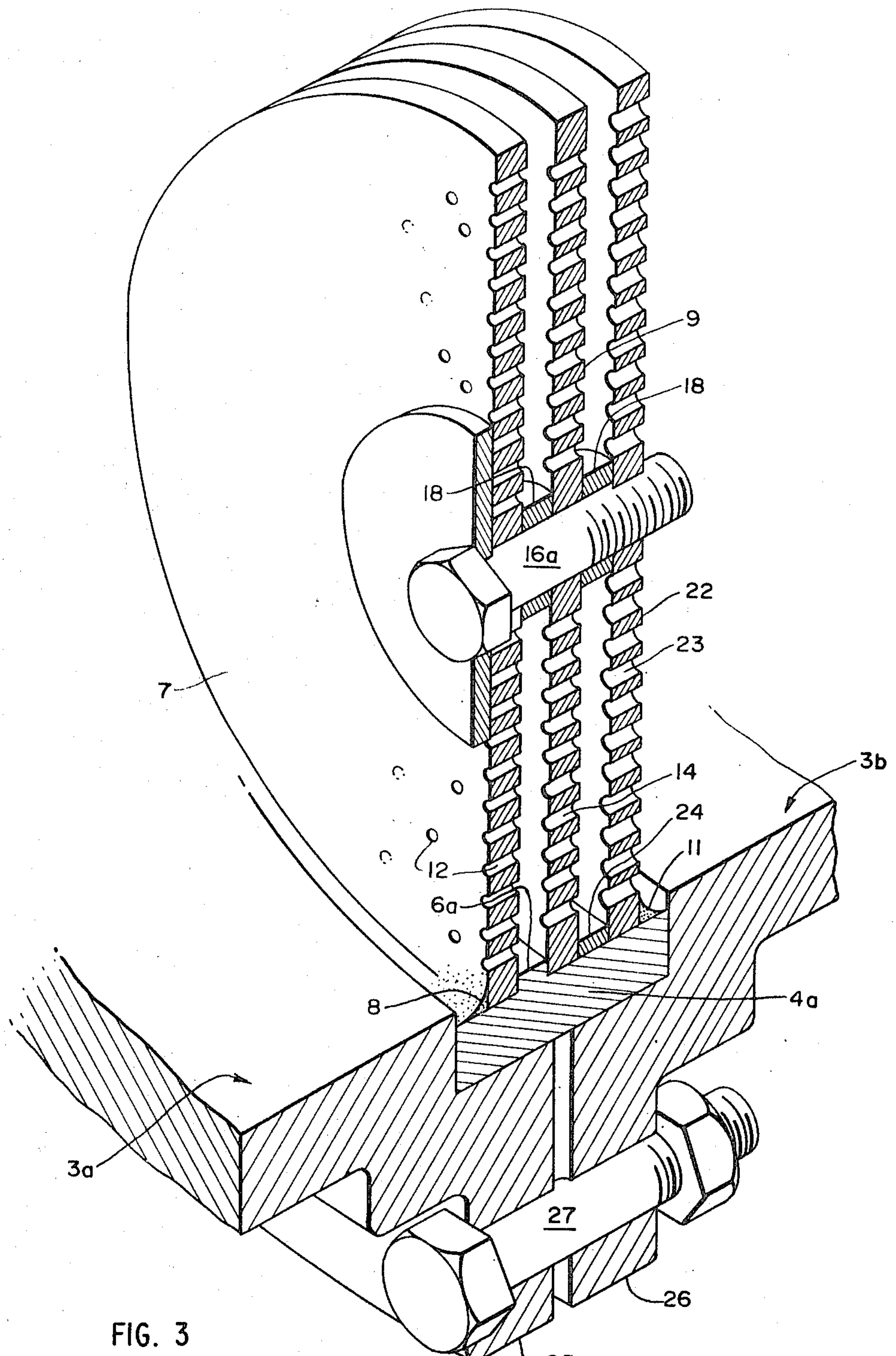

FIG. 3

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APPARATUS FOR REDUCING FLOWING FLUID PRESSURE WITH LOW NOISE GENERATION

BACKGROUND OF THE INVENTION

The invention pertains to apparatus for reducing the pressure of gaseous or liquid media flowing through a pipe or duct, and more particularly for accomplishing the fluid pressure reduction with minimum or greatly reduced generation of noise, or unwanted sound. The problems attendant upon the annular of noise are well known to include not only the human reaction criteria of annoyance, damage to hearing, and reduction in work efficiency, but also the effects on physical structures and equipment, such as structural fatigue, and equipment malfunction.

