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3,030,979

INDUCTION FLUID AMPLIFIER

Filed Nov. 16, 1960

3 Sheets-Sheet 1

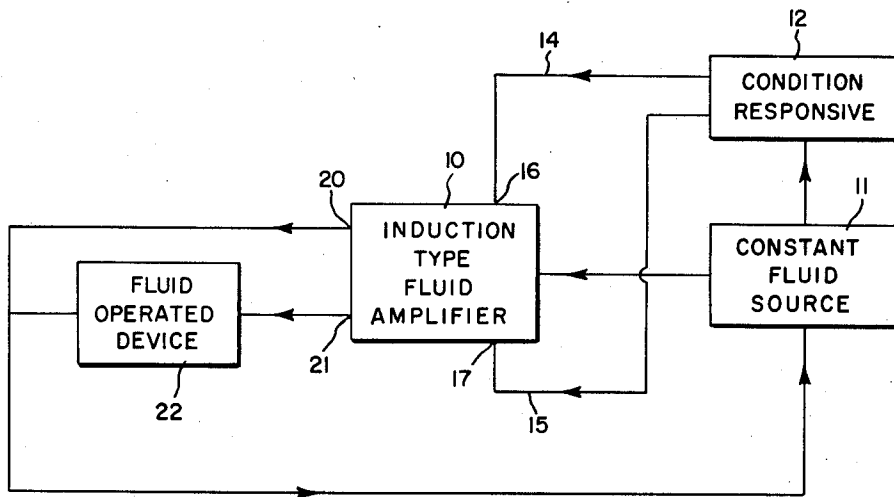


Fig-1

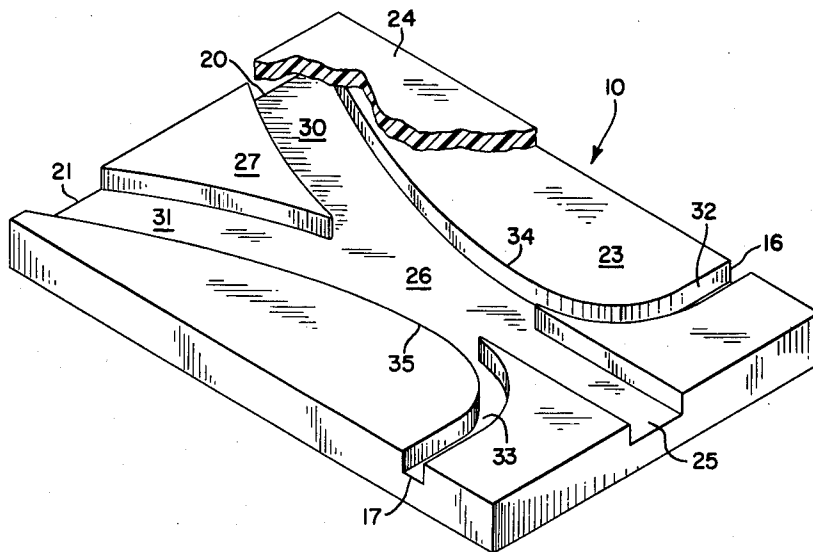


Fig-2

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3 Sheets-Sheet 2

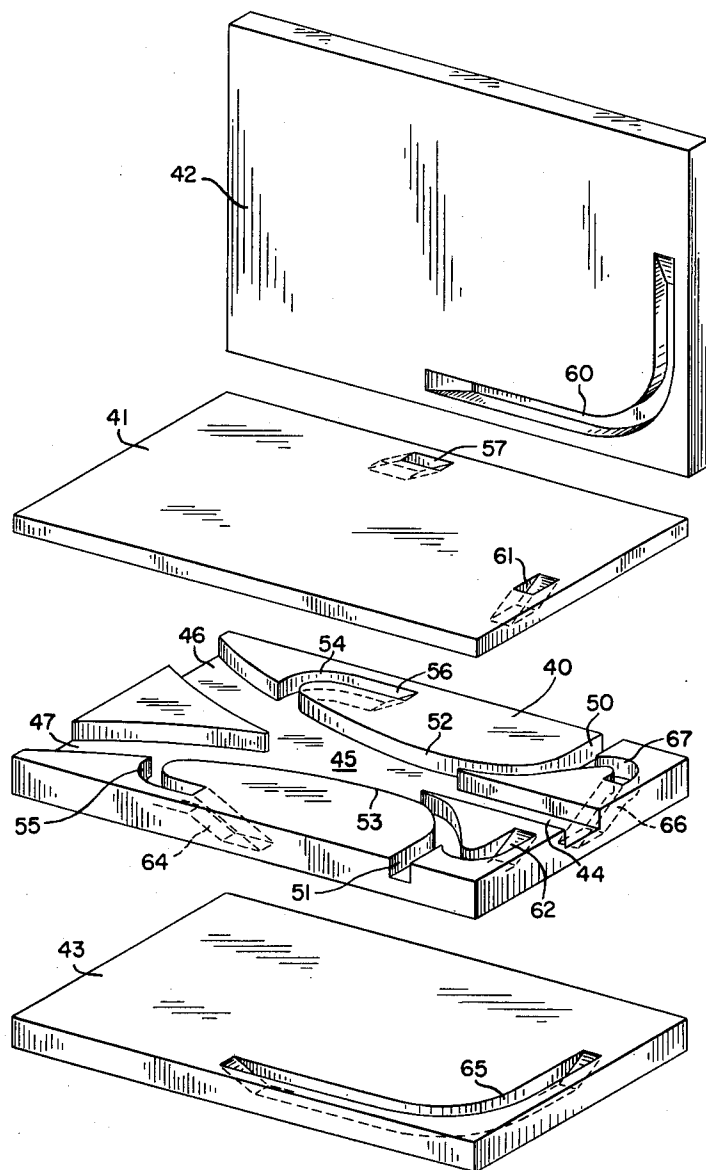


Fig. 3

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INDUCTION FLUID AMPLIFIER

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13 Claims. (Cl. 137—624.14)

The present invention is directed to a unique type of induction fluid amplifier or element that utilizes the viscous forces existing between flowing fluids and associated fluids or fixed partitions. More specifically, the present invention is directed to a fluid flow element or system that utilizes no moving parts in control of a main fluid stream by the use of an inducing controlled fluid stream.

A continuing effort has been underway to simplify and thereby improve the reliability of various systems. This is true in fluid control systems where the fluid control devices have been improved by the reduction in the number of movable parts. In the process of simplification, it has been felt that it would be desirable to have a fluid control system which utilizes no moving parts other than the controlled fluid. Certain systems have either approached or reached this optimum condition and rely basically on a transfer of momentum or pressure differentials for their operation. These systems undoubtedly are ideal for certain applications but there is an area of application that requires other approaches. The present invention helps complete the grouping of fluid control elements or amplifiers that utilize fluid characteristics as a means of control as opposed to mechanically movable elements.

