United States Patent

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[54] **PULSATION DAMPENER**
25 Claims, 10 Drawing Figs.

[52] **U.S. Cl.** **138/37,** 138/26, 137/98
[51] **Int. Cl.** **F15d 1/00,** F161 55/04
[50] **Field of Search** 138/26, 37, 39, 40, 41, 42, 44; 137/98, 101, 574; 230/134.5

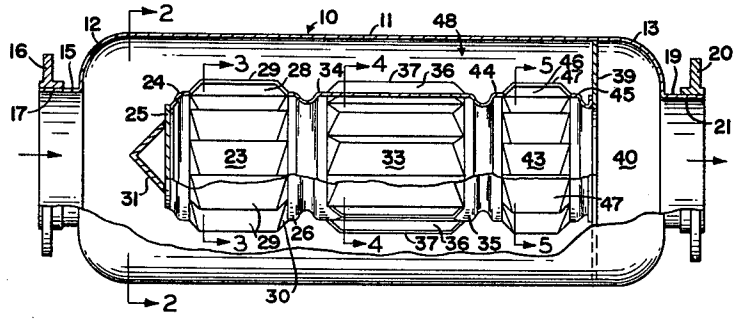
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Assistant Examiner— R. J. Sher
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ABSTRACT: A method and apparatus for dampening the pulsation of fluid in a fluid-transmission system wherein a portion of fluid is caused to rotate in one direction and another portion of the fluid is caused to rotate in the opposite direction. By subsequently re-combining the counter-rotating portions of fluid flow, pulses in the fluid are effectively minimized or removed. A plurality of rotation-inducing members are provided in a housing, each having louvered segments and slots so arranged that the desired rotating, counter-rotating and cancelling effects are achieved.