In industrial plants, gas pressure reducing stations, and the like where are found the throttling valve or aerodynamically generated sound effects with which the invention is particularly concerned, the noise problems attendant thereon are rapidly intensifying in absolute terms, and have attained more recently a magnitude heightened also be increased human sensibility to noise pollution. But noise control efforts have heretofore been limited generally in this country to the use of mufflers, attenuation chambers and the like, or devices for absorption or insulation of the generated noise. This invention, in contrast, cuts throttling noise at the source, and thereby achieves superior results both in reducing throttling noise and in reducing mechanical vibration from levels experienced with conventional pressure reducing valves.

BRIEF SUMMARY OF THE INVENTION

In view of its novel aspects, the theoretical considerations on which the invention is rested are here set forth in aid of its full and clear understanding by those skilled in the art.

Fluid dynamic theory predicates a high dependence of the herein concerned throttling noise energy on the pressure drop ratio and fluid flow velocity. High pressure differentials across a jet or constriction in the fluid flow generate noise energy which increases at a rate greater than the rate of increase in the pressure drop in ratio. The noise or vibration energy generated also varies with the eighth power of the fluid velocity in the jet. Both a high velocity, and a pressure drop ratio, then, lead to high accoustical efficiency, or high energy conversion to noise.

By far the most efficient way to reduce throttling noise is, of course, to decrease the velocity of the flow. In accomplishing this by increasing the effective flow area only some of the resultant noise reduction is offset by the noise being a function also of flow area.

Any solid or fluid medium vibrating in response to noise energy waves will convert a portion of the energy it receives to heat. With fluids it is the fluid viscosity which occasions the conversion, or damping. A similar noise energy damping reaction occurs as well in solids.

Further, the amount of energy passed on through such media varies with the negative power of the distance that the energy travels within the medium. And in solids like the metals found in pipes, the attenuation in the medium increases with the frequency of the noise energy.

It is thus an object of the present invention to provide apparatus for pressure reduction or throttling of fluid flow with a low accoustical efficiency.

It is a further object of the invention to provide an accoustical filter for absorbing downstream the noise of conventional valves and thereby preventing the radiation of that noise through the fluid conduit walls to its external surroundings.

It is a further object of the invention to provide a device for throttling fluid flow with greatly reduced noise generation by minimum fluid velocity constricting jet means.

It is a further object of this invention to provide a pressure reducing or throttling device having constricting jet means characterized by lowered pressure drop thereacross.

It is a further object of the present invention to provide a pressure reducing apparatus which increases the viscous damping of the noise energy in the flowing fluid.

It is a further object of the present invention to provide a fluid pressure throttling device which generates noise at a frequency which provides for greater attenuation of the noise energy by the fluid conduit.

It is a further object of the invention to absorb part of the aerydynamically created noise by a process of resonant damping within said throttling device.

BRIEF DESCRIPTION OF DRAWINGS

In the drawings:

FIG. 1 is a plan view of the invention apparatus; and

FIG. 2 is a section along any bisecting line of FIG. 1; and

FIG. 3 is a perspective view of a modified form of the apparatus.

DETAILED DESCRIPTION OF THE INVENTION

In the form of FIGS. 1 and 2 of the drawings a herein circular, radially symmetrical conduit C is shown as having an inner wall defining two axially in-line parts 3*a*, 3*b* which extend to either side of a ring or annular spacer 4. The spacer 4 has a larger diameter, cylindrical inner face 5 coaxial with conduit axis A—A′, and an intermediate, annular, infacing flange or lip 6 of full circumferential extent.

A pair of transverse wall forming means or plates 7, 9 having a tight fit within spacer 4 are held by suitable means, herein the collars 8 and 11, against the opposite faces of lip 6. The collars 8 and 11 are in turn closed against the plates 7, 9 by the ends of smaller diameter shoulders of conduit parts 3*a*, 3*b* when the same are assembled with the spacer 4 as by external clamping means which may be conventional and are, therefore, not shown.

Under the invention, the plates 7, 9 may be parallel mounted with the ring 4 in a rigid assembly or frame in any desired manner, and wherein the circumferentially containing means 4 is inserted in or is a portion of the conduit C.

Upstream plate 7 is passaged by a multiplicity of jet orifices or holes 12. The number of holes 12 is great, and their cross-sectional area is small. The holes 12 will be understood to be utilized in a number: cross-sectional area combination which for a given fluid at a given or maximum expected flow rate produces the desired low pressure drop across the plate 7, in the fluid flow traversing the same in the left-right direction A—A′.

Under the invention the holes 12 are made numerous and individually of small cross-sectional area also to increase the vibratory frequency of the noise energy accompanying the pressure drop in said flowing fluid.

