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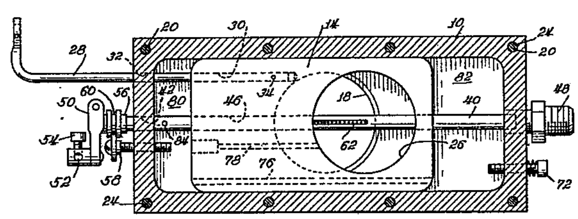
(54) **Fluid mixing device - carburetor.**

(57) A fluid mixing device in the form of a carburetor is described which has a system for metering fuel. The carburetor includes an air passageway (16, 18), and a throttle valve (14) which has a throttle aperture (26) and is movable across the air passageway (16, 18) to control the effective cross-sectional dimension of the throttle opening. The fuel metering system includes a fuel metering tube (40) extending through a complimentary lateral aperture (46) in the throttle valve such that the throttle valve (14) is slidable upon the metering tube (40). A longitudinal fuel distribution outlet extends (62) along one side of the fuel metering tube and the effective length of the distribution outlet (62) is controlled in dependence on the cross-sectional dimension of the throttle opening by the position of the throttle valve (14). The flow of fuel through the distribution outlet (62) is further controlled in relation to the pressure of air in the air passageway (16, 18), in a number of ways.



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Fluid Mixing Device - CARBURETOR

This invention relates to a fluid mixing device and in particular, though not exclusively, to a carburetor having a fuel metering system for supplying a homogeneous mixture of fuel and air across the throttle opening of the carburetor while precisely controlling fuel and air flow rates.

For so long as internal combustion engines have been in existence, various carburetors have been developed to supply a required air-fuel mixture to the engine to promote proper and efficient combustion. Although myriads of carburetion schemes and devices have deen developed, a continuing problem has been metering of the air-fuel mixture in a consistently homogeneous blend such that the air-fuel mixture received by each cylinder of the internal combustion engine is the same as that supplied to each other cylinder.

In addition, not only is it important to control the homogeneity of the fuel-air mixture, it is also important to control the actual quantity of the fuel injected into the air stream in relation to the density of the air passing through the carburetor. Thus, when the air density decreases, it is important to also reduce the fuel flow rate so that the air-fuel blend supplied to the internal combustion engine is not fuel rich. This is particularly important in aircraft, where at high altitudes, the air density is considerably reduced. A commensurate reduction in the flow rate of the fuel must be made in order to properly lean the mixture to avoid fuel waste or possible engine flooding.

In conventional carburetors or fuel injection systems, the velocity of the air passing through a venturi portion is assumed to correspond directly to the air mass flow. This assumption remains correct so long as there is no change in air density. If the ambient air temperature or pressure does change, then the resultant change in density invalidates this assumption and the carburetor or injection system experiences a change in air-fuel ratio. If the air density increases, then the air-fuel ratio becomes leaner and if the air density decreases, then the air-fuel ratio becomes richer. In most carburetor applications except aircraft the recent low cost of fuel has made mixture control not cost effective. In aircraft, where density-related mixture changes due to altitude result in large power reductions, mixture control has always been a necessary feature.

The venturi system of measuring air flow and metering fuel is based upon the Bernoulli principle as expressed by the Bernoulli equation as follows:

$$1/2\ V^2 + P/\rho = \text{Constant}$$

Where P = Pressure, V = airflow velocity, ρ = air density

As the Bernoulli equation applies to air flow in a venturi, it can be rewritten as follows:

$$1/2\ (V_2^2 - V_1^2) + \frac{P_2 - P_1}{\rho} = 0$$

or,

$$1/2\ (V_2^2 - V_1^2) = \frac{P_1 - P_2}{\rho}$$

with the subscripts 1 and 2 referring to different axial locations in the flow tube. If the velocity at location 2 is high (such as occurs at the throat of a venturi) the pressure is lower than the pressure at a location where the velocity is low. From the Bernoulli equation, it is seen that the amount of pressure difference is much greater than the velocity difference because the velocities in the equation are squared.

The pressure that is sensed in a direction perpendicular to the direction of local flow in a venturi is the static pressure and is equal to that which would be sensed by a pressure instrument moving with the air flow. The pressure that is sensed by a probe inserted in the flow path and oriented with its opening facing the oncoming air is defined as the total pressure. The difference between the total pressure and the static pressure is the dynamic pressure and is related to the flow velocity by Bernoulli's equation as follows:

$$P_T - P_S = 1/2 \rho V^2$$

In the absence of friction, the total pressure remains constant along the length of a flow tube or venturi. In an area where the flow velocity increases due to a constriction in flow area, the static pressure is commensurately low.

Slide-type carburetors consisting of an air passage and a throttle plate movable to provide an adjustable throttle opening to alterably constrict the air passageway have been in existence for some time, as evidenced by U.S. Patents No. 3,709,469 and 3,957,930. Such devices provide for throttling of the air flow in combination with mechanical control of the fuel quantities added to the carburetor. However, because fuel is injected into one side of the throttle opening in either of these devices, they suffer from an inability to supply a homogeneous air-fuel mixture across the throttle opening and do not permit a full range of air-fuel mixture control.

Other devices are known for metering fuel flow across the throat of a carburetor, as evidenced by U.S. Patents No. 1,142,763 and 4,205,024. While such devices do permit fuel distribution effectively across the carburetor, it is difficult with such devices to adjust the air-fuel mixture as the carburetor air passageway is throttled.

The present invention seeks to provide a fluid mixing device, preferably in the form of a carburetor, which overcomes the above-delineated short comings of the prior art,and others.

Accordingly the invention provides fluid mixing device comprising: a fluid passageway for a first fluid, an adjustable throttle valve which has a throttle aperture which is so arranged in relation to the passageway so as to form in the passageway a throttle opening of controllable cross-sectional dimension, and a fluid metering system means for supplying a second fluid to the passageway through a distribution outlet which extends across the passageway and the effective length of which is determined by the cross-sectional dimension of the throttle opening, and means for altering the proportionate flow of the second fluid through the distribution outlet in relation to the flow of the first fluid in the passageway.