More specifically, it has been recognized that a fluid flowing continuously from a nozzle can be diverted from a straight line by jets applied to the side of the main fluid nozzle. The jets cause fluid to impinge on the main fluid jet, thereby diverting it to a side. This type of unit has been long recognized and utilizes a momentum transfer arrangement for operation. That is, the momentum of the side jet impinging on the center or primary jet causes the primary jet to be diverted. The diversion of the primary jet can then be used for a control function. This type of arrangement is desirable in certain systems but has certain defects, including the requirement that the impinging flow be of substantial momentum in order to move the higher volume center flow from what would be its ordinary course of travel. The momentum transfer principle has been used for years in certain types of devices but is not acceptable for certain types of amplification because of the high amount of energy required in the side jets.

More recently, a fluid control element or system has been developed which utilizes a main or center fluid flow and a side jet which diverts the main or center flow. The diversion, once it occurs, is stable because of a pressure differential which occurs across the main fluid flow stream by means of the walls of the system that contain the fluid flow. More specifically, in a system of this nature, the main fluid flow is diverted by a side jet and the side jet moves the main control flow by a momentum type principle. Once the fluid has moved, it locks itself onto a wall of the fluid flow passage because the high velocity of the fluid flow along the wall creates a lower pressure than the velocity of the outer surface along an open area adjacent the other wall of the fluid flow passage. This pressure differential keeps the main fluid flow locked to the outer wall until the pressure differential is relieved. This can be accomplished by energizing a jet on the side opposite from the original jet and thereby relieving the pressure. The second jet can be used either to relieve the pressure or to direct the main stream of

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flow back to its original position. The momentum transfer and pressure locking arrangement operate well in certain applications but still do not provide the answer in certain other conditions as does the invention of the present application.

