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3 APPARATUS FOR CONTROLLING PRESSURE RECOVERY

5 STATEMENT OF GOVERNMENT INTEREST

6 The invention described herein may be manufactured and  
7 used by or for the Government of the United States of America  
8 for governmental purposes without the payment of any royalties  
9 thereon or therefor.

11 BACKGROUND OF THE INVENTION

12 (1) Field of the Invention

13 This invention generally relates to an apparatus for  
14 controlling pressure recovery. More particularly, the  
15 invention relates to an apparatus for controlling pressure  
16 recovery in a submarine cylindrical shutter way/guide-can  
17 recess.

18 (2) Description of the Prior Art

19 The current art and known construction of a submarine  
20 torpedo launchway causes a substantial recovery of dynamic  
21 pressure in a cylindrical shutterway/guide-can recess (SGR).

22 Referring to the conventional art of FIG. 1, the known  
23 SGR is illustrated therein. Specifically, the portion of the  
24 submarine showing the launchway location of a torpedo T prior

1 to launch is depicted in general by reference number 10. The  
2 launchway 10 includes a shutterway 12, and a guide-can recess  
3 14 in longitudinal alignment with the shutterway 12. An  
4 entering flow of sea water 16 passes into a first end 12a of  
5 the shutterway 12 and enters the guide-can 14 at a passage  
6 opening 18 at a second end 12b of the shutterway 12 and a  
7 first end 14a of the guide-can 14. The guide-can 14 and  
8 shutterway 12 are those portion of the launchway 10 through  
9 which the torpedo T passes upon firing the torpedo from the  
10 submarine.

11 The second end 14b of the guide-can 14 terminates in an  
12 opening, thereby defining an open area 20 between the guide-  
13 can 14 and a launch tube 22 of the submarine. The entering  
14 flow 16 becomes either stagnation flow 24 or redirected flow  
15 26 as explained in the following.

16 Just prior to launch, when a muzzle door (not shown) of  
17 the torpedo launch tube 22 has opened, the pressure head of  
18 water that has built up at the entrance to the launch tube 22,  
19 or otherwise termed "recovered pressure", induces an adverse  
20 pressure gradient along a length of the torpedo T while the  
21 torpedo is in the tube 22. An adverse pressure gradient means  
22 that the pressure is higher at the nose of the torpedo  
23 compared to the pressure at its tail end. This condition

1 energizes a breechward movement of the torpedo T that could  
2 result in structural damage to the weapon if this condition  
3 becomes excessive. Furthermore, fluid flow from the torpedo  
4 tube 22 to the turbine pump is reversed, thereby causing an  
5 undue stress on the turbine pump of the torpedo at start-up.  
6 Over time, this undue stress may structurally fatigue a  
7 turbine pump clutch of the torpedo.

8 An inspection of the submarine launchway reveals the  
9 probable cause for the adverse pressure gradient along the  
10 torpedo while in the tube 22. Specifically, the large  
11 separation between the second end 14b of the guide-can 14 and  
12 the torpedo tube 22 permits flow through the SCR and into a  
13 free-flood region 28 of the submarine. This separation is  
14 necessary to allow opening of the torpedo tube muzzle door  
15 just prior to launch of the torpedo. Note that the free flood  
16 region 28 of the submarine is formed to be outwardly  
17 concentric with the shutterway 12/guide-can 14 portion, and  
18 receives the redirected flow 26 from the guide-can 14. It is  
19 also revealed that the free-flood region 28 is not isolated  
20 from the flow dynamics external to the hull of the shutterway  
21 12 and guide-can 14. In particular, the sides and rear of  
22 doors to the shutterway 12 do not seat tightly against the  
23 external hull in their closed position. Large gaps which

1 frame the shutter doors permit low-velocity flow, indicated at  
2 28a, through the free-flood region that eventually leads to  
3 the flow dynamics external to the submarine hull. The high-  
4 momentum/low-volume flow through the SGR is supported by a  
5 low-momentum/high-volume flow through the free-flood region.  
6 The high-momentum flow through the SGR stagnates locally at  
7 the torpedo tube muzzle door as shown by 24, thereby  
8 recovering the full dynamic pressure of the flow through the  
9 SGR.