Preferably the fuel metering system means incorporates a fuel metering tube which extends across the throttle opening. The distribution outlet is preferably located in metering tube for metering of fuel across the entire width of the throttle opening, not matter what size throttle opening is presented.

In one embodiment of the invention, the fuel metering system includes means to alter the flow of fuel through the distribution outlet by changing the orientation of the fuel metering tube from a maximum lean position, where fuel flow may be essentially eliminated, to a full fuel flow position, thereby providing the richest possible air-fuel mixture.

In this embodiment, in order to alter the flow of fuel through the fuel distribution outlet, the fuel metering tube preferably is rotatable about its longitudinal axis to change the circumferential location of the distribution outlet. The outlet is positionable between a maximum lean condition facing upstream in the direction of air passage, and a maximum rich condition 90 degrees therefrom in which the distribution outlet faces across the path of air flow.

In another embodiment of the invention, the fuel supply comprises a fixed metering tube having its distribution outlet extending along one side and oriented perpendicular to air flow through the throat of the carburetor. In order to control the fuel flow, a pressure detecting tube is located in communication with the air passageway to sense a portion of the dynamic pressure of the air as it passes through the carburetor. This detected pressure is then used to maintain the pressure of the fuel at the detected pressure as the fuel is introduced into the fixed metering tube.

In this second embodiment of the invention, the detecting tube has an inlet in one side and is very similar to the fuel metering tube of the first embodiment of the invention. The detecting tube is rotatable to change the circumfernetial location of the inlet and therefore change the amount of the dynamic air pressure that is sensed Therefore, because of the rotatable nature of the detecting tube, the tube can be made to sense any pressure between the total pressure and the static pressure of the air flow.

In order to control the fuel flow in this embodiment of the invention, the invention includes a balancing regulator which is regulated by the sensed pressure. The balancing regulator has an inlet on one side for the fuel, and includes a control responsive to the sensed pressure and operable to permit the flow of fuel through the fuel inlet at such a rate so as to maintain equality between fuel pressure and the sensed pressure.

In another embodiment of the invention, the fuel metering tube is also fixed with the distribution outlet extending perpendicular to the air flow. A pressure transmitting tube having one end extending into the air flow is oriented to detect the total pressure of the air. A second pressure transmitting tube has one end extending into the air at the throttle passageway in order to detect the static pressure of the air passing therethrough. The tubes are joined at their other ends and a third pressure transmitting tube leads from this junction to a balancing regulator to control pressure of the fuel. The second pressure transmitting tube has a valve operable to permit a portion of the total pressure in the first pressure transmitting tube to bleed into the second pressure transmitting tube, leaving a resultant differential pressure in the third pressure transmitting tube. The resultant differential pressure is used to control the pressure of the fuel as it is introduced into the fuel outlet.

In this embodiment of the invention, a balancing regulator is again used to control the fuel flow. The balancing regulator senses the differential pressure and has an inlet for the fuel. The regulator includes a fuel control responsive to the sensed differential pressure and operable to permit flow of fuel through the fuel inlet at such a rate so as to maintain equality of pressure between the fuel and the sensed differential pressure.

In both latter embodiments of the invention, the fuel is delivered to the inlet of the balancing regulator from some external source such as a fuel pump or elevated fuel reservoir. The balancing regulator therefore is used to reduce the pressure of the fuel to the required pressure before fuel is permitted to enter the fuel metering tube.

In accordance with the invention, the fuel metering system comprises a normally axially stationary fuel metering tube extending across the throttle opening. In one form, the distribution outlet in the fuel metering tube comprises a plurality of apertures spaced axially along one side of the metering tube. In another form, the distribution outlet comprises an axial slot along one side of the metering tube. In all cases, the metering tube preferrably is positioned in registration with the throttle valve and extends through a complimentary lateral aperture in the throttle valve. The throttle valve is slidable upon the metering tube to adjust the throttle opening and change the effective length of thefuel distribution outlet. Therefore, no matter how large the throttle opening, a uniform distribution of fuel is maintained across the throttle opening.

The throttle valve is adjustable between limits to provide a maximum throttle opening and a minimum throttle opening. In order to precisely control the fuel-air mixture at the minimum throttle opening, the axial location of the fuel metering tube can be adjusted. Thus, a greater or lesser portion of the distribution outlet can be presented across the throttle opening at its minimum setting.

Often, in situations of increased acceleration, it is necessary to momentarily enrich the fuel-air mixture. To do so, the invention includes a fuel reservoir in communication with the air passageway. As the throttle opening is enlarged to increase the cross-sectional dimension of the air passageway, the invention includes means to inject supplemental fuel into the air passageway. Such injection occurs only when the throttle opening is increased in dimension, and only when the rate of increase of the throttle opening is such that an enriched fuel mixture is required.

BRIEF DESCRIPTION OF THE DRAWINGS

The above features of the invention, and others, are described in greater detail in the following description of a number of preferred embodiments, where reference is made to the accompanying drawings, in which:

Figure 1 is an exploded illustration of the invention, with some parts omitted and other parts in cross-section to permit illustration of the primary components of the invention.

Figure 2 is a cross-sectional illustration of the assembled invention, illustrating the throttle valve closed to a minimal throttle opening.

Figure 3 is an illustration similar to Figure 2, but with the throttle valve translated sufficiently to provide a partial throttle opening.

Figure 4 is a view similar to Figure 2 but with the throttle valve being withdrawn sufficiently to provide a full throttle opening.

Figure 5 is an enlarged cross-sectional illustration taken along lines 5-5 of Figure 4.

Figure 6 is an enlarged cross-sectional illustration taken along lines 6-6 of Figure 2.

Figure 7 is an enlarged cross-sectional illustration taken along lines 7-7 of Figure 4.

Figure 8 is an enlarged, partially truncated view of one embodiment of the fuel metering tube according to the invention.

Figure 9 is an elongated cross-sectional illustration taken along lines 9-9 of Figure 8.

Figure 10 is a truncated top plan view of an alternative embodiment of the fuel metering tube according to the invention.