The present invention is specifically directed to a fluid amplifier element or system wherein a flow of fluid is supplied constantly to a primary nozzle in a closed fluid system. The constant flow passes out of the nozzle and down one or more fluid channel outlets. In order to move the main fluid flow from its normal flow, it is possible to interject a fluid flowing parallel to the original fluid flow from a side orifice or secondary inlet. The secondary inlet flow is directed down a wall of one of the outlets of the amplifier element and attaches itself to the wall due to the viscous forces which exist in the fluid. As long as the fluid is flowing along the wall there are no major forces which tend to divest it of its attachment to the wall. The flow of the fluid along the wall, from a control or secondary orifice, induces the main fluid flow from the primary outlet to follow along with the secondary flow due to the viscous forces that exist between the two flowing fluids.

With the arrangement just described, there is practically no transfer of momentum from the side inlets or secondary fluid flow inlets to the primary fluid flow inlet, but merely a control function by an attraction between the two fluid flows due to the viscous forces that exist between these two flows. The flow of the primary inlet in no way locks to the walls of the outlets but merely follows the guide or secondary flow as long as the secondary flows exists. If the secondary flow is caused to stop, the primary inlet flow would revert to its original direction and flow outlets.

By utilizing this concept it is possible to build a fluid control element or amplifier that utilizes the viscous forces for controlling a main fluid flow by reason of the secondary fluid flows from one or more inlets along the various outlet paths from the fluid control elements. This arrangement will be described in detail in connection with the present specification and will be explained in various versions of specific physical configurations.

It is a primary object of the present invention to provide a basic fluid control element or fluid control system which can control any type of fluid material without the need of a single moving part.

Another object of the present invention is to provide an amplifier element that utilizes the viscous forces existing between a flowing fluid and either a fixed wall or another flowing fluid to gain control of a large fluid flow with a relatively small controlled fluid flow.

Yet another object of the present invention is to provide a fluid control element or system that provides a control function, such as amplification of a small fluid signal to a large signal, and yet uses no moving parts.

Yet a further object of the present invention is to provide a fluid control element that can be responsive to its own output to yield a stable condition or an oscillatory condition, depending on the arrangement of the feedback of the output to the input of the unit.

And still another object of the present invention is to provide a basic fluid control element that can be used by itself or in cascade to control a fluid flow without the use of valves, veins, or other mechanically movable expedients.

These and other objects of the present invention will become apparent when the present specification and drawings are fully considered.

In the present drawings,

FIGURE 1 is a schematic representation of a typical system utilizing an induction type fluid amplifier;

FIGURE 2 is an isometric view of a simple induction fluid amplifier element itself;

FIGURE 3 is an exploded isometric view of a fluid amplifier element that utilizes feedback arrangements to in turn provide an oscillatory output; and,

FIGURE 4 is a diagrammatic view of the device of FIGURE 3 in one plane with the interconnecting fluid paths shown external to the unit for clarity's sake.

The schematic system disclosed in FIGURE 1 incorporates an induction type fluid amplifier at 10 of the type disclosed in the present application. The fluid amplifier 10 is fed from a constant fluid source 11 and is controlled through a condition responsive device 12. The fluid condition responsive device 12 is shown as obtaining its energizing fluid from the constant fluid source 11 and providing two outputs 14 and 15 to the secondary fluid inlets 16 and 17 of the induction fluid amplifier 10. The manner in which this control comes about will become apparent with the discussion of the detailed FIGURES 2 and 3. The induction type fluid amplifier 10 has a pair of fluid flow outlet means 20 and 21. The outlet 20 is connected directly back to the constant fluid source 11 while the outlet means 21 is connected to a fluid operated device 22. The output of the fluid operated device 22 is then fed back to the constant fluid source 11.