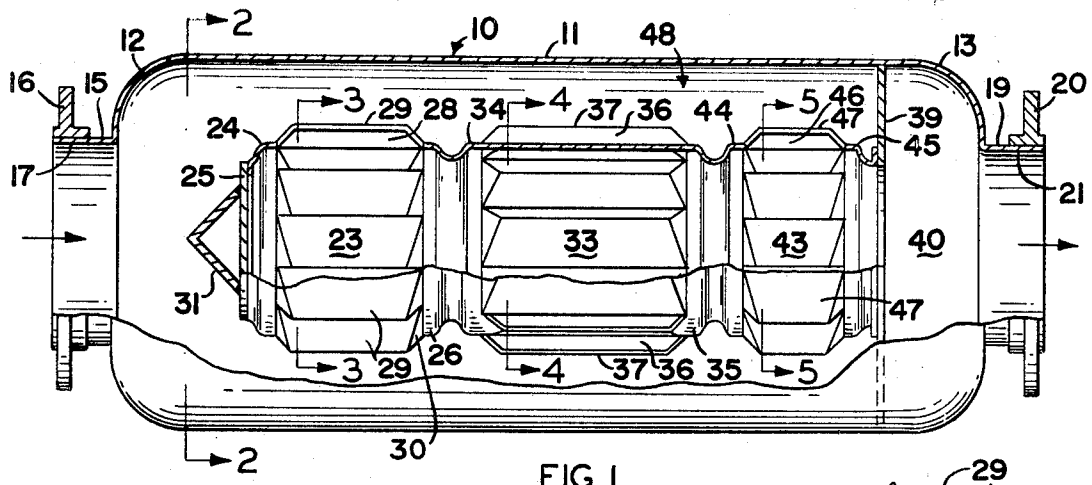


FIG. 1

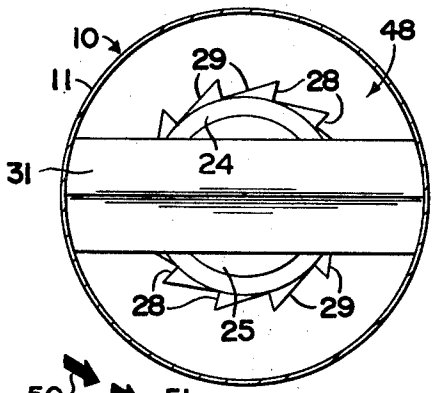


FIG. 2

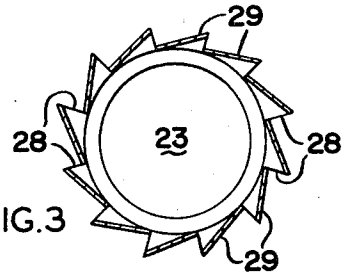


FIG. 3

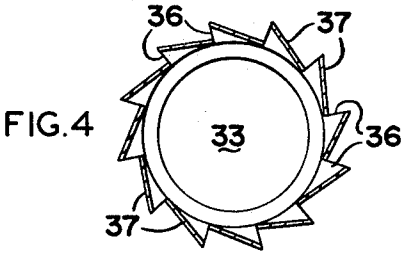


FIG. 4

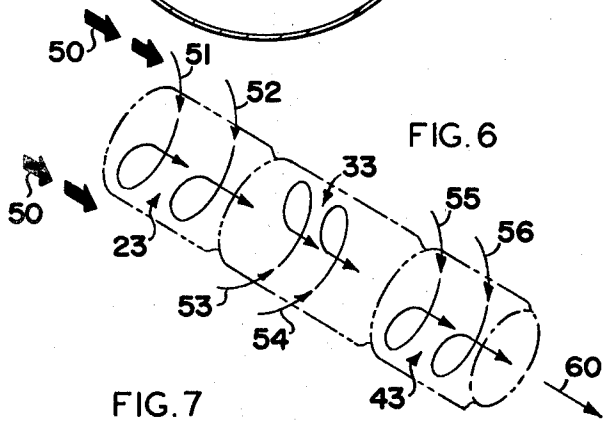


FIG. 6

FIG. 7

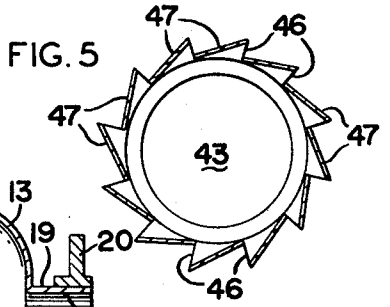
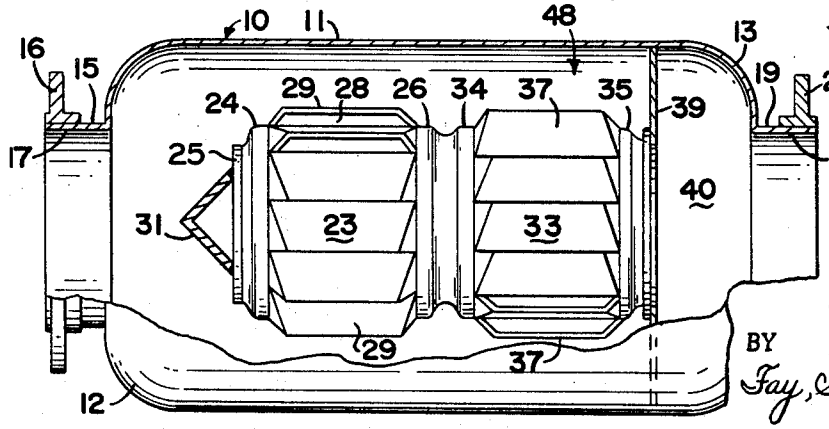


FIG. 5



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FIG. 8

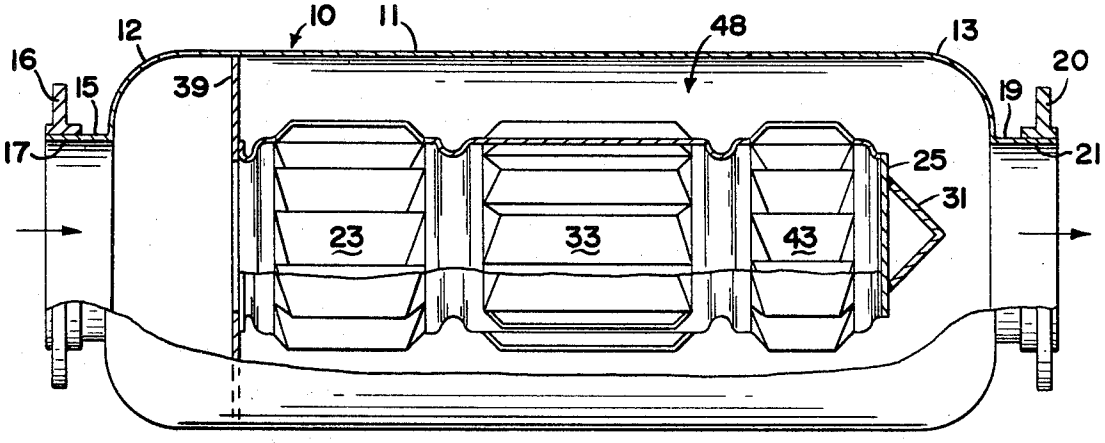


FIG. 9

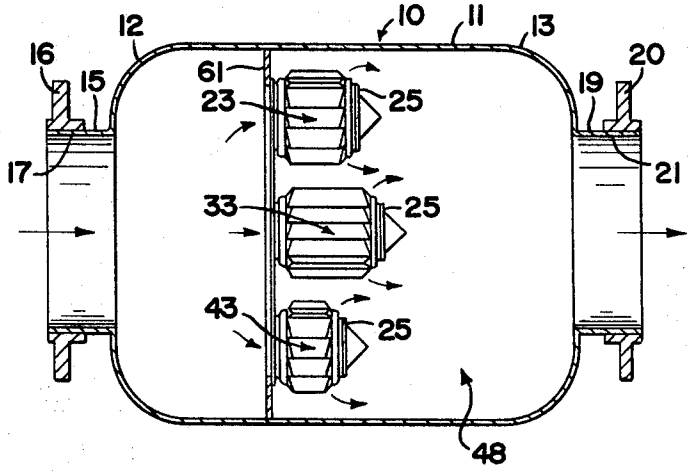
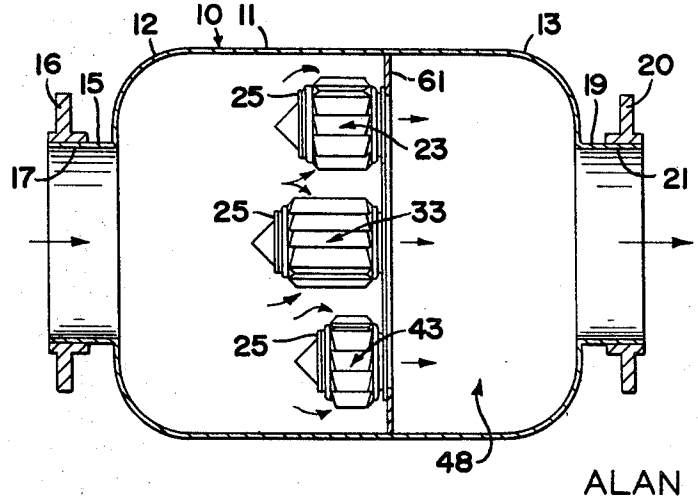