Figures 11 through 13 illustrate rotation of the fuel metering tube respectively between a lean mixture setting, and a rich mixture setting.

Figures 14 illustrates, in cross section, a modified embodiment of the invention.

Figure 15 illustrates a modification of the embodiment of Figure 14, showing another form of the fuel metering system.

Figure 15a through 15c illustrate a partial cross-section taken along lines 15a - 15a of Figure 15, with Figures 15b and 15c showing rotation of the pressure detecting tube.

Figure 16 illustrates a further modification of the embodiment of Figure 14, showing yet another form of the fuel metering system.

Figure 17 illustrates a further modification of the embodiment of Figure 14, showing a final form of the fuel metering system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A fluid mixing device according to the invention, in the form of a carburetor, is shown in assembly fashion in Figure 1. Primary components of the carburetor include a top plate 10, a bottom plate 12, and a throttle valve 14. Although the top plate 10 and bottom plate 12 are delineated as such, it should be obvious that the designations "top" and "bottom" are for the purposes of explanation only, and the respective roles of the plates 10 and 12 can be reversed as necessary. In addition, the top plate 10 has been shown in cross-section for the purposes of description, and would include a second half complimentary to that shown in Figure 1.

The top plate 10 includes an air inlet 16. The bottom plate 12 includes an air-fuel outlet 18 located in concentric registration with the air inlet 16. The inlet 16 and outlet 18 are preferably of equal diameter.

When the carburetor is assembled, the throttle valve 14 is sandwiched between the top plate 10 and the bottom plate 12 for sliding movement between the two plates. The plates 10 and 12 are suitably fixed together as by means of a plurality of screws 20 passing through apertures 22 in the bottom plate 12 and engaging corresponding threaded apertures 24 in the top plate 10.

Although, as indicated above, the throttle valve 14 is situated between the plates 10 and 12 for sliding movement, the throttle valve 14 is dimensioned for a close fit in the aperture formed between the plates 10 and 12 when assembled. The throttle valve 14 may be formed of a material susceptible to forming a seal, such as Teflon, while the plates 10 and 12 may be formed of aluminum, steel or other relatively stiff material. Other materials may be used as desired.

As best shown in Figure 1, the throttle valve 14 includes a throttle aperture 26. The cross sectional dimension of the aperture 26 is the same as the diameters of the inlet 16 and outlet 18 so that if the inlet 16, opening 26 and outlet 18 are aligned, an uninhibited throttle opening or bore is formed through the carburetor. At this position, as described in greater detail below, air flow is maximum and, as is well known, the carburetor is at its full throttle position.

As best shown in Figures 2 through 4, the position of the throttle valve 14 between the sandwiched plates 10 and 12 is determined by means of a control rod 28. The rod 28 is secured within a bore 30 formed in the throttle valve 14 and passes through an aligned aperture 32 formed in the sidewall of the top plate 10. A pin or set screw 34, passing through a hole 36 in the rod 28 and lodged within a hole 38 formed in the throttle valve 14, secures the control rod 28 within the throttle valve 14.

For fuel metering, the carburetor includes a fuel metering tube 40 which passes longitudinally through the entire throttle valve 14 and extends through apertures 42 and 44 at opposite ends of the top plate 10. The throttle valve 14 includes a close-fitting longitudinal aperture 46 through which the fuel metering tube 40 passes and upon which the throttle valve 14 is mounted for sliding between the extreme locations shown in Figures 2 through 4. The longer bore of the longitudinal aperture 46 may include sealing rings or the like (not illustrated) to assure a fluid-tight seal between the fuel metering tube 40 and the aperture 46.

The aperture 44 is threaded, as illustrated. A fuel connection nipple 48 is engaged on the threads of the aperture 44 and is shaped for connection to an external fuel source (not illustrated) in a well known manner not further described herein. The fuel connection nipple 48 may include a sealing ring or some similar device to provide a fluid tight seal between the nipple 48 and the fuel metering tube 40.

The fuel metering tube 40 is rotatable about its longitudinal axis to control the fuel-air ratio. Rotation is controlled by means of an arm 50 attached to the end of the fuel metering tube 40 opposite to that of the connection nipple 48. The arm 50 sealingly closes the tube 40 at its point of connection, and is controlled for rotation by suitable means (not illustrated), such as a control cable which may be clamped to the arm 50 through a bore 52 by a bolt 54.

Immediately adjacent the arm 50, a collar 56 is permanently secured to the fuel metering tube 40. A keeper screw 58, threadedly secured within the top plate 10, engages a circumferential channel 60 formed in the collar 56. Thus, the keeper screw 58 maintains precise axial alignment of the fuel metering tube 40. By suitable adjustment of the keeper screw 58, the axial position of the fuel metering tube 40 may be altered for purposes described in greater detail below.

As best shown in Figures 1 and 4, the fuel metering tube 40 includes a distribution outlet 62 extending across the entire width of the throttle aperture 26 when the throttle valve 14 is in the full throttle position. Thus, with the axial alignment of the fuel metering tube 40 being fixed by the keeper screw 58, no matter what the position of the throttle valve 14 between the top and bottom plates 10 and 12, fuel is dispensed across the entire width of the effective throttle opening.

As shown in enlarged fashion in Figures 8 and 9, in this first embodiment, the distribution outlet 62 is composed of a plurality of holes 64 spaced axially along one side of the fuel metering tube 40. The holes 64 may be evenly spaced. However, if the internal diameter of the fuel metering tube 40 is quite small, and if the fuel pressure is low, the internal flow resistence created within the fuel metering tube 40 is sufficient to reduce the flow to a large enough extent so that the fuel flow rate through the right-most holes 64 (Figure 8) is significantly more than that flowing through the left-most holes. In order to avoid this result, the holes 64 may be grouped and those in an area of less fuel pressure (and consequently, less fuel flow rate) can be grouped closer together so that the fuel flow rate along the entire distribution outlet 62 remains essentially constant. As shown in Figure 8, the holes 64 have been gathered in three groups 66, 68 and 70 in order to overcome the reduction of the fuel flow rate over the length of the distribution outlet 62. Of course, as indicated above, should the reduction of the fuel flow rate along the length of the distribution outlet 62 be minimal, the spacing of the holes 64 need only be constant or may be spaced such that each hole is positioned at the center of equal air flow areas when the throttle valve is in its open position.