The system disclosed in FIGURE 1 could be compared to the following typical heating system. The constant fluid source 11 could be a hot water boiler and pump which supply hot water to the induction type fluid amplifier 10. The hot water is either passed around the fluid operated device 22, which would be a radiator, or through the device 22. Depending on whether the fluid flowed around the device 22 or through it, the space in which the radiator was located would be heated. The condition responsive device 12 could be a thermostat which utilizes hot water from the constant fluid source 11 and in turn controls the induction type fluid amplifier 10 by either causing flow into the secondary fluid inlet 16 to bypass the fluid operated device 22, or in the secondary fluid inlet means 17 to cause the main flow to pass through the fluid operated device 22. It can thus be seen that the system of FIGURE 1, while being schematic in nature, could readily represent a heating system and plant utilizing thermostatic control over the flow of hot water through the system. The details of the induction type fluid amplifier 10 will now be explained in connection with FIGURES 2 and 3.

In FIGURE 2 the induction fluid amplifier 10 is made up of a flat plate 23 which has a number of grooves or channels cut into it. These channels could be drilled or formed to have any configuration. They do not have to be rectangular. The plate 23 is covered by a plate 24 to form a fluid-tight system of channels. The manner in which the plates 23 and 24 are clamped or sealed together is not material but could be accomplished by bonding of the plates by means of an adhesive, clamping of the plates together, or screwing them together by any other means, not shown. All that is required is that the plates 23 and 24 form a fluid-tight arrangement so that fluid can flow through specific channels that will be detailed below.

A primary fluid inlet means 25 is disclosed as a rectangular channel cut into plate 23. The primary fluid inlet means 25 is directed into a larger cavity 26 which is separated by divider 27 into a flow outlet means in the form of two individual channel means 30 and 31. Outlet channel 30 has an outlet 20 and channel 31 has an outlet 21, both of which correspond to the outlets disclosed in FIGURE 1.

At this point it is obvious that if a fluid were introduced on the primary fluid inlet 25, it would flow into the chamber 26 and then split equally between the outlet channels 30 and 31. It is the object of the present invention to cause the fluid entering into the primary fluid inlet 25 to be wholly diverted into either channel 30 or into channel 31, as selected by an outside condition. To some

extent modulation is possible, if desired. In order to make this selection, two additional channels 32 and 33 are provided. Channels 32 and 33 are of smaller cross section than the balance of the channels as they are the control elements and require a much smaller flow than is present in the primary fluid channel 25. The secondary fluid inlet means or channels 32 and 33 have inlets 16 and 17 to correspond to the disclosure in FIGURE 1. The channel 32 and the channel 33 gradually slope in and follow the walls 34 and 35 of the plate 23 so that any fluid introduced into the inlets 16 or 17 pass through the channels 32 or 33 and then continue along adjacent to their respective wall 34 or 35.

At this point it should be pointed out that the plates 23 and 24 can be manufactured of any convenient material which is compatible with the fluid to be used. If the fluid being utilized is such as water or air, the plates 23 and 24 could readily be made of plastic, metal, ceramic, or any other common type of material. It can be readily seen that the various channels can be milled or cast into the surface of the plate 23 and then sealed fluid-tight by the plate 24 being cemented to the top of plate 23.

In operation, a fluid, such as water, entering the primary fluid inlet 25 would flow equally into the outlet channels 30 and 31. If a signal is introduced, say into the secondary fluid inlet 16, and passes through the channel 32, it would flow along the wall 34 and out of the outlet channel 30. The control fluid passing through channel 32 adheres to the wall 34 due to the viscous forces that exist between a flowing fluid and a fixed wall or secondarily flowing fluid. The flow of the control fluid along the wall 34 would attract through these viscous forces the fluid being injected into the primary fluid inlet 25. All of the fluid coming into the inlet 25 would thus divert and pass out of the outlet channel 30 and through the outlet opening 20. It should be noted that the cross sectional area of the channel 30 normally is equal to or larger than the cross sectional area of the primary inlet channel 25 combined with the cross sectional area of the channel 32.