10       The ensuing event of the above flow path centers on flow  
11 stagnation 24 at the torpedo nose just prior to launch.  
12 Complete conversion of the dynamic pressure to static pressure  
13 gives a much higher static pressure at the torpedo nose  
14 compared to the pressure at its tail. A simple, but  
15 synonymous example, is a jet flow impinging on a flat plate  
16 where the recovered pressure is directly attributed to a quick  
17 termination of stream wise flow momentum due to the presence  
18 of the solid wall at the entrance to the torpedo tube 22. At  
19 the wall, the flow stagnates (24) and recovers its entire  
20 dynamic head. In this example, the flow redirects at 26  
21 laterally along solid end walls 30 of the launch tube 22.  
22 Translated into submarine geometry, the flow redirects to the  
23 free-flood region 28.

1           Possible corrections for reducing the stagnation pressure  
2   24 at the muzzle door/end walls 30 center on preventing any  
3   external flow from entering the SGR. Geometric modifications  
4   to the launchway include sealing the gaps between the shutter  
5   doors and the submarine hull, or enclosing the open zone 20  
6   between the guide-can 14 and the torpedo tube 22. Although  
7   these changes address the symptoms of the recovered pressure  
8   problem, their functionality may not be one hundred percent  
9   assured. In particular, other access ports from the free-  
10  flood region 28 to the hull also generate external flow  
11  dynamics, but more importantly, fluid entrainment or its  
12  associated mass exchange entering the SGR can not be fully  
13  prevented due to the large characteristic length of the  
14  shutterway 12. These geometric fixes simply translate the  
15  recovered dynamic pressure zone to within the SGR itself. The  
16  stagnation pressure 24 at the torpedo nose may remain  
17  unchanged.

18           Thus, a problem exists in the art whereby there is a need  
19  to reduce or eliminate the stagnation flow or pressure head  
20  build up at the door of the launch tube 22. This should be  
21  done in a retrofit manner to accommodate existing submarine  
22  launch apparatus without undue expense or modification of the  
23  existing structure.

1           The following patents, for example, disclose various  
2 types of pressure recovery devices, but do not disclose an  
3 apparatus for controlling pressure recovery utilizing a  
4 plurality of retrofit circumferential chokes as occurs in the  
5 present invention.

6           U.S. Patent No. 4,383,552 to Baker;

7           U.S. Patent No. 5,020,943 to Filipelli; and

8           U.S. Patent No. 5,521,340 to Thawani et al.

9           Specifically, the patent to Baker discloses an adjustable  
10 choke for automatically regulating high velocity flow through  
11 a pipe line. The choke comprises a generally cylindrical  
12 elongated body including an axially-directed inlet port at one  
13 end, means for selectively controlling flow through the  
14 regulator at the other end, and a radially-directed outlet  
15 port intermediate of the body. A pair of slidable, annular  
16 rings contained in the body adjacent the inlet port comprise  
17 an upstream ring and a downstream ring. Each of the rings are  
18 spring biased from the other. The upstream ring includes a  
19 flow passageway and a flow obstructing portion. The  
20 downstream ring includes a plurality of flow passageways, at  
21 least one of the downstream ring flow passageways being  
22 disposed out of communicable flow alignment with the upstream  
23 ring flow passageway. Upon impingement of sufficient flow

1 against the obstructing portion of the upstream ring, the  
2 upstream ring is slid into abutment with the downstream ring  
3 for closing the one downstream ring flow passageway and for  
4 limiting fluid flow through the choke. Upon dissipation of  
5 the sufficient flow, the upstream ring is spring biased away  
6 from the downstream ring. The means for selectively  
7 controlling the flow is selectively, operatively engaged to  
8 the downstream ring whereby the downstream ring may be  
9 selectively slid into abutment with the upstream ring for  
10 closing the one downstream ring flow passageway. The means  
11 for selectively controlling also includes a selectively  
12 advanceable valve stem for closing the downstream ring flow  
13 passageways other than the one downstream ring flow  
14 passageway. It should be noted that the primary function of  
15 Baker s invention is limiting high velocity, which only  
16 indirectly limits high pressure. The proposed invention does  
17 not limit the centerline velocity, only the centerline  
18 pressure. Further, only two ring devices of complex geometry  
19 obstruct the flow in Baker s invention, rather than a series  
20 of chokes as in the proposed invention. Flow control (in  
21 Baker s invention) is obtained through structural obstruction,  
22 rather than turbulence ingestion in the main flow direction as  
23 in the proposed device. Next, the rings of Bakers's invention