Figure 10 illustrates an alternative embodiment of the distribution outlet, designated as 62'. In this embodiment, the holes 64 are eliminated and instead the distribution outlet 62' comprises an axial slot opening along one side of the metering tube 40. In the same manner as grouping of the holes 64 in the distribution outlet 62, if there is a fuel flow reduction within the fuel metering tube 40 from one end of the distribution outlet 62' to the other, the slot of the distribution outlet 62' may be formed in an increasing taper fashion, as illustrated, in order to maintain constant fuel outlet flow through the distribution outlet 62'. Again, if there is a negligible fuel flow reduction, tapering of the distribution outlet 62' is unnecessary and the outlet may be formed as a longitudinal slot of constant dimension.

The fuel distribution outlet 62 may take other forms, depending on the fuel distribution characteristics desired. A series of two or more circumferentially spaced outlets can be used, and holes or slots for fuel distribution can be used in combination, or can be replaced by equivalent outlet means. As an alternative, the distribution outlet 62 may follow other than a straight pattern in order to alter fuel metering capabilities along its length.

As is well known, depending on the position of the throttle valve 14 and therefore the cross sectional dimension of the throttle opening through the carburetor, air flow through the carburetor is controlled. With the throttle valve 14 in the position illustrated in Figures 4, 5 and 7, maximum air flow is permitted and therefore the carburetor is at full throttle. With the throttle valve 14 at the position indicated in Figures 2 and 6, the carburetor is at its throttle closed position. The location shown in Figure 3 is a mid-throttle position. As shown in Figure 2, the maximum closure of the throttle valve 14 is determined by a set screw 72. With the set screw 72 adjusted to the position shown in Figure 2, a minimum air passageway 74 is formed. As shown in the drawings, the dimension of minimum air passageway 74 can be increased or decreased as desired by adjustment of the set screw 72. In fact, if desired, the minimum air passageway 74 can be omitted completely, although such a situation is not normally acceptable.

Also as shown in Figure 2, only a very small portion of the distribution outlet 62 extends into the minimum air passageway 74. If desired, a greater portion of the distribution outlet can extend into the minimum air passageway 74 by adjustment of the keeper screw 58. Assuming that, in the position shown in Figure 2, a single hole 64 (Figure 8) of the distribution outlet 62 extends into the minimum air passageway 74, by suitable adjustment of the keeper screw 58, a greater portion of the distribution outlet 62 can appear in the minimum air passageway 74, allowing one or more additional holes 64 to inject fuel into the minimum air passageway. Thus, by adjustment of the set screw 72 and the keeper screw 58, the dimensions of the minimum air passageway 74 are dictated, and also the fuel metering capacity at this minimum setting is determined.

In many carburetors, such as an aircraft carburetor of the nature of the invention, fuel pressure entering the carburetor fuel metering section is esentially equal to ambient pressure. Therefore, fuel is aspirated from the distribution outlet 62 of the fuel metering tube 40 by pressure differences created within the effective air passageway. In many situations, and in particular in an aircraft, the carburetor must have the capability of reducing the fuel flow as increases in aircraft altitude reduce the density of the air entering the air inlet 16 of the carburetor. Changes in the air-fuel mixture are effected by rotation of the fuel metering tube 40, as best shown diagrammatically in Figures 11 through 13. With the fuel metering tube 40 in the position shown in Figure 11, the distribution outlet is aimed upstream directly toward the air inlet 16, and the carburetor is in the "idle cutoff" position. When the fuel pressure in the metering tube is regulated in such a way so as to be maintained approximately equal to the total pressure of the air, the dynamic air pressure within the air inlet 16 completely inhibits the flow of fuel, causing the engine to stop.

In the position shown in Figure 13, the distribution outlet 62 is turned at 90 degrees to the airflow. This is the position for providing the richest possible air-fuel mixture such as is normally required at low altitudes. In this position, the fuel flow from the distribution outlet is being aspirated into the air passageway by the difference in pressure between the fuel inside the fuel metering tube 40 and the static air pressure outside of the distribution outlet 62 which is reduced below ambient pressure in accordance with the Bernoulli equation.

To adjust the carburetor to a leaner air-fuel mixture as would be required at higher altitudes, the fuel metering tube 40 is rotated to a mid-way orientation such as that shown in Figure 12. In this position, the air pressure outside of the fuel distribution outlet 62 is increased by a dynamic component of the velocity of the air entering the air inlet 16. This reduces the differential between the static and dynamic pressures which aspirates the fuel from the distribution outlet 62, and therefore reduces the fuel flow rate from that of the orientation shown in Figure 13. Consequently, a leaner fuel mixture is attained without fuel flow cutoff as shown in Figure 11.

Therefore, the invention achieves an even fuel distribution with precise air-fuel mixing to enable the carburetor to control an engine no matter what ambient conditions may be encountered. Not only does the throttle valve 14 control the air flow through the carburetor, but also the throttle valve 14, when sliding along the fuel metering tube 40 across the distribution outlet 62, maintains the air-fuel mixture constant no matter what the throttle position, contrary to conventional carburetors. In addition, by rotation of the fuel metering tube 40, the richness of the air-fuel mixture can be precisely controlled to account for changes in ambient air density.

In some internal combustion engines it is necessary to inject additional fuel into the throttle aperture 26 during periods of engine acceleration. Because fuel is available directly at the outlet 62, acceleration enrichment is not normally required with the present invention. If desired, however, the throttle valve 14 may include bores 76 and 78. Normally, as shown in Figure 2, a reservoir 80 formed between the plates 10 and 12 is flooded with fuel. If the throttle valve 14 is opened rapidly during a period of high acceleration, some of the fuel in the reservoir 80 will pass through the bore 78 and be emitted directly into the throttle aperture 26. The remainder thereof will pass through the larger bore 76 into a second reservoir 82 on the opposite side of the throttle valve 14. The more rapidly the throttle valve is opened (right to left in Figures 2 through 4), the greater the quantity of fuel which is forced through the bore 78 into the throttle aperture 26. On the other hand, if the throttle valve 14 is withdrawn at a slow rate, very little, if any, fuel passes through the bore 78, the majority thereof passing through the bore 76 into the newly-formed reservoir 82. Thus, during periods of high acceleration, an additional quantity of fuel is injected into the throttle aperture 26.