FIG. 10



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PULSATION DAMPENER

BACKGROUND OF THE INVENTION

This invention generally relates to pulsation dampening devices. More particularly, this invention relates to pulsation dampening in fluid transmission systems which include reciprocating equipment. Still more particularly, this invention relates to a pulsation dampener including a plurality of rotation-inducing members operative to rotate a portion of the entering fluid in a first direction, rotate another portion of the entering fluid in the opposite direction, and then recombine the rotating and counter-rotating portions of fluid to cancel and thus dampen any pulsation which was present in the fluid flow.

A wide variety of approaches in the prior art have attempted to overcome the problem of pulsation dampening in systems using reciprocating equipment, such as air compressers, blowers, vacuum or pressure pumps, and the like. Vibration and pulsation often are a result of the inherent physical characteristics of the fluid source. Since pulsation created at some point in a fluid transmission system may be propagated to other points in the system both through th the fluid conduit and through the fluid itself, it is desirable, and often necessary, to eliminate or minimize pulsation and vibration wherever possible. Because the fluid, particularly compressible fluid such as air, is a media of propagation for pulsation which has the properties of mass, or inertia, and elasticity, the created vibration or pulses may be propagated throughout the media in accordance with the principles governing the propagation of elastic waves.

In effect, the particular details of pulsation travel and wave theory as applied to fluid transmission systems are beyond the scope of this description. It will suffice, however, to state that the details of pulsation theory involve complicated problems of superimposed steady and alternating fluid flows, which, in many instances, are not well understood in the art.

Undampened pulsation or vibration in a fluid transmission system, such as that utilized for the flow of compressible fluids such as air, may result in a variety of problems. The transmission structure, including the piping, may suffer permanent damage from pulsation-induced failures. The efficiency of the fluid transmission system is decreased because of the increased propensity of the fluid within the system to travel in a turbulent condition. A precise determination of pressures within a system is impaired because of the presence of pulses superimposed upon the steady state flow of fluid. Environmental safety and emotional well-being of operating personnel may also be effected by failure to attend to the problems of pulsation and vibration within a fluid transmission system.

Prior art solutions to the above and related problems have not been totally effective for a number of reasons. A typical approach taken by devices of the prior art to minimize or abate pulses in a fluid pulse system utilizes a structure to increase the flow path of all or a portion of fluid through the device. By creating, for example, a spiral path through the device, the frictional interference between the fluid flowing therethrough and the walls of the structure operate to minimize the presence of pulses therein. Such devices have proved unsatisfactory because of their particularly high pressure drop and complicated structure.

Another similar prior art approach utilizes a plurality of spiral passages leading from one end of the device to divide the incoming fluid into a plurality of streams all of which traverse an increased path length. Upon re-combination of the plurality of streams, all of which have been traversing a spiral in the same rotational direction, the noise level is somewhat attenuated. As before, however, a deficiency in this type of device is its increased pressure drop and structural complexity.

Another device of the prior art utilizes an arrangement whereby the incoming pulse wave is broken into a plurality of smaller waves which mutually interfere. By directing segments or portions of the wave at each other, pressure surges are somewhat nullified. However, increased cost and a structural complexity mitigate against the mass production of such a structure.

Still another type of pulsation dampener utilizes dampening chambers, generally including a resilient diaphragm pressurized with an inert gas and capable of movement in accordance with the rise and fall of pressure in the compressible fluid so as to dampen the pressure pulses of the fluid traveling within the system. Such structures, primarily because of their plurality of moving parts, and corresponding increased maintenance costs, have also proven unsatisfactory. A still different approach encompasses a structure which divides the incoming flow into several linearly flowing portions of varying length for later re-combination to eliminate or minimize pulses therein. These devices alternate pulses by utilizing the principle of linear cancelation, as it is known in the art.

SUMMARY OF THE INVENTION

In order to overcome the above and other related difficulties in the prior art, method and apparatus are provided for the attenuation and minimization of pulses in a fluid-flow system. The device in various modifications, according to the invention, includes means for causing the rotation of a first portion of fluid passing through the device in a first rotational direction. Additional means are provided for causing the rotation of another portion of the fluid in a rotational direction opposite to the direction of rotation of the first portion. Mixing chamber means are provided for combining the rotating and counter-rotating portions of the fluid. Thereby, pulsation present in the fluid at the inlet port of the device is effectively dampened.

In the preferred embodiment, three similar rotation inducing sections are provided, each being of a generally annular construction with slots of a louvered character. The end of the rotation-causing section nearest the inlet portion of the housing is closed and the opposite end is open. The adjacent rotation-causing section is attached to the first rotation-causing section in such a manner that the rotating and counter-rotating portions of the fluid are effectively combined. Where three such rotation sections are used, the relative dimensions of the sections are selected so that the moment of momentum of the incoming fluid which is caused to rotate in the clockwise direction is approximately equal to the moment of momentum of the fluid which is caused to rotate in the counter-clockwise direction. The rotation section furthermost disposed from the inlet portion of the housing of the preferred embodiment is attached to a bulkhead to open into a final volumetric dampening section within the housing.