1 do not maintain geometric similarity of the main housing  
2 geometry. Each ring contains one large diameter center hole  
3 with five surrounding small diameter holes. The proposed  
4 invention preserves geometric similarity of the main external  
5 housing. Still further, the primary flow is redirected 90  
6 degrees from inlet to outlet in Baker s invention, whereas the  
7 flow in the proposed invention is continuous. Bakers  
8 invention requires user control to make the invention  
9 effective, whereas the proposed invention has fixed chokes.

10 The patent to Filipelli discloses a cylindrical pipe of  
11 internal diameter  $d$ , intended for pneumatic transport of solid  
12 polymer particles. The pipe has constrictions located over  
13 its length in such a way that the distance  $l$  between two  
14 consecutive constrictions is between  $d$  and  $10 \times d$ . Each  
15 constriction consists of a non-uniform restriction of the  
16 cross-sectional area  $S$  of the pipe. That restriction defines  
17 a new internal cross-sectional area  $S'$  of between  $0.900 \times S$   
18 and  $0.995 \times S$  and has at least one unrestricted free passage  
19 defined by a circular sector of the area  $S$  with a vertex  
20 situated on the axis of the pipe and an angle at the vertex  
21 ranging from  $5$  to  $60$  . It should be noted that the Filipelli  
22 invention is not for flow control. Instead, Filipelli inserts  
23 a series of smooth rings, which are very far apart, that

1 inhibit the formation of polymer threads. The presence of  
2 these threads would disturb and restrict the efficient  
3 transport of the polymer particles by a hot carrier gas. In  
4 addition, Filipelli does not attempt to control either the  
5 velocity or the pressure of the main flow gas.

6 Thawani et al. disclose an apparatus for attenuating  
7 noise produced by fluid pressure pulsations in a hydraulic  
8 system in an automotive vehicle. The apparatus includes a  
9 muffler device comprising a generally elongate tubular member  
10 having a predetermined number of attenuating zones therein,  
11 each zone having a cross-sectional area of different size than  
12 the cross-sectional area of the tubular member. The  
13 attenuating zones are spaced at unequal lengths from one  
14 another to achieve maximized noise reduction benefits. Once  
15 again, the Thawani et al. invention is not for flow control.  
16 Instead, Thawani et al. insert a series of smooth rings for  
17 the primary purpose of reducing noise in the various piping  
18 systems of an automobile. The device is actually a muffler  
19 that contains a series of smooth rings much like the Filipelli  
20 invention. These rings attenuate any pressure fluctuations  
21 that are responsible for noise. Further, Thawani et al. do  
22 not attempt to reduce either the streamwise velocity or the  
23 static pressure of the main flow.



1           In accordance with one aspect of this invention, there is  
2 provided an apparatus for controlling fluid pressure recovery  
3 which includes an elongated housing having an opening at a  
4 first end thereof, an opening at a second end thereof, an  
5 inner peripheral surface, and a fluid flow passageway  
6 therethrough. The apparatus further includes a plurality of  
7 choke members fixed to the inner peripheral surface of the  
8 housing, each of the plurality of choke members being spaced  
9 from an adjacent choke member and projecting a predetermined  
10 distance into the fluid flow passageway of the longitudinal  
11 housing. The plurality of choke members sequentially produce  
12 a reduced turbulent free shear fluid layer from the first end  
13 to the second end of the elongated housing.