If at any time it is desired to cause the flow of fluid to cease passing through the outlet channel 30, it is only necessary to introduce a fluid flow to opening 17 and thus into channel 33. At the same time the fluid being introduced into channel 32 would be cut off and the only fluid being introduced for control purposes would pass into and along channel 33 following wall 35. This would then attract the primary flow from the inlet 25 through the outlet channel 31 and outlet 21. It can thus be seen that, by introducing a slight fluid flow in a proper control channel, a larger fluid flow can be diverted from a primary inlet to one of a group of specific outlets. If the control signal is removed from both the inlets 16 and 17, any fluid flowing into the inlet means 25 would split substantially equally, depending on the geometry of the chamber 26 and the outlets 30 and 31.

On tests of the device of the type disclosed, fluid response has been excellent in that the fluid flowing in the primary inlet 25 was switched between the outlets 30 and 31 by the introduction of a small control signal. For this reason it can be seen that an amplifier has been built and tested which utilizes a unique principle that allows for switching of a flowing fluid between two outlets without the use of any moving parts.

In FIGURES 3 and 4 there is disclosed an oscillator utilizing the principles disclosed in connection with FIGURES 1 and 2. The oscillator in FIGURES 3 and 4 does not fit the schematic representation of FIGURE 1 but is an entirely different type of induction type fluid amplifier that operates on the principles disclosed previously. More specifically, a plate 40, having a plurality of channels cut into it, is supplied along with cover plates 41, 42, and 43. The cover plates 41, 42, and 43 have various interconnecting channels cut into them and when the plates 40 through 43 are assembled, by any conven-

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ient means, a number of interconnecting passages are developed that did not exist in the device disclosed in FIGURE 2. The plate 40 has a primary fluid inlet 44 which empties into a chamber 45 that in turn supplies fluid to two outlet channels 46 and 47. These areas correspond exactly with the similar areas in FIGURE 2.

Two secondary inlet channels are provided at 50 and 51 and correspond to the channels 32 and 33 of FIGURE 2. The inlet channels 50 and 51 have flow directed along walls 52 and 53 so that any fluid entering the passages 50 or 51 flows along their adjacent wall and down to the outlets 46 and 47. To this point the description of FIGURE 3 is identical to the configuration of FIGURE 2.

In addition, two feedback channels are disclosed in FIGURE 3 that provide fluid flow in the unit so that the unit will oscillate. More specifically, a pair of feedback channels starting at 54 and 55 are provided in the walls 52 and 53. Each of the feedback channels 54 and 55 are designed to scoop part of the fluid flowing along the adjacent wall into the channel or feedback passage thereby providing fluid that will flow through the following described passages. In connection with the feedback channel 54, a passage 56 is provided which passes up into plate 41 by means of opening 57 and then into plate 42 and the elongated passage 60. The elongated passage 60 provides an opening to a hole 61 that passes back through the plate 41 to a passage 62 that interconnects into the channel 51. It can thus be seen that when all of the plates are laminated together, the passage or feedback channel 54 connects the output channel 46 through the passage 56, hole 57, passage 60, hole 61, and passage 62 into the secondary inlet channel 51 to provide a fluid flow along wall 53.

A second feedback passage starting at 55 passes down through the plate 40 along 64 into an elongated groove 65 in plate 43 and then back up into a groove 66 which connects at 67 into the secondary fluid inlet 50. In this case, some fluid flowing down along the wall 53 is picked up by the feedback passage 55 and is fed back through the associated passages to the inlet channel 50, thereby providing a cross linkage between the outlet 47 and the secondary fluid inlet at 50.

A description of operation of this particular unit will aid understanding of the constructional details. If fluid is injected in the main inlet 44 and passes into the chamber 45, it would divide equally between the outlets 46 and 47. By supplying a control pulse of fluid into the inlet passage 50, fluid would flow along the wall 52 and down to the feedback passage 54 as well as out of the outlet 46. This would immediately induce all of the fluid flowing in the primary inlet 44 to shift along wall 52 and would create a flow into the inlet of the feedback passage 54. This feedback fluid then passes up through the plates 41 and 42 and crosses over the unit, coming back down into the inlet 62 and secondary fluid inlet 51. The flow of fluid into the chamber 45 from the secondary inlet 51 causes all of the fluid to shift from the wall 52 over to the wall 53. This immediately causes a feedback flow into the feedback passage 55 which is connected back to the secondary inlet 50. This again causes the unit to switch from flow along wall 53 to wall 52. It can thus be seen that an oscillatory function occurs once the unit has been started.