Each of the rotation-causing sections include a plurality of spaced-louvered slots in the walls of the sections which are so arranged so that the portion of the compressible fluid entering or leaving the interior of the section through said slots is caused to rotate in one rotational direction or the other. In this manner, a generally helical or spiral flow of fluid through each section is obtained. While two such rotation causing sections have been satisfactory to achieve the desired results of the invention, the preferred embodiment utilizes three such sections for increased pulse dampening efficiency. However, any number of sections similar to those disclosed may be utilized, as long as the induced rotation of the fluid by any particular section is opposite to the induced rotation of the fluid by the adjacent section.

Thus, it can be observed that the device according to the invention eliminates the need for special or reinforced piping structures, complex pulse attenuators, or pulsation dampeners utilizing moving parts which are susceptible to maintenance problems.

Accordingly, it is an object of this invention to provide a pulsation dampening device of relatively simple construction which is capable of being manufactured at low cost and easy to install.

It is another object of this invention to provide a vibration-control device which is characterized by the absence of moving parts.

It is still another object of this invention to provide a device utilizing means for the creation and combination of rotating and counter-rotating fluid flow therein so that pulsation present in the incoming fluid is effectively dampened.

It is a still further object of this invention to provide a high-pulse attenuation with a minimum of pressure drop for the effective dampening of pulses in a fluid flow system.

It is a still further object of this invention to provide an inexpensive yet durable pulse dampener small in size and high in efficiency.

Other objects and features of this invention will become more apparent upon a consideration of the detailed description and a study of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view in partial section of a first embodiment of the device according to the invention.

FIG. 2 is a sectional view taken along line **2-2** of **FIG.** 1.

FIG. 3 is a sectional view taken along line **3-3** of **FIG.** 1.

FIG. **4** is a sectional view taken along line **4-4** of **FIG.** 1.

FIG. 5 is a sectional view taken along line **5-5** of **FIG.** 1.

FIG. 6 is a diagrammatic sketch illustrating by arrow the axial and rotational flow of fluid through the device of **FIG. 1.**

FIG. 7 is a second embodiment of a device incorporating the principles of the invention.

FIG. 8 is a third embodiment of a device incorporating the principles of the invention.

FIG. 9 is a fourth embodiment of a device incorporating the principles of the invention.

FIG. 10 is a fifth embodiment of a device incorporating the principles of the invention.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1is a side elevational view, partially in section, of one embodiment of a device incorporating the principles of the invention. A generally cylindrical housing is shown at **10** as comprising a cylindrical body **11** and end portions **12** and **13** designed for the axial flow of fluid, for example, compressible fluid, through the device. Inlet end portion **12** may be suitably connected to a tubular member **15**, such as by spot welding. Alternately, member **15** may comprise a unitary part of end portion **12**. Connecting flange **16** is connected to tubular member **15** and is utilized for connecting the device in a fluid transmission system. Tubular member **15** and connecting flange **16** define an inlet port **17** comprising the inlet portion of the device for the inlet of pulsation containing fluids.

Similarly, outlet end portion **13** is connected to body **11** and to a tubular outlet member **19**, which is in turn connected to an outlet flange **20** for the convenient installation of the device in a fluid transmission system. Tubular member **19** and flange **20** define an outlet port **21** for the passage of fluid from the device in the system.

Housing **10** may be constructed of any suitable material, particularly metal, in accordance with the applicable construction codes or prevailing structural requirements. The particular selection of the construction, material, and wall thickness is determined by the particular piping and pressure requirements for the intended installation of the device within the fluid system.

Within the housing **10**, means **23** are provided for causing the rotation of a portion of the fluid flow through the housing. Rotation-causing means **23** comprises an annular element having a generally cylindrical wall **24** with the end nearest the inlet port **17** closed by plate **25**, and the other end formed by cylindrical wall **26** is open.

It should be understood that annular elements, as used in this description, embrace a number of rotation-inducing members which may be of different constructions, but are generally of the louver type illustrated by rotation-causing means **23**.

A plurality of spaced-louvered slots, generally depicted by numeral **28** are disposed in the wall **24** of element **23** and are so arranged that a portion of the fluid entering housing **10** by way of inlet port **17** enters the interior of the element **23** through slots **28** and is caused to rotate within the confines of element **23** while continuing to axially flow through the element. As depicted, wall **24** and the general orientation of slots **28** may be co-axial with housing **10**.

Slots **28** may be conveniently formed, such as by stamping, pressing, or casting, from a cylinder of material having a wall as shown by walls **24** and **26**. A plurality of openings, or slots, **28** are provided in the wall of the element defined by a plurality of segments **29** of walls **24** and **26**. Accordingly, slots **28**, particularly at the ends as typified by numeral **30** may assume an irregular contour due to the change of direction of material at this point. The inner edges of segments **29** lie approximately on the inside diameter of walls **24** and **26**. The outer edges of segments **29** are positioned at a radius greater than the outside radius of walls **24** and **26** and are approximately equidistant from the center from the axis of element **23** so that each of the slots **28** formed thereby have approximately equal area.