Most of the noise energy generated in the upstream set of holes 12 is radiated by pressure waves from a region of noise energy turbulence downstream of plate 7, and tends to proceed out through the walls of the conduit C. In responding to these pressure waves, the conduit C absorbs a portion of the energy from the waves by damping effect of the conduit material.

This attenuation by the conduit may be expressed as:

$$A = 17 \log (mf)$$

where

m = mass density of the wall and

f = frequency of the vibration.

The frequency is, of course, a direct function of the passages or hole diameter. Under the invention, then, by reducing the diameter of the upstream holes 12, and thereby increasing the frequency of the noise energy generated therein, a larger portion of the noise energy is attenuated in the conduit walls, and a corresponding reduction is achieved in the noise radiated to or polluting the environment.

The downstream plate 9 has a set of orifices or holes 14 which are seen as offset from the holes 12. The number and cross-sectional area of these holes is again adjusted to the desired pressure drop, for a given fluid and flow rate, and is selected also and novelly to provide, as before, increased frequency of vibration of, and thereby enhanced conduit wall attenuation of, the generated noise.

By varying the size and number of the holes **14** in the downstream plate **9**, compensation is made for the change in fluid density by the reduction in pressure through the upstream plate **7**. Further, the total cross-sectional area of the holes **14** is made larger than the total cross-sectional area of the holes **12**, by the provision either of more or larger holes **14** through the second plate **9**.

In accordance with the invention, then, the pressure drop across the perforated plates **7** and **9** is split up into equal or substantially equal ratios. This results in a substantial decrease of the overall noise level, since as above noted, the level of noise energy generated in a jet increases more rapidly than the rate of increase in the pressure drop ratio across the jet. In other words, by thus keeping the pressure drop ratio across each perforated plate smaller, there is achieved a reduction of noise energy generated, over that for a single plate with a higher accoustical efficiency in noise generation due to its higher pressure drop.

For example, with a total pressure drop ratio of 4 the acoustical efficiency for a single plate is 36 times greater than the efficiency it would have with a pressure drop ratio of 2 across its set of holes. With two plates each producing a pressure drop ratio of 2 the total noise energy from the two plates in one-eighteenth what it would have been with a single plate.

Centrally, a fastening or bolt **16** having a head **17** is passed through an oversized opening in one of the plates **7**, **9** and through an intervening collar **18** and threaded into the other of the plates **7**, **9**, in part to intermediately clamp the plates **7**, **9** together with the spacer **6** in a unitary assembly, or frame.

The bolt **16** may also mount various flow restricting means such as the flow regulating plate **19**, which may be positioned between the plates **7** and **9**, or upstream of plate **7**, the same to effectively block a portion of the first and/or second of the channel sets **12**, **14** thereby reducing the flow capacity of the plates so as to maintain the same total pressure drop under different, reduced flow conditions.

The aforementioned offsetting of the downstream holes **14**, as clearly shown in FIG. **2**, will be understood to improve the pressure reducing capability of the plates **7**, **9** and at the same time to enhance the resonant effect in the cavity or volume **21** defined by or within the frame formed by the plates **7**, **9** and the spacer **4**. The longitudinal or axial length of the collar **18** and the spacer lip **6** then, is calculated to comprehend or contain the desired amount of fluid within the frame volume **21**. For a particular conduit, and given that the resonant frequency of the volume **21** varies with its size, the same can be controlled, then, by adjusting the length as aforesaid of the collar **6** and spacer **18**.

The equation relating the plates **7**, **9** may be stated as:

$$f = Ac/2\ Vk$$

where

A = total area of the holes contained in the first plate **7**;
c = the speed of sound in the fluid used;
V = the volume of the cavity **21**; and
k = a constant.

By making a resonant frequency of the volume **21** nearly equal to the frequency of noise energy generated in the holes **12** of the upstream plate **7**, large resonant pressure differentials will be built up in the volume **21** at that frequency. Through the process of resonant damping, and due to the viscosity of the fluid, the high resonant pressure differentials result in an increased conversion of noise energy to fluid heat.

It will be understood that the pressure reducing apparatus of the invention may comprise the plates **7**, **9** and also any other transverse wall forming means susceptible of channeling by jet passages such as the hole sets **12**, **14**.

Further, the desired resonant cavity may under the invention be provided by a volume **21** having shape and proportion other than that defined by the frame spacer **6** and plates **7**, **9** herein particularly disclosed and described.

Still further, the resonant cavity may be defined by and within a frame comprising a plurality other or more than the described two spaced transverse plates, or other wall forming means.