In a unit of the type disclosed in FIGURES 3 and 4, an oscillator which has a continuous change of function has been fully described. This unit can be modified in many ways. More specifically, a feedback passage could be utilized connecting one of the outlet passages to its own control secondary inlet thereby locking the system on one wall once the unit had started. This would entail a single feedback passage without the cross-over feature.

In the description of the devices in FIGURES 1 to 4, the term "fluid" has been used in its broadest sense. The

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fluid could be in the form of a gas, a liquid, a combination of a gas and a liquid, or any other type of material which will flow under pressure. It should further be understood that the fluid flowing in the primary inlet can be wholly different from the fluid being used to control the device as long as there is a sufficient energy in the viscous layer that connects the two fluids as they flow along the walls of the fluid amplifier. It is further noted that the term "element" has been used in referring to the present device, but it is noted that the present device could be readily considered an over-all system or fluid amplifier as well as an individual element. The elements utilized could be cascaded so that one would control a succeeding element. More specifically, it would be possible to utilize an induction fluid amplifier 10 of FIGURE 1 and a pair of induction fluid amplifiers in the condition responsive device at 12 so that one fluid amplifier was used to control a succeeding fluid amplifier.

Since the device disclosed in the present application is of an exceedingly basic nature, it is obvious that endless numbers of modifications and variations are possible. As such, the applicant wishes to be limited in the scope of his invention only by the scope of the appended claims.

I claim as my invention:

1. A fluid control element having primary fluid inlet means supplied with a fluid to be controlled; fluid flow outlet means; secondary fluid inlet means adjacent said primary fluid inlet means and having an opening directed along a wall of said outlet means; and a secondary fluid flow issuing from said secondary inlet means following along said wall; said secondary fluid flow inducing said primary flow to follow said secondary flow in said fluid flow outlet means by forces existing between said flows.

2. A fluid amplifier having primary fluid inlet means supplied with a fluid to be controlled; fluid flow outlet means; control fluid inlet means adjacent said primary fluid inlet means and having an opening directed along a wall of said outlet means; and a control fluid flow of substantially smaller magnitude than said controlled fluid issuing from said control inlet means following along said wall; said control fluid flow inducing said controlled flow to follow said control flow in said outlet means by forces existing between said flows.

3. A fluid control element having primary fluid inlet means supplied with a fluid to be controlled; fluid flow outlet means; secondary fluid inlet means adjacent said primary fluid inlet means and having an opening directed along a wall of said outlet means; and a secondary fluid flow of a second fluid issuing from said secondary inlet means following along said wall; said fluid flow outlet means capable of handling both said fluid flows; said secondary fluid flow inducing said primary flow to follow said secondary flow in said fluid flow outlet means by viscous forces existing between said flows.

4. A fluid control element having a primary fluid inlet supplied with a fluid to be controlled; a plurality of fluid flow outlets; secondary fluid inlet means adjacent said primary fluid inlet and having an opening directed along a wall of one of said outlets; and a secondary fluid flow issuing from said secondary inlet means following along said wall; said fluid flow outlets each being capable of handling said fluid flows; said secondary fluid flow inducing the flow from said primary inlet to follow said secondary flow in said fluid flow outlet having said wall by forces existing between said flows.

5. A fluid control element having a primary fluid inlet continuously supplied with a fluid to be controlled; a plurality of fluid flow outlets; a secondary fluid inlet adjacent said primary fluid inlet and having an opening directed along a wall of one of said outlets; and a secondary fluid flow of said fluid issuing from said secondary inlet and following along said wall; said fluid flow outlets each being capable of handling both of said fluid flows; said secondary fluid flow inducing substantially all of said primary flow from said primary inlet to follow said sec-

ondary flow in the fluid flow outlet having said wall by viscous forces existing between said flows.

6. A fluid control element having primary fluid inlet means supplied with a fluid to be controlled; two fluid flow outlet channels; two secondary fluid inlets each adjacent opposite sides of said primary fluid inlet means and each having an opening directed along an adjacent wall of said outlet channels; and a secondary fluid flow issuing from a selected one of said secondary inlets and following along said adjacent wall; said secondary fluid flow inducing said primary flow to follow said secondary flow by the forces existing between said flows.