14

15                                   BRIEF DESCRIPTION OF THE DRAWINGS

16           The appended claims particularly point out and distinctly  
17 claim the subject matter of this invention. The various  
18 objects, advantages and novel features of this invention will  
19 be more fully apparent from a reading of the following  
20 detailed description in conjunction with the accompanying  
21 drawings in which like reference numerals refer to like parts,  
22 and in which:

1 FIG. 1 is a simple diagram illustrating flow paths  
2 through a known submarine shutterway/guide-can recess;

3 FIG. 2 is a diagram illustrating flow paths through a  
4 shutterway/guide-can recess as modified according to a  
5 preferred embodiment of the present invention;

6 FIG. 3 is a side view of flow control apparatus according  
7 to the first preferred embodiment of the present invention;

8 FIG. 3A is a sectional view taken along line A-A of FIG.  
9 3;

10 FIG. 4 is a comparison graphical representation of a  
11 reducing recovered pressure; and

12 FIG. 5 is a detailed view of a choke ring assembly  
13 according to the present invention.

14

15 DESCRIPTION OF THE PREFERRED EMBODIMENT

16 In general, the present invention is directed to an  
17 apparatus for controlling pressure recovery. More  
18 specifically, the purpose of the invention is to control the  
19 pressure recovered in a submarine cylindrical shutter  
20 way/guide-can recess, generally shown at 40 in FIG. 2. This  
21 control can minimize movement of a torpedo vehicle 36 while in  
22 a launch tube 42, which movement may be potentially harmful to  
23 the success of the torpedo launch.

1 Referring still to FIG. 2 and additionally to FIG. 3, the  
2 apparatus of the present invention deviates considerably from  
3 the above concepts discussed in connection with the known art  
4 of FIG. 1. The operation of the present invention is to  
5 decrease a stagnation pressure at a nose portion 38 of the  
6 torpedo 36 by minimizing the recovered pressures. That is, by  
7 inserting a flow control apparatus (FIG. 3) as a replacement  
8 to the known guide-can 14, a loss of recovered pressure is  
9 realized prior to the flow stagnating at the torpedo nose 38.

10 The overall structure includes a shutterway 44 into which  
11 an entering flow 46 will be received. The shutterway 44 is  
12 circumferentially aligned with a control apparatus 48, the  
13 control apparatus 48 replacing the known guide-can 14. Flow  
14 passing through the shutterway 44 and the control apparatus 48  
15 is effectively dispersed prior to confrontation with a closed  
16 door 50 of a torpedo launch tube 42.

17 Similar to the known art, a free flood region 52 is  
18 formed circumferentially and outwardly from the shutterway  
19 44/control apparatus 48 assembly of the launch area. It will  
20 be understood that the launch tube door 50 is selectively  
21 opened prior to launch of the torpedo 36 and the torpedo nose  
22 38 is that portion of the torpedo closest to the launch tube  
23 door 50.

1           The control apparatus 48 contains a plurality of  
2 circumferential chokes 54 placed periodically along an inner  
3 peripheral surface thereof, and along its length as  
4 illustrated in FIGS. 2 and 3. Physically, the chokes 54  
5 induce downstream turbulent regimes locally whose intensity  
6 extract energy from a main flow 60 through the core of the  
7 apparatus 48. This extraction translates into a loss of flow  
8 momentum through the apparatus 48 and thus a concurrent  
9 reduction of recovered pressure at the door 50 of the launch  
10 tube 42. By achieving a reduction of recovered pressure in  
11 the apparatus 48, the subsequent stagnation pressure at the  
12 torpedo nose 38 is decreased.

13           A sketch of the apparatus design is drawn in FIG. 3 with  
14 the flow control thereof illustrated in FIG. 4. The plurality  
15 of circumferential chokes 54 are mounted on the inner  
16 peripheral wall 56 of the apparatus. As the high-momentum  
17 flow from the shutterway 44 enters the apparatus 48 at the  
18 first of the plurality of chokes 54, the high-momentum flow  
19 impacts on the first circumferential choke 54a. Downstream of  
20 choke 54a, a turbulent free-shear layer 58 immediately  
21 develops which interacts with the adjacent main core flow 60.  
22 This viscous interaction locally extracts energy from the core  
23 flow 60 which translates ultimately to a permanent loss of the

1 recoverable dynamic pressure. Because the extraction of  
2 energy that is caused by the single choke 54a decreases with  
3 downstream distance through the apparatus, the core flow 60  
4 must impart on a second choke 54b to continue further  
5 reduction of the recoverable dynamic pressure through the  
6 apparatus 48. This process continues until the flow exits the  
7 apparatus at 62 and enters an open zone 64 at that location.  
8 Due to the presence of the plurality of circumferential chokes  
9 54, the recovered pressure (and flow momentum) at the  
10 apparatus exit 62 has been substantially lowered compared to  
11 the exit of the known guide-can 14.