Thus, in FIG. **3** is shown a modified embodiment comprising a plurality of three transverse plates, incorporating upstream plate **7** and a pair of downstream plates **9**, **22**. In this arrangement, the downstream plate **22** will be understood to have openings **23** having the similar position and proportion relationship to the openings **14** of downstream plate **9** as the latter have to the openings **12** of upstream plate **7**. Also, the plates **7**, **9**, **22** will be understood to define resonant cavities, and to divide the frame volume, in accordance with the invention teachings as hereinbefore explained.

To accommodate the additional plate **22**, the modified ring **4*a*** may have a lip **6*a*** against which upstream plate **7** is held by collar **8**, and downstream plate **9** is engaged by insert ring **24**, against the opposite face of which the downstream plate **22** is in turn held by collar **11**. And modified bolt **16*a*** will be understood to be passed through intermediate plate **9** for threading into downstream plate **22**, with the plates being spaced thereat by a pair of the collars **18**.

Also shown in FIG. **3** is one expedient for closing the ends of conduit portions **3*a***, **3*b*** against the sides of the rings **4*a***, comprising integral flanges **25**, **26** on said conduit portions **3*a***, **3*b***, and a series of radially disposed nut and bolt or similar fastenings **27** therethrough as shown.

It will also be understood that the frame hereof may comprise the described plate pluralities and the intervening conduit wall portion as defined by the herein disclosed spacer, or by the securing of the wall forming means or plates to the conduit inner wall and in spaced assembly in any other desired or convenient manner.

Further, in accordance with the invention, the plate assembly or frame hereof may be utilized in downstream conjunction with a conventional, single orifice throttling valve. It will be appreciated that in such application the low noise plates hereof operate to filter the major noise emanating from the throttling valve, preventing the noise from travelling into the downstream pipe and hence from radiating through that to the outside environment.

I claim:

1. Low noise generating apparatus for reducing the pressure of fluid flow in a conduit, comprising:
   a. upstream transverse wall means;
   b. multiple, small, flow throttling passages of calculated total area in and establishing small fluid pressure drop across and high frequency of noise generation by said upstream wall means;
   c. one or more downstream transverse wall means;
   d. multiple, small, flow throttling passages of calculated total area in and establishing small fluid pressure drop across and high frequency of noise generation by said one or more downstream wall means,
   the number and/or size of said multiple, small, flow throttling passages relatively increasing, and said calculated total areas of said passages progressively increasing in constant ratio, from each to the next in the succession of said upstream and downstream transverse wall means,
   said multiple, small, flow throttling passages in said upstream and downstream transverse wall means provided in such determined large number and small cross section as radiates noise energy at a frequency at which it is highly attenuated within said conduit, and whereby it accords the apparatus low accoustical efficiency; and
   e. means circumferentially containing the fluid flow intermediate said upstream and downstream throttling passages and forming with said transverse wall means a frame supporting and spacing said throttling passages,
   said circumferentially containing means comprising, with the one or more pairs of any two adjacent of said upstream and downstream transverse wall means, one or more resonant damping chambers,
   each said resonant damping chamber defining, by the spacing of said transverse wall means, a volume calculated to produce the resonant frequency of the sound waves generated by the fluid flow through said transverse wall means.

2. The apparatus of claim 1, wherein the number and/or size of the throttling passages of one is varied from the number and/or size of the throttling passages of other adjacent of said upstream and downstream transverse wall means such as to divide the pressure drop across said apparatus into substantially equal ratio pressure drops across the individual of said upstream and downstream transverse wall means.

3. The apparatus of claim 1, wherein the throttling passages of one are offset in the flow direction from the passages of another of said upstream and downstream transverse wall means.

4. The apparatus of claim 1, wherein said transverse wall means are plates, and wherein said throttling passages are holes defining jet orifices in said plates.

5. The apparatus of claim 1, wherein said transverse wall means comprise annular plates, and wherein said circumferential containing means comprises a spacer ring.

6. The apparatus of claim 1 and means uniting said transverse wall means centrally of said circumferential containing means, said centrally uniting means comprising a fastener engaging and adapted to draw together said transverse wall means.

7. The apparatus of claim 6, and spacer means limiting said drawing together by said fastener, said spacer means comprising one or more collars, and said fastener engaged behind one of said transverse wall means, passed through said one or more collars, and adjustably secured to another said transverse wall means.

8. The apparatus of claim 1, and means positioning said transverse wall means for determined upstream-downstream spacing of said flow throttling passages.

9. The apparatus of claim 1, and means for adjusting the flow capacity of said frame.

10. The apparatus of claim 9, wherein said flow capacity adjusting means comprises means for closing a determined portion of the passages of one or another of said wall means.

11. The apparatus of claim 10 wherein said passage closing means comprise plate means removably supported against the upstream side of said one or another wall means.

12. The apparatus of claim 11, wherein said plate means are carried on fastener means removably securing together said wall means centrally of said circumferential containing means.

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