The slots **28**, together with the segments **29**, provide a path to the incoming fluid and divide the incoming fluid into a plurality of streams which are directed to the interior of section **23** imparting a generally helical or spiral flow to the fluid while within the section. Thus, within section **23**, entering fluid experiences a rapid whirling or vortical action.

Element **23** is shown as supported in housing **10** by a generally V-shaped baffle **31** attached to end plate **25** and to the interior of the body wall **11**. The connecting means, however, may also comprise a plurality of spaced connectors interconnecting the closed end **25** of element **23** with housing **10** to impart a stabilization of the structure contained within housing **10**. Moreover, the particular design of the connecting means may be selected in accordance with the aerodynamic needs of the device. A second rotation causing member or element **33** having two open ends is provided for causing the rotation of a second portion of the fluid flow through the housing **10** in a direction opposite to the rotation of the fluid flow in element **23**. Means **33** comprises an element, similar in construction to element **23**, having generally cylindrical walls **34** and **35**. The open end is suitably connected by either integrally forming therewith or attaching to the open end of element **23** defined by cylindrical wall **26**.

Similarly, a plurality of spaced-louvered slots **36** are disposed in the wall of element **33** in such a manner that the portion of the fluid passing adjacent to element **33** enters the interior through slots **36** and is caused to rotate within element **33** in a direction opposite to the direction of rotation of fluid within element **23**. As described with respect to element **23**, element **33** may conveniently comprise slots **36** defined by pressing, casting, or stamping a plurality of segments **37** in the wall. Slots **36**, along with segments **37**, provide a path for a portion of the fluid passing on the outside of element **33** and divide a portion of the incoming fluid into a plurality of streams which are directed into the interior of element **33** to impart a generally helical or spiral flow to the portion of the fluid passing therein.

Thus, within element **33**, as described with respect to element **23**, the portion of the fluid entering into the interior of the element experiences a rapid whirling or vortical action, but in a direction opposite to the whirling or vortical action of the portion of the fluid axially flowing through element **23**.

Element **33** thus also achieves a second function; namely, that of combining the rotating portion of fluid axially flowing therein with the flow from the adjacent proceeding element. It can be understood that the portion of the fluid rotating within element **23** and axially passing therethrough while rotating in a counter-clockwise direction (as viewed from the inlet) meets and is commingled with the fluid rotating within element **33** and axially flowing therethrough in the clockwise direction.

As can best be seen in **FIG.** 4 slots **36** and the plurality of segments **37** forming the slots are oppositely directed to the slots **28** and segments **29** of **FIG.** 3 to achieve the desired counter-rotational effect.

In accordance with the principles of this invention hereinbefore discussed, FIG. 7 shows a second embodiment of a device according to the invention comprising a rotation-causing member 23 and a rotation-causing and combining member 33. The device depicted in FIG. 7 is similar to the device thus far described in FIG. 1, like parts bearing like reference numerals.

In FIG. 7, the open end of element 33 defined by end wall 35 is connected to the open portion of an annular bulkhead 39 forming a volumetric chamber 40 which provides the final pulse dampening portion of the device.

While it is not necessary for the satisfactory operation of the device according to the invention, it is preferred that the slots of elements 23 and 33 respectively be dimensioned so that the moment of momentum or angular momentum of fluid caused to rotate within element 23 in a first rotational direction is nearly equal to the moment of momentum of fluid caused to rotate within element 33 in the opposite rotational direction. In this manner, the resultant moment of momentum of the fluid is nearly zero at the outlet port of the housing. It can be understood, of course, that to achieve this result, variations within the parameters depicted may be selected. By way of example, the relative length of the slots, the relative spacing of the walls defining the slots, the angles of inclination, the overall dimensions of the parts of the device, all may be varied to achieve the desired net rotational velocity considering the fluid mass.

Returning to FIG. 1 wherein is described the preferred embodiment of the device according to the invention, a third rotation-inducing member 43 is provided which, like elements 23 and 33 comprises a plurality of spaced-louvered slots 46 disposed in the wall and so arranged that the portion of the fluid entering the interior of element 43 is caused to rotate within the confines of element 43 while continuing to axially flow therethrough. The direction of rotation of the fluid within element 43 is opposite to the direction of rotation of the fluid within proceeding element 33. While any number of a plurality of elements of the general construction depicted may be used, the device illustrated in FIG. 1 has proved to be satisfactory, without the increased expense of additional similar element sections. Where additional element sections are used, it is within the scope of the invention that the portion of the fluid entering the interior of any one of the plurality of elements through the slots thereon is caused to rotate while axially flowing therethrough in a direction opposite to the direction of rotation of the fluid in an adjacent element, or in both adjacent elements, and that the rotating fluid combine with the counter-rotating fluid at the adjacent upstream element.

The element section furthermost disposed from the inlet end is connected to the open section of annular bulkhead 39 in a suitable manner to define an outlet of volumetric dampening section 40, similar to that described with respect to FIG. 7.

It is preferred, when using a plurality of elements of the type described that the slots, in terms of length, size of opening and number are selected so that the moment of momentum of fluid caused to rotate in a first rotational direction is nearly equal to the net moment of momentum of fluid caused to rotate in the opposite rotational direction. For the device depicted in FIG. 1, the fluid caused to rotate in a counter-clockwise direction (when viewed from the inlet) by elements 23 and 43 is nearly equal to the amount of fluid caused to rotate in a clockwise direction by element 33 so that the resultant moment of momentum at the outlet port 21 is nearly zero.