An alternate method is available to provide acceleration enrichment if the fuel metering tube 40 is provided with a fuel bleed orifice 84 in substitution for the bore 78. In this configuration, a sudden throttle movement leftward causes the throttle plate 14 to force the fuel contained in the reservoir 80 through the bleed orifice 84 into the metering tube 40 and out of the distribution outlet 62 into the throttle aperture 26.

It should be apparent that other forms of acceleration enrichment can be included as well. In addition, rather than forming a bore 76 as illustrated in the drawings, one or both of the sides of the throttle valve 14 abutting the top plate 10 can include a groove extending from the reservoir 80 to the reservoir 82. Additionally, if the carburetor is constructed such that fuel is absent from the reservoirs 80 and 82, other means of injecting additional fuel in response to the speed of translation of the throttle valve 14 can be employed as well.

Figure 14 illustrates an alternative embodiment of the invention having modification of the throttle valve and fuel system leading to the fuel inlet tube 40. Other components of the invention remain the same and therefore bear the same reference numerals. Since these elements were described above, further description is omitted.

As illustrated, the throttle valve 14' in Figure 14 is truncated, omitting a portion of the throttle valve 14 which is unnecessary. As shown, the throttle valve 14' includes a throttle aperture 26' having a diameter equal to that of the air-fuel mixture outlet 18 so that, in a full throttle open position (such as that illustrated in Figure 4), there is no obstruction to flow by the throttle valve 14'.

In this embodiment, the invention includes a balancing regulator 90 operable to control fuel pressure in the fuel inlet tube 40 to ambient pressure. The balancing regulator 90 has an inlet 92 for fuel under pressure. The inlet 92 leads to a nipple 94 which may be connected to a source of fuel (not illustrated).

The inlet 92 is terminated by a fluid control ball valve 96 or by a conventional needle valve and seat assembly (not illustrated). The valve 96 has an internal orifice 98 which may be closed by a pair of balls 100. An arm 102, pivotally connected in its mid-section at 104 to the balancing regulator 90, has one end which bears against the larger of the balls 100. The other end of the arm 102 bears against a biasing compression spring 106 which in turn bears against a screw 108 threaded into the body of the top plate 10. Depending on the compression strength of the spring 106, the spring normally pivots the arm about the pivot 104, urging the balls 100 into the orifice 98 to preclude fuel flow through the inlet 92 into the interior of the balancing regulator 90 and from there into the fuel inlet tube 40. Fine adjustment of the compression strength of the spring 106 with the screw 108 to achieve this end is well-known.

The balancing regulator 90 also includes a movable diaphragm 110 having a central contact 112 in alignment with one end of the arm 102. The balancing regulator 90 also includes an opening 114 to the ambient surroundings.

The metering system of the balancing regulator 90 operates in a well-known manner. Since the opening 114 is to the ambient pressure which is usually equal to the airflow total pressure, the ambient pressure normally urges the contact 112 against the arm 102, permitting fuel to enter the regulator 90 through the inlet 92. Not only does the entering fuel flow through the fuel inlet tube 40 and exit through the distribution outlet 62, the fuel also bears against the opposite side of the diaphragm 110 from that open to the ambient pressure experienced through the opening 114. If the fuel pressure is higher than the ambient pressure, the increased pressure of the fuel tends to urge the contact 112 away from the arm 102, permitting the spring 106 to pivot the arm about the pivot 104, urging the balls 100 into the closed position. Therefore, the diaphragm 110 always positions itself as necessary to equalize the fuel pressure on the fuel side of the diaphragm with the ambient air pressure on the air side of the diaphragm. Thus, the fuel pressure in the inlet tube 40 is always maintained at approximately the same pressure as the ambient air pressure surrounding the carburetor.

Figure 15 illustrates a modified version of the invention in which fuel flow is controlled totally by air pressure and the fuel inlet tube 40 is fixed with the inlet

62 oriented so as to sense static pressure, in this embodiment perpendicular to the direction of air flow through the carburetor.

As seen in Figure 15, the opening 114 of the balancing regulator 90 is not opened to ambient pressure. Rather, a conduit 116 leads from the opening 114 to a pressure detecting tube 118 extending across the air inlet 16. The tube 118 must be immediately adjacent the fuel distribution outlet 62, and is shown directly above the tube 40 in Figure 15. The detecting tube 118 includes an aperture 120 therein, thus permitting the tube 118 to sense the air pressure in the air inlet 16. The tube 118 is axially rotatable as shown in Figure 15 and in Figures 15a - 15c in order to permit altering the circumferential location of the aperture and therefore vary the percentage of the dynamic pressure that is sensed.

Since the distribution outlet 62 of the fuel inlet tube 40 is fixed at an orientation perpendicular to the air flow through the carburetor, the distribution outlet 62 experiences only the static component of the total air pressure in the carburetor at its particular location. So long as the fuel introduced into the inlet tube 40 is at a pressure greater than the static pressure existing at the distribution outlet 62, fuel will flow from the distribution outlet and be mixed with the incoming ambient air.

The pressure balancing function of the balancing regulator 90 causes the pressure in the metering tube 40 to be equal to the pressure sensed by the pressure detecting tube 118. With the orientation of the aperature 120 shown in Figure 15 and Figure 15a (open to the air flow), the aperture 120 detects the total pressure of the air at this location. The balancing regulator adjusts the fuel pressure in the metering tube 40 to equal the total pressure sensed by the aperture 120. Since the pressure at the fuel outlet 62 is equal to the static pressure, fuel flow occurs through the fuel outlet 62.