12 The chokes 54 may be integrally formed with the inner  
13 peripheral wall 56 of the apparatus housing, either as a one-  
14 piece construction or separately fixed thereto. FIG. 5 is a  
15 detailed view of a choke ring assembly according to the  
16 present invention. Specifically, the choke ring assembly is  
17 shown herein as being of a one piece construction having a  
18 series of spaced chokes 54 and a plurality of longitudinal  
19 ribs 66 spaced around the outer periphery of the chokes 54 for  
20 holding the chokes 54 together. It should also be understood  
21 that the number and placement of the chokes 54 may vary  
22 according to the application of the device and the density or  
23 viscosity of the fluid in which it is used. As such, if a

1 one-piece apparatus is constructed, the spacing of the chokes  
2 54 may be predetermined or calculated according to their end  
3 use. Likewise, if the chokes 54 are separately installed into  
4 the housing wall 56, then the installation and number of  
5 chokes may be similarly calculated according to their end use.

6 A pressure profile illustrating the loss of pressure  
7 through the apparatus compared to that observed in the known  
8 guide-can 14 is illustrated in FIG. 4. With a lower recovered  
9 pressure and a lower momentum of flow exiting the apparatus,  
10 the stagnation pressure on the torpedo nose 38 will  
11 consequently be lowered. Thus, the resultant adverse pressure  
12 across the torpedo 36 is reduced thereby minimizing the  
13 potential for harmful damage to the torpedo, including any  
14 attached devices. In addition, the reverse flow through the  
15 impeller is concurrently reduced, thereby minimizing the  
16 potential structural fatigue at start-up.

17 The advantages and new features of this invention include  
18 a series of equidistant circumferential chokes for generating  
19 high turbulent activity within the apparatus, the design of an  
20 apparatus for reducing recovered pressure and thereby reducing  
21 the stagnation pressure at the torpedo nose prior to launch.  
22 Further, the design is such that the reduction of recovered  
23 pressure is directly proportional to the number of chokes

1 within the apparatus. The beneficial results include  
2 minimizing harmful damage to the torpedo, minimizing  
3 mechanical fatigue to the impeller at startup due to a reverse  
4 flow, and easy replacement of the guide-can with the  
5 apparatus.

6 It should also be understood that alternatives are  
7 available in connection with the present invention for  
8 potentially reducing the stagnation pressure at the torpedo  
9 nose. These include sealing the gaps between the shutter  
10 doors and the submarine hull, and preventing the flow from  
11 entering the SGR by enclosing the separated zone between the  
12 guide-can and the shutter door.

13 Finally, it is anticipated that the invention herein will  
14 have far reaching applications other than those of underwater  
15 vehicles.

16 This invention has been disclosed in terms of certain  
17 embodiments. It will be apparent that many modifications can  
18 be made to the disclosed apparatus without departing from the  
19 invention. Therefore, it is the intent  
20 to cover all such variations and modifications as come within  
21 the true spirit and scope of this invention.

1 Attorney Docket No. 79612

2

3 APPARATUS FOR CONTROLLING PRESSURE RECOVERY

4

5 ABSTRACT OF THE DISCLOSURE

6 An apparatus for controlling fluid pressure recovery  
7 includes an elongated housing having an opening at a first end  
8 thereof, an opening at a second end thereof, an inner  
9 peripheral surface, and a fluid flow passageway therethrough.  
10 The apparatus further includes a plurality of choke members  
11 fixed to the inner peripheral surface of the housing, each of  
12 the plurality of choke members being spaced from an adjacent  
13 choke member and projecting a predetermined distance into the  
14 fluid flow passageway of the longitudinal housing. The  
15 plurality of choke members sequentially produce a reduced  
16 turbulent free shear fluid layer from the first end to the  
17 second end of the elongated housing.