FIG. 5 is best illustrative of slots 46 and segments 47 disposed on element 43 in the same directions as slots 28 and segments 29 are disposed on element 23. FIG. 5, as well as FIG. 3, disclose slots and segments oppositely directed from those depicted in FIG. 4.

In FIG. 8 there is shown a third embodiment of a pulsation dampener utilizing the principles of the invention. Where possible, similar reference characters have been used as in FIG. 1. The device of FIG. 8 comprises a generally cylindrical housing 10 with end portions 12, 13 defining respectively an inlet 17 and an outlet 21.

Within the housing 10 of FIG. 8, three rotation causing annular elements 23, 33, 43 are disposed. These elements are similar to the elements of FIG. 1, and a complete description of them may be had with reference to FIG. 1. Element 23 is shown as supported in housing 10 of FIG. 8 by a generally annular shaped bulkhead 39. Elements 33 and 43 are disposed adjacent element 23 and may be supported within housing 10 by element 23. Additional supporting members (not shown) may depend from the inner surface of wall 10 to provide extra support for the elements 33, 43. An end plate 25 is secured to the outer end portion of element 43. It is to be understood that the respective ends of elements 23, 33 are open whereas, only the end of element 43 closest to bulkhead 39 is open. As in FIG. 1, the spaced louvered slots of element 33 are disposed in such a manner that fluid flowing from the interior of element 33 to the exterior of said element is caused to rotate in a direction opposite to the direction of rotation of fluid leaving elements 23, 43.

To briefly describe the operation of the device of FIG. 8, fluid entering the housing 10 via the inlet 17 will will be channeled into the cylindrical envelopes defined by elements 23, 33, 43 by the bulkhead 39. In passing from the interior of elements 23, 33, 43 to chamber 48, the respective portions of fluid will experience a rapid whirling or vortical action. Fluid flowing from element 33 will be rotating in a direction opposite to the fluid leaving elements 23 and 43. A recombining or mixing of the respective portions of the fluid takes place within chamber 48 where pulsation present originally in the incoming fluid is effectively dampened.

A fourth embodiment of a pulsation dampener utilizing the principles of this invention is shown in FIG. 9. As with FIGS. 8 and 1, similar reference characters will be used in denoting like parts where possible. The device of FIG. 9 includes a housing 10 and end portions 12, 13, respectively defining an inlet 17 and an outlet 21. A bulkhead 61 is disposed within housing 10 with elements 23, 33 and 43 attached thereto. End plates 25 are provided for each element. Bulkhead 61 is generally circular in cross section with three apertures provided therein corresponding to the end opening of elements 23, 33, 43. It is to be understood that elements 23, 33, 43 are identical to the elements of FIGS. 1 and 8 in that fluid flow from the interior of the element to the exterior of the element will be characterized by a rapid whirling or vortical action. The direction of rotation of fluid flow from element 33 will be opposite to the rotation of the fluid flow from elements 23, 43.

To briefly describe the operation of the device of FIG. 9, fluid entering housing 10 via the inlet port 17 will be channeled into the elements 23, 33, 43 by the bulkhead 61. Due to the presence of the end plates 25, fluid flow will thus be established from the interior of the respective elements to the chamber 48.

Due to the disposition of the spaced louvered slots in the elements 23, 33, 43 the flow of fluid from elements 23, 43 will be clockwise as viewed from the inlet. The flow of fluid from element 33 will be counterclockwise as viewed from the inlet. The rotating and counter-rotating portions of the fluid are then mixed and combined in the chamber 48 where pulsation originally present in the fluid at the inlet port is effectively dampened.

The fifth embodiment of a pulsation dampener utilizing the principles of this invention is shown in FIG. 10. The embodiment of FIG. 10 is similar to the embodiment of FIG. 9 with the exception that the end plates 25 are located on the inlet side of bulkhead 61 of FIG. 10 rather than at the outlet side of bulkhead 61 as in FIG. 9. As shown in FIG. 10, the elements 23, 33, 43 are attached to the bulkhead 61 with end plates 25 attached to the respective elements at the end nearest the inlet 17. Unlike FIG. 9, however, the flow of fluid in the device of FIG. 10 is from the exterior of elements 23, 33, 43 to the interior of the elements. As with FIG. 1 the flow of fluid within element 33 is characterized by a generally helical or spiral flow path in a direction opposite to the flow path of fluid flowing through elements 23 and 43. The rotating and counter-rotating portions of the fluid are mixed and combined in the

chamber **48** where the pulsations originally present in the inlet fluid are removed.

While it is not necessary for the satisfactory operation of the embodiments of **FIGS.** 8 , 9 and 10 , it is preferred that the slots of elements **23, 43** respectively be dimensioned so that the moment of momentum of fluid caused to be rotated by the elements **23, 43** in a first rotational direction is nearly equal to the moment of momentum of fluid caused to be rotated by the element **33** in the opposite rotational direction. In this manner, the resultant moment of momentum of the fluid is nearly zero at the outlet port of the housing.