If, on the otherhand, the aperture 120 is oriented as shown in Figure 15b, the aperture 120 senses a lower pressure that is equal to the static pressure plus a lesser dynamic component that depends on the upstream orientation of the aperture 120. This lower pressure is transmitted through the conduit 116 to the diaphram 110. The diaphram 110 positions itself such that the ball valve 96 admits fuel to the fuel side of the diaphragm 110 at such a rate so as to make the fuel pressure in the metering tube 40 equal to the air pressure sensed by the aperture 120 in the pressure detecting tube 118.

When the pressure sensing aperture is oriented as shown in Figure 15c, the resulting pressure in the fuel metering tube 40 is equal to the static pressure existing at the outlet 62. With the orientation shown in Figure 15c, no fuel would flow.

Figure 16 illustrates a modification of the system for injecting fuel into the carburetor. A portion of the air inlet 16 of the top plate 10 is shown superimposed above the cross-sectional illustration of the carburetor as depicted and described in Figure 14. In this embodiment, a first pressure transmitting tube 122 leads from the air inlet 16 and joins a second pressure transmitting 124 leading from the mixture outlet 18. A third pressure transmitting tube 126 leads from the juncture of the tubes 122 and 124 to the opening 114 of the balancing regulator 90. As shown, the end 128 of the tube 122 in the air inlet 16 faces upstream and therefore senses the total air pressure in the air inlet 16. The tube 124 is introduced at the side of the mixture outlet 18, and therefore detects the static pressure at that location. An adjustable needle valve 130 is located in the tube 124 and may be adjusted to close the tube 124 completely, or permit any opening required.

Because the end 128 of the tube 122 is opened to the total pressure, and because the tube 124 is opened to the lower static pressure, if the needle valve 130 is opened slightly, a portion of the total pressure in the tube 122 is bled through the needle valve 130 into the tube 124. This leaves a resultant differential pressure in the tube 126, which is directed through the opening 114 to the interior of the balancing regulator 90. Thus, by judicious adjustment of the needle valve 130, the differential pressure experienced by the balancing regulator 90 may be adjusted as desired. Since the distribution outlet 62 of the fuel inlet tube 40 is oriented perpendicular to the flow direction, and therefore experiences only the static pressure of the flow, the balancing regulator 90 is operated as described above and fuel is driven through the outlet 62 by the difference between the differential pressure within the tube 126 and the static pressure at the distribution outlet 62. So long as the differential pressure is greater than the static pressure, fuel will flow.

Figure 17 illustrates another embodiment of the invention having modification of the throttle valve and fuel system leading to the fuel inlet tube 40. Components which have been described above bear the same reference numerals and perform the same functions. Further description, therefore, is omitted.

In this embodiment, the invention includes a fuel metering float regulator 140 operable to maintain fuel pressure in the fuel inlet tube 40 at ambient pressure. The float regulator 140 includes the fluid control ball valve 96 and associated component described above. The arm 102 of the prior embodiments of Figures 14 through 16 is replaced with an arm 142 which is pivotally connected in its mid-section at 144. One end of the arm 142 bears against the larger of the balls 100. The other end of the arm 142 is connected to a float 146 maintained within a fuel reservoir 148 of the float regulator 140. The float 146 is situated such that during normal operation, the level of the fuel 150 within the fuel reservoir 148 is sufficient to allow fuel to enter the fuel inlet tube 40. If the pressure of the fuel 150 within the reservoir 148 is greater than the air pressure experienced at the distribution outlet 62 of the inlet tube 40, fuel will flow from the distribution outlet. Conversely, if the air pressure is the same as or higher than the fuel pressure, no fuel will flow from the distribution outlet 62.

As shown diagrammatically, the fuel reservoir 148 includes an aperture 152 open to the ambient surroundings. Therefore, the fuel 150 within the reservoir 148 is maintained at ambient pressure.

The metering system of the float regulator 140 operates in a known manner. Since the aperture 152 is opened to ambient pressure, and assuming fuel pressure in the inlet 92 is greater than ambient pressure, fuel enters the reservoir 148 from the inlet 92 and maintains a level permitted by the float 146. The fuel 150, at ambient pressure, also enters the fuel inlet tube 40, and is present at the distribution outlet 62. With the distribution outlet aimed upstream in the orientation illustrated in Figure 17, the total pressure is experienced. Since the total pressure equals the ambient pressure, at the orientation illustrated, fuel flow through the outlet 62 will be prevented. However, if the fuel inlet tube 40 is rotated slightly, the pressure experienced at the distribution outlet will be less than the total pressure. Thus, fuel will flow from the distribution outlet 62. The fuel/air mixture is therefore controlled by the rotational orientation of the fuel inlet tube 40, in the same manner as described above with regard to prior embodiments.

In this embodiment of the invention, fuel will enter the reservoir 148 from the inlet 92 so long as the fuel in the inlet 92 is under pressure. Therefore, when an internal combustion engine incorporating the invention is stopped, operation of the pump (not illustrated) supplying fuel to the inlet 92 must also be stopped. The fuel 150 contained within the reservoir 148 will, therefore, at maximum drain to a lower level where no fuel enters the inlet tube 40.

The invention provides a novel, precise system for metering fluid flow and mixing of two fluids. By appropriate orientation of the fuel outlet 62 of the fuel inlet tube 40 in combination with regulated fuel pressure and appropriate adjustment of the throttle valve 14, optimum fuel/air ratio can be provided over the full range of engine power and operating environment.

Because no obstructions exist downstream of the fuel outlet, the carburetor according to the invention is non-icing. This feature is quite advantageous particularly in aircraft which operate at altitudes or temperatures where icing can occur in conventional carburetors.

Conventional carburetors which are used in automotive applications require a choke valve of some nature to provide extra richness for engine starting. No choke valve is required in the present invention since the required richness for starting can be obtained by the combination of the fuel inlet tube 40, throttle valve 14, and pressure and outlet rate of the fuel within the inlet tube 40.

Acceleration enrichment is not normally required with the invention. In a conventional carburetor, fuel is kept in a float reservoir at some distance from the fuel outlet, and thus some finite period of time is required when additional fuel flow is needed. In the present invention, additional fuel flow capability is always present at the outlet 62.