7. A fluid control element having primary fluid inlet means supplied with a fluid to be controlled; two fluid flow outlet channels; two secondary fluid inlets each adjacent opposite sides of said primary fluid inlet means and each having an opening directed along an adjacent wall of said outlet channels; and a secondary fluid flow of a second fluid issuing from a selected one of said secondary inlets and following along said adjacent wall; each said outlet channel being capable of handling both of said fluid flows; said secondary fluid flow inducing said primary flow to follow said secondary flow by the viscous forces existing between said flows.

8. A fluid amplifier having a primary fluid inlet continuously supplied with a fluid to be controlled; two fluid flow outlet channels; two control inlets each adjacent opposite sides of said primary fluid inlet and each having an opening directed along an adjacent wall of said outlet channels; and a control fluid flow of substantially smaller magnitude than said controlled fluid issuing from a selected one of said control inlets and following along said adjacent wall; said control flow inducing said controlled flow to follow said control flow by the viscous forces existing between said flows.

9. A fluid control element having a primary fluid inlet continuously supplied with a fluid to be controlled; two fluid flow outlet channels; two secondary fluid inlets each adjacent opposite sides of said primary fluid inlet and each having an opening directed along an adjacent wall of said outlet channels; and a secondary fluid flow issuing from a selected one of said secondary inlets and following along said adjacent wall; each said outlet channel being capable of handling both of said fluid flows; said secondary fluid flow inducing substantially all of said primary flow to follow said secondary flow in the outlet channel adjacent said selected secondary inlet by the viscous forces existing between said flows; said primary flow changing to the other outlet channel upon said secondary fluid flow issuing from the other of the secondary inlets instead of the first selected secondary inlet.

10. A fluid control element having primary fluid inlet means supplied with a fluid to be controlled; fluid flow outlet means; secondary fluid inlet means adjacent a side of said primary fluid inlet means and having an opening

directed along an adjacent wall of said outlet means; feedback flow means connecting said outlet means to said secondary fluid inlet means; and secondary fluid flow issuing from said secondary inlet means and following along said adjacent wall; said secondary fluid flow inducing said primary flow to follow said secondary flow by the forces existing between said flows with said feedback channel means supplying fluid from said outlet means to said secondary fluid inlet means.

11. A fluid control element having primary fluid inlet means continuously supplied with a fluid to be controlled; a plurality of fluid flow outlets; secondary fluid inlet means adjacent a side of said primary fluid inlet means and having an opening directed along an adjacent wall of said outlet means; feedback channel means connecting an outlet to said secondary fluid inlet means; and secondary fluid flow issuing from said secondary inlet means and following along said adjacent wall; said secondary fluid flow inducing said primary flow to follow said secondary flow by the viscous forces existing between said flows with said feedback channel means supplying fluid from said outlet to said secondary fluid inlet means.

12. A fluid control element having a primary fluid inlet continuously supplied with a fluid to be controlled; two fluid flow outlets; two secondary fluid inlets adjacent opposite sides of said primary fluid inlet and each having an opening directed along an adjacent wall of said outlets; a feedback channel connecting at least one of said outlets to at least one of said secondary fluid inlets; and secondary fluid flow issuing from one of said secondary inlet and following along said adjacent wall; each said outlets being capable of handling substantially all of said fluid flows at any one time; said secondary fluid flow inducing said primary flow to follow said secondary flow by the viscous forces existing between said flows with said feedback channel means supplying fluid from said outlet to said secondary fluid inlet.

13. A fluid oscillator element having a primary fluid inlet continuously supplied with a fluid; two fluid flow outlets; two secondary fluid inlets adjacent opposite sides of said primary fluid inlet and each having an opening directed along an adjacent wall of said outlets; a feedback channel connecting each outlet to a secondary fluid inlet on the opposite side of said primary inlet; and secondary fluid flow issuing from said secondary inlets and following along the adjacent walls; each said outlets being capable of handling all of said fluid flows; said secondary fluid flow inducing said primary flow to follow said secondary flow by the viscous forces existing between said flows with said feedback channels supplying fluid from said outlets to said secondary fluid inlets alternately thereby switching said primary fluid flow between the fluid flow outlets.

No references cited.