The method of dampening pulsation by utilizing the principles of the invention described is also included within the scope of this invention. As best illustrated by **FIG.** 6 , both as a description of the method of dampening pulsation and as explanatory of the principles thereof, as embodied in **FIG.** 1 , the method of pulsation dampening according to the invention comprises the steps of providing a pulsation-containing flow of fluid shown generally by arrows **50** as flowing in a direction of the structure. A portion of the fluid is caused to be rotated in a counter-clockwise direction (as viewed from the inlet) as illustrated by arrows **51** and **52**. Another portion of the flow **50** is caused to be rotated in a clockwise direction (as viewed from the inlet), as shown by arrows **53** and **54**. Still another portion of the incoming fluid **50** is caused to be rotated in a counter-clockwise direction (as viewed from the inlet), or in the same direction as the portion rotated by element **23** as illustrated by arrows **55** and **56**. It can be seen that the direction of rotation induced by element **43** is opposite to that induced by the adjacent element. In the preferred embodiment, the moment of momentum or angular momentum in a counter-clockwise direction illustrated by arrows **51, 52, 55,** and **56** is nearly equal to the moment of momentum of fluid depicted by arrows **53** and **54** so that the resultant momentum at the outlet, shown by arrow **60,** is nearly zero.

Continuing with the method steps included within the scope of this invention, the rotating portions of fluid are then mixed or combined in a chamber prior to being discharged from the device. In **FIG.** 1 mixing also takes place in the interior of elements **33, 43**. In element **33** it may be expected that counter-clockwise rotating fluid from element **23** will be combined and mixed with clockwise rotating fluid in element **33** as both portions of fluid move axially into element **43**. Within element **43** a still further combining of the portions takes place as the counter-clockwise rotating fluid of elements **23** and **43** combines with the clockwise rotating fluid of element **33**. Chamber **40** of **FIG.** 1 provides a still further mixing zone for the fluid portions prior to discharge thereof through the outlet port **21**.

In the embodiment shown in **FIG.** 7 combining or mixing of the rotating and counter-rotating fluids takes place within element **33** and the chamber **40**. Thus, the counter-clockwise rotating fluid within element **23** flows axially into the interior of the element **33** where the fluid portion mixes or combines with clockwise rotating fluid entering the element **33** through slot **36**.

In the embodiment as shown in **FIG.** 8 the mixing zone is exterior of the elements **23, 33, 43.** Thus, whereas fluid from inlet **17** is initially conducted into the interior of the respective elements **23, 33, 43,** rotation is imparted to the respective fluid portions as they pass from the interior of a respective element to the chamber **48**. It is within the chamber **48** that mixing and combination of the respective fluid portions takes place as the entire fluid mass moves toward the outlet port **21**.

In the embodiment as shown in **FIG.** 9 incoming fluid from inlet port **17** is directed into the interior of the respective elements **23, 33, 43**. After passing through the respective elements, the various rotating and counter-rotating fluid portions are combined or mixed in chamber **48** prior to discharge from the outlet port **21**.

In the embodiment as shown in **FIG.** 10 the incoming fluid from the inlet port **17** is initially disposed about the exterior surface of the respective elements **23, 33, 43.** Movement of fluid portions into the interior of the respective elements **23, 33, 43** imparts clockwise and counterclockwise rotation to the respective portions as previously described. As the respective rotating and counter-rotating fluid portions move axially from the interior of the respective elements **23, 33, 43,** they mix and commingle in the chamber **48.** Thereafter, the entire fluid mass is discharged at the outlet port **21.**

The method of dampening pulsation by utilizing the principles of the invention described may be briefly summarized as comprising the steps of :

(a) Providing a pulsation containing flow of fluid at the inlet of a pulsation dampener;

(b) Rotating a portion of the fluid in a clockwise direction;

(c) Rotating another portion of the fluid in a counter-clockwise direction;

(d) Combining or mixing the rotating and counter-rotating portions; and

(e) Discharging the entire fluid mass from the pulsation dampener.

As previously described, it is not considered necessary for the satisfactory operation of the device to provide for equal amounts of rotating and counter-rotating fluid within the pulsation dampener. However, in the embodiments as described the relative length of the slots, the relative spacing of the walls defining the slots, the angles of inclination, and the overall dimension of the various elements may be varied to achieve the desired moment of momentum of portions of fluid.

As was previously pointed out, the particular details of pulsation travel and wave theory as applied to the method and apparatus of this invention are not well understood. Details of pulsation theory involve complicated problems of superimposed, steady and alternating fluid flows, the solutions of which far exceed present-day knowledge of acoustic theory and noise control. It is not uncommon, therefore, that structures and methods for dampening pulsations are devised empirically. Such is the situation with the apparatus and method of this invention. It is believed that underlying the effectiveness of the apparatus and method of this invention is the fact that the incoming fluid is divided into separate rotating and counter-rotating portions which, when mixed or combined in an atmosphere of turbulent flow, produce a high degree of pulsation dampening.

For ease of description, the principles of the invention have been set forth in connection with five illustrated embodiments. It is not my intention that the illustrated embodiments nor the terminology employed in describing them be limiting inasmuch as variations in these may be made without departing from the spirit of the invention. Rather I desire to be reflected only by the scope of the appended claims.

I claim:

1. A device comprising the combination of:

housing means including an inlet port and an outlet port providing for the flow of fluid therethrough,

first means disposed within said housing for rotating a first portion of a moving fluid in a first direction about an axis substantially parallel with said fluid flow, second means disposed within said housing for rotating a second portion of the moving fluid in a direction opposite to the rotational direction of said first portion,

combining means for the rotating first portion and the counter-rotating second portion,

whereby pulsation present in the fluid at the inlet port is effectively dampened.