With the exception of the embodiment of Figure 17, the invention can be used at any attitude orientation, and also with the exception of the embodiment of Figure 17 can be used in any condition of horizontal or vertical acceleration Conventional carburetors having a float system for fuel metering require a substantially consistant orientation to prevent fuel starvation or flooding in the carburetor.

Although the invention has been disclosed in the environment of a carburetor, it should be evident that the novel fluid mixing and metering characteristics of the invention may be employed in other applications requiring precise control of the mixing the two fluids, either one of which may be liquid or gas.

CLAIMS

1. A fluid mixing device comprising: a fluid passageway for a first fluid, an adjustable throttle valve which has a throttle aperture which is so arranged in relation to the passageway so as to form in the passageway a throttle opening of controllable cross-sectional dimension, and a fluid metering system means for supplying a second fluid to the passageway through a distribution outlet which extends across the passageway and the effective length of which is determined by the cross-sectional dimension of the throttle opening, and means for altering the proportionate flow of the second fluid through the distribution outlet in relation to the flow of the first fluid in the passageway.

2. A mixing device according to claim 1 in which said fluid supply includes a normally axially stationary metering tube extending across said throttle opening.

3. A mixing device according to claim 2 in which said distribution outlet is located in said metering tube across said throttle opening.

4. A mixing device according to claim 3 in which said distribution outlet comprises a plurality of apertures spaced axially along at least one side of said metering tube.

5. A mixing device according to claim 3 in which said distribution outlet comprises at least one axial slot along one side of said metering tube.

6. A mixing device according to claim 2 in which said metering tube is positioned in registration with said throttle valve and extends through a complementary longitudinal aperture in said throttle valve, and said throttle valve is slidable upon said metering tube to adjust the throttle opening and change the effective length of said distribution outlet.

7. A mixing device according to claim 2 including means to adjust the axial location of said metering tube.

8. A mixing device according to claim 7 in which said throttle valve is adjustable between limits to provide a maximum throttle opening and a minimum throttle opening, and further including means to alter said minimum throttle opening.

9. A mixing device according to claim 1 in which said supply means comprises a normally axially stationary metering tube having said distribution outlet extending along at least one side thereof, and said means to alter comprises means to rotate said metering tube about its longitudinal

axis to change the circumferential location of said distribution outlet.

10. A mixing device according to claim 1 in which said supply means comprises a fixed metering tube having said distribution outlet extending along one side thereof, and said means to alter comprises a pressure detecting tube in communication with said first fluid, said detecting tube including means to sense a pressure of said first fluid, and said means to alter further including means to control the pressure of said second fluid at said sensed pressure of said first fluid.

11. A mixing device according to claim 10 in which said means to sense comprises an inlet in one side of said detecting tube, said detecting tube being rotatable to change the circumferential location of said inlet and thereby change the sensed pressure of said first fluid.

12. A mixing device according to claim 10 in which said means to control comprises a balancing regulator regulated by said sensed pressure, said balancing regulator having an inlet for said second fluid, and including a fluid control responsive to said sensed pressure and operable to permit flow of said second fluid through said second fluid inlet at such a rate so as to cause equality of pressure between the second fluid and the sensed pressure.

13. A mixing device according to claim 1 in which said means to alter comprises a first pressure transmitting tube having one end extending into said first fluid

oriented so as to detect the total pressure thereof and a second pressure transmitting tube having one end extending into said first fluid at said first fluid passageway oriented so as to detect the static pressure thereof, said tubes being joined at their other ends and having a third pressure transmitting tube leading therefrom, said second pressure transmitting tube having valve means therein operable to permit a portion of the total pressure in said first pressure transmitting tube to bleed into said second pressure transmitting tube leaving a resultant differential pressure in said third pressure transmitting tube, and said means to alter further including means to control the pressure of said second fluid at said differential pressure.

14. A mixing device according to claim 13 in which said means to control comprises a balancing regulator regulated by said differential pressure, said balancing regulator having an inlet for said second fluid, and including a fluid control responsive to said differential pressure and operable to permit flow of said second fluid through said second fluid inlet at such a rate so as to maintain equality of pressure between said second fluid and said differential pressure.

15. A mixing device according to claim 1 including a source of said second fluid maintained at a pressure at least as great as the total pressure of said first fluid, and further including means to control the pressure of said second fluid in said fluid supply at a pressure approximately equal to the total pressure of said first fluid.

16. A mixing device according to claim 15 in which said means to control comprises a balancing regulator having an inlet for said second fluid from said source, and including a fluid control operable to permit flow of said second fluid through said second fluid inlet at such a rate so as to maintain equality of pressure between said second fluid and the total pressure of said first fluid.

17. In a carburetor having an air passageway, a movable throttle valve having a throttle aperture which is so arranged in the air passageway so as to form a throttle opening of controllable cross-sectional dimension, a fuel source for supplying fuel to the air passageway for mixture with air passing therethrough, and a fuel metering system having

a. a normally axially stationary fuel metering tube connected to said fuel source and extending across said air passageway, said metering tube being positioned in registration with said throttle valve and extending through a complementary lateral aperture in said throttle valve such that said throttle valve is slidable upon said metering tube with said metering tube extending across the throttle aperture,

b. a longitudinal fuel distribution outlet in said metering tube extending substantially across the width of said air passageway, and

c. means to rotate said metering tube about its longitudinal axis to change the circumferential location of said fuel distribution outlet and thereby alter the flow of fuel through said fuel distribution outlet.