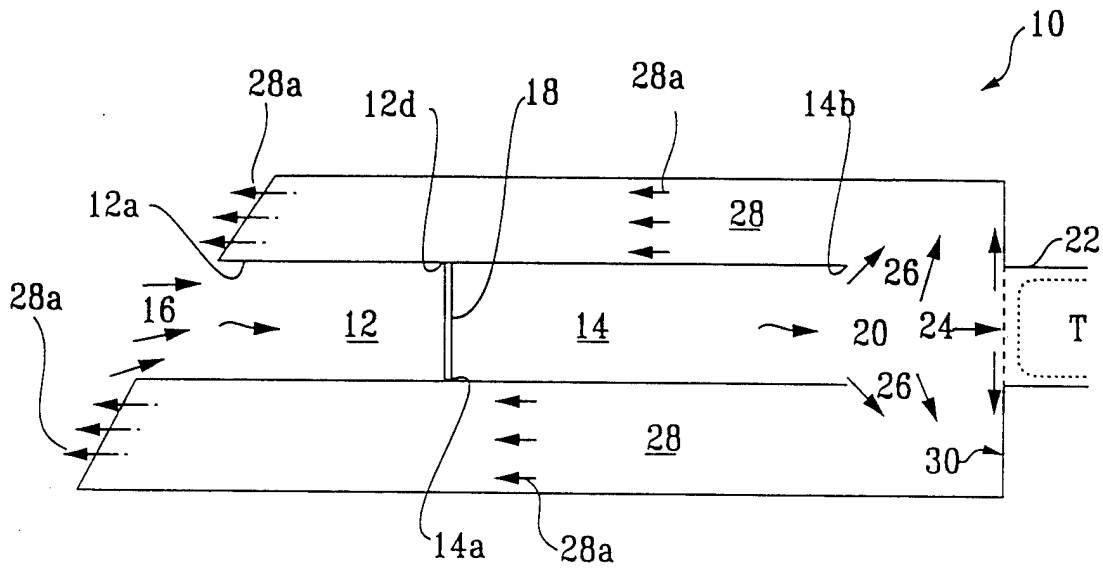


FIG. 1  
PRIOR ART

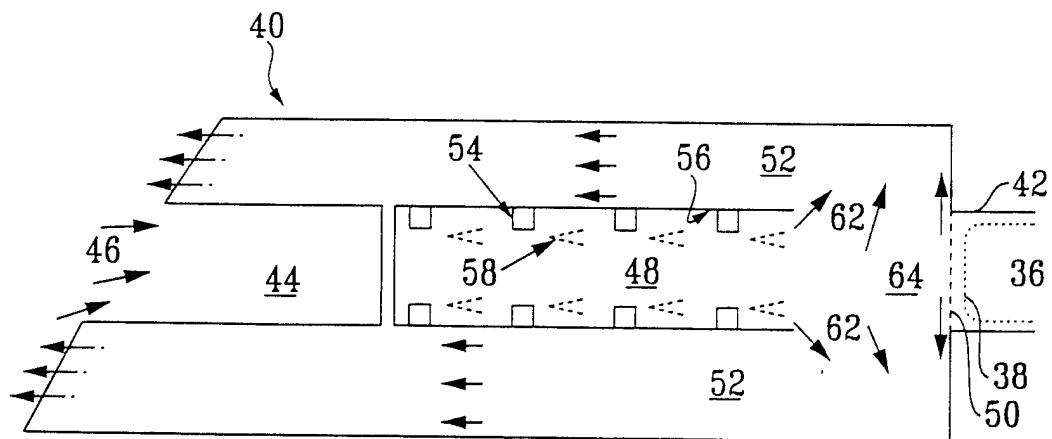


FIG. 2

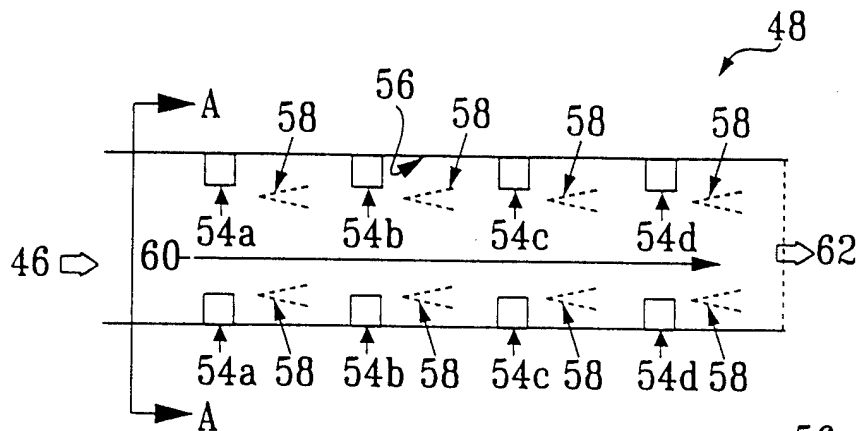