2. The device as defined in claim 1 wherein said first and second means for rotating the fluid comprise a generally annular member having the end nearest said inlet port closed and the opposite end open to said outlet port and including:

a plurality of spaced-louvered slots in the wall of said annular member oriented and disposed so that the said first and second portions of said fluid enter the interior of said member from without said member through said slots, and are caused to rotate in opposite directions while axially flowing therethrough.

3. The device as defined in claim 2 further including means interconnecting said closed end of said annular member and said housing for supporting the said annular member within the housing.

4. The device as defined in claim 2 wherein said annular member comprises first and second annular elements joined end to end at open ends thereof,

a plurality of spaced-louvered slots in the wall of each of said elements so arranged that a respective portion of said fluid entering the interior of a respective element is caused to be rotated,

and said combining means is defined as the interior of the downstream element into which said first and second portions flow.

5. The device as defined in claim 4 wherein the slots of said first and second elements are dimensioned so that the amount of fluid caused to rotate within said first element is nearly equal to the amount of fluid caused to rotate said second element so that the resultant moment of momentum of said fluid is near zero at the outlet port of said housing.

6. The device as defined in claim 4 further including an annular bulkhead contained within said housing near said outlet port, an open end of said second element being connected to said bulkhead to permit flow of fluid from within said second element through said bulkhead to said outlet port.

7. The device as defined in claim 6 in which a chamber is provided between said bulkhead and said outlet port.

8. The device as defined in claim 2 wherein said annular member comprises a plurality of elements each having two open ends and a plurality of spaced-louvered slots in the walls of said elements so arranged that the portion of said fluid entering the interior of one of said plurality of elements through said slots is caused to rotate while axially flowing therethrough in a direction of rotation opposite to the direction of rotation of said fluid in an adjacent element and combine with the rotating fluid from the adjacent upstream element.

9. The device as defined in claim 8 further including an annular bulkhead disposed within said housing near the outlet port and connected to an open end of the element nearest said outlet port.

10. The device as defined in claim 8 wherein the slots of said element are dimensioned so that the amount of fluid caused to rotate in one rotational direction is nearly equal to the amount of fluid caused to rotate the opposite rotational direction.

11. The device as defined in claim 1 in which said first and second means for rotating portions of the fluid comprise a generally annular member having the end nearest said inlet port open and the opposite end closed and including,

a plurality of spaced-louvered slots in the wall of said annular member oriented and disposed so that the said first and second portions of said fluid flow to the exterior of said annular member from within said annular member and are caused to rotate in opposite directions.

12. The device as defined in claim 11 in which said combining means is defined as a chamber exterior of said annular member and into which said first and second portions flow.

13. The device as defined in claim 12 further including an annular bulkhead contained within said housing near said inlet port, the open end of said annular member being connected to said bulkhead.

14. The device as defined in Claim 1 in which said first and second means for rotating portions of the fluid comprise at least two annular elements disposed within said enclosure means, each element having an open end and a closed end and a plurality of spaced-louvered slots in the walls thereof oriented and disposed so that the said first and second portions of said fluid flow through respective walls of said elements and are caused to be rotated in opposite directions.

15. The device of claim 14 in which fluid flow through the respective walls is from within the element to without the element.

16. The device of claim 15 in which there is included an apertured bulkhead contained within said housing near said inlet port, the open end of said elements being connected to said bulkhead with the closed end downstream of said open end.

17. The device of claim 16 in which said combining means is defined as a chamber defined by said housing means and said bulkhead downstream of said elements.

18. The device of claim 14 in which fluid flow through the respective walls is from without the element to within the element.

19. The device of claim 18 in which there is included an apertured bulkhead contained within said housing near said inlet port, the open end of said elements being connected to said bulkhead with the closed end upstream of said open end.

20. The device of claim 19 in which said combining means is defined as a chamber defined by said housing means said bulkhead downstream of said elements.

21. The method of dampening fluid pulsation comprising the steps of:

(a) providing a pulsation-containing flow of fluid at the inlet of a housing,

(b) rotating a first portion of said fluid in a first rotational direction about an axis substantially parallel with said flow,

(c) rotating a second portion of said fluid in a direction opposite the said first direction,

(d) combining the oppositely-rotating portions of said fluid, whereby pulsation contained within said fluid at said inlet is effectively dampened.

22. The method as defined in claim 21 further characterized in that a third portion of said fluid is rotated in one of said directions and combined with said first and second portions.

23. The method of claim 21 further characterized in that the amount of fluid rotated in one direction is substantially equal to the amount of fluid rotated in the opposite direction.

24. The method of dampening fluid pulsation in a fluid line having a first axis comprising the steps of:

(a) imparting angular momentum about an axis substantially parallel with said first axis in a first vector direction to at least one portion of the fluid,

(b) imparting angular momenutum in a vector direction opposite to said first vector direction to another portion of the fluid,

(bC) mixing said one portion and said another portion, whereby fluid pulsation is effectively dampened.

25. The method of claim 24 wherein the angular momentum of the fluid rotating in one direction is substantially equal to the angular momentum of the fluid rotating in the direction opposite thereto.