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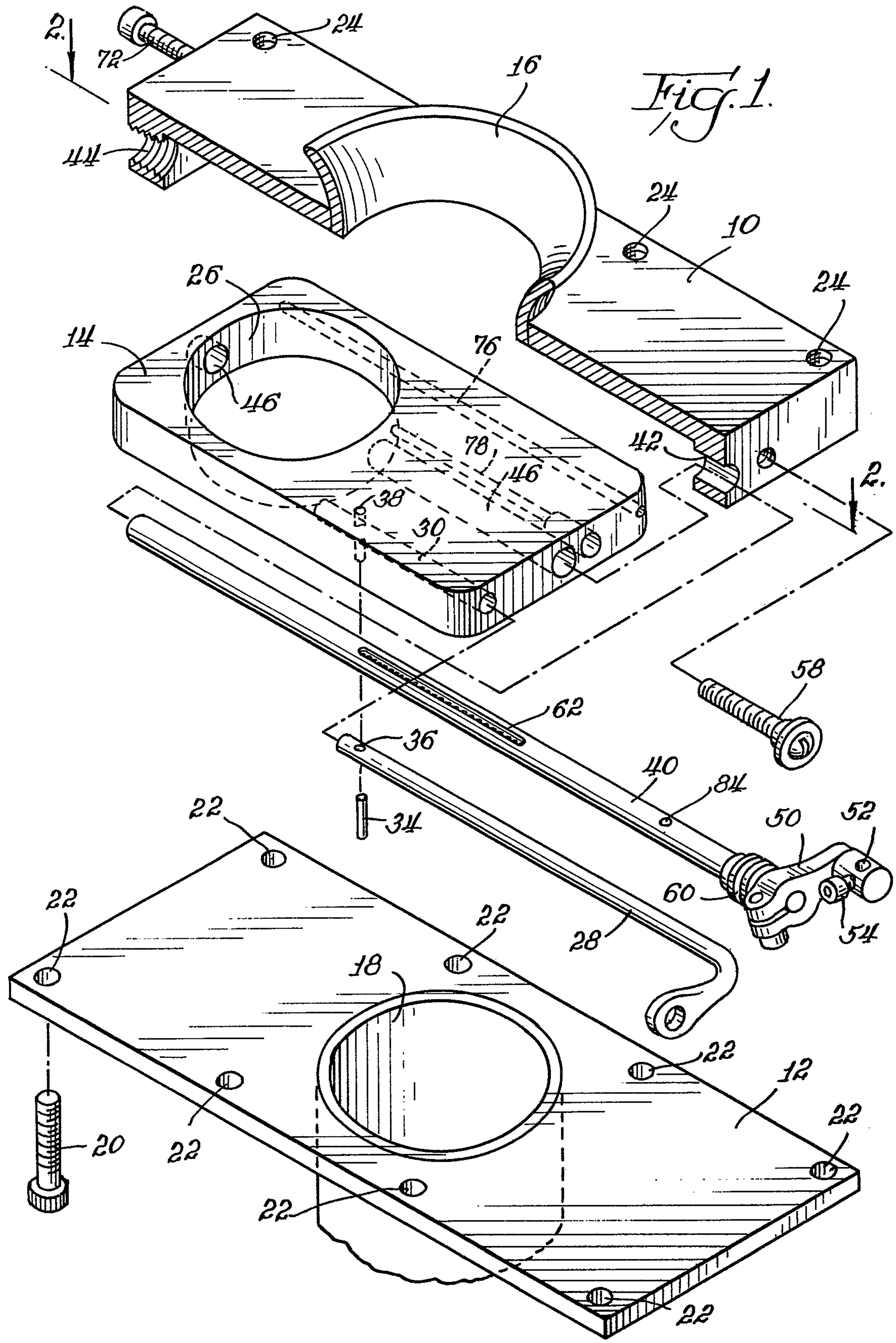

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Fig. 1
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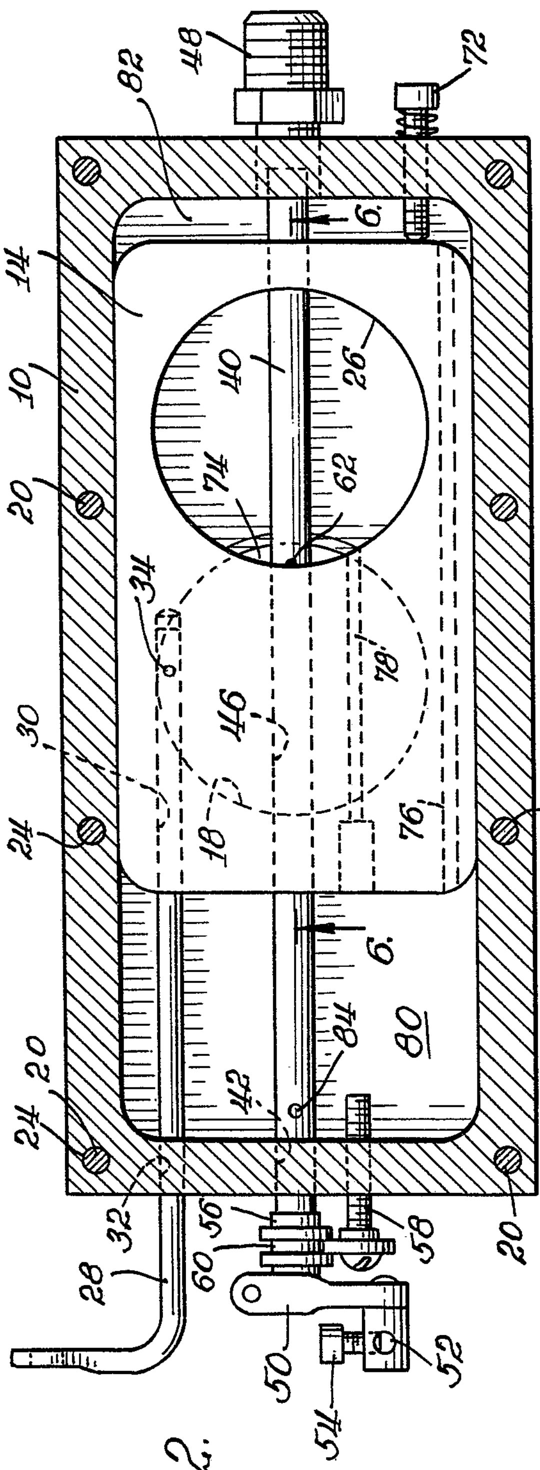

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Fig. 2.