FIG. 3

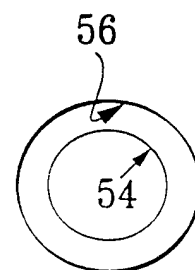


FIG. 3A

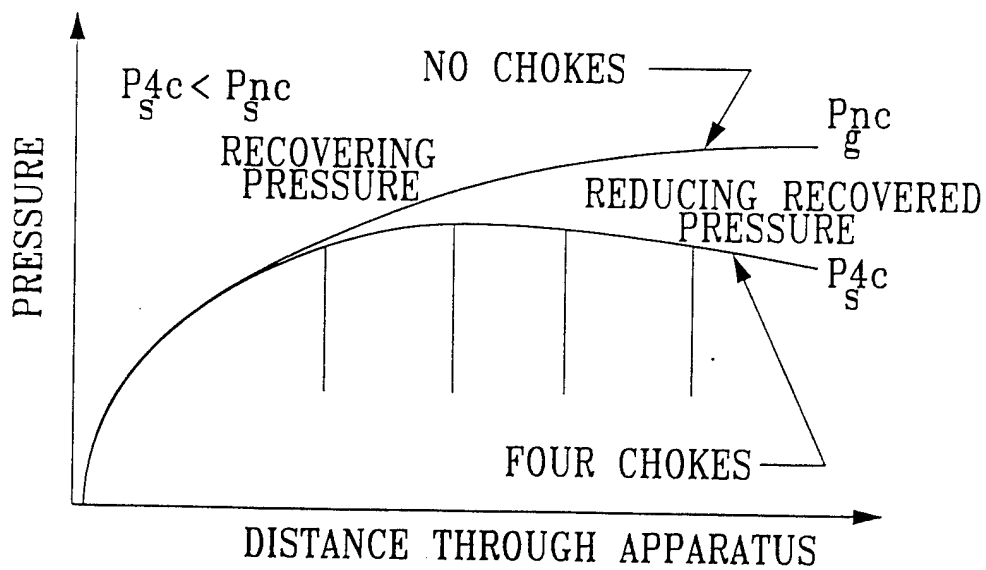


FIG. 4

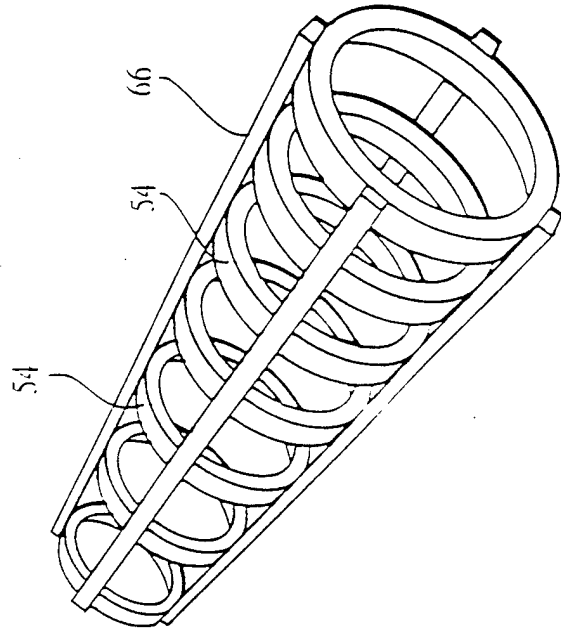


FIG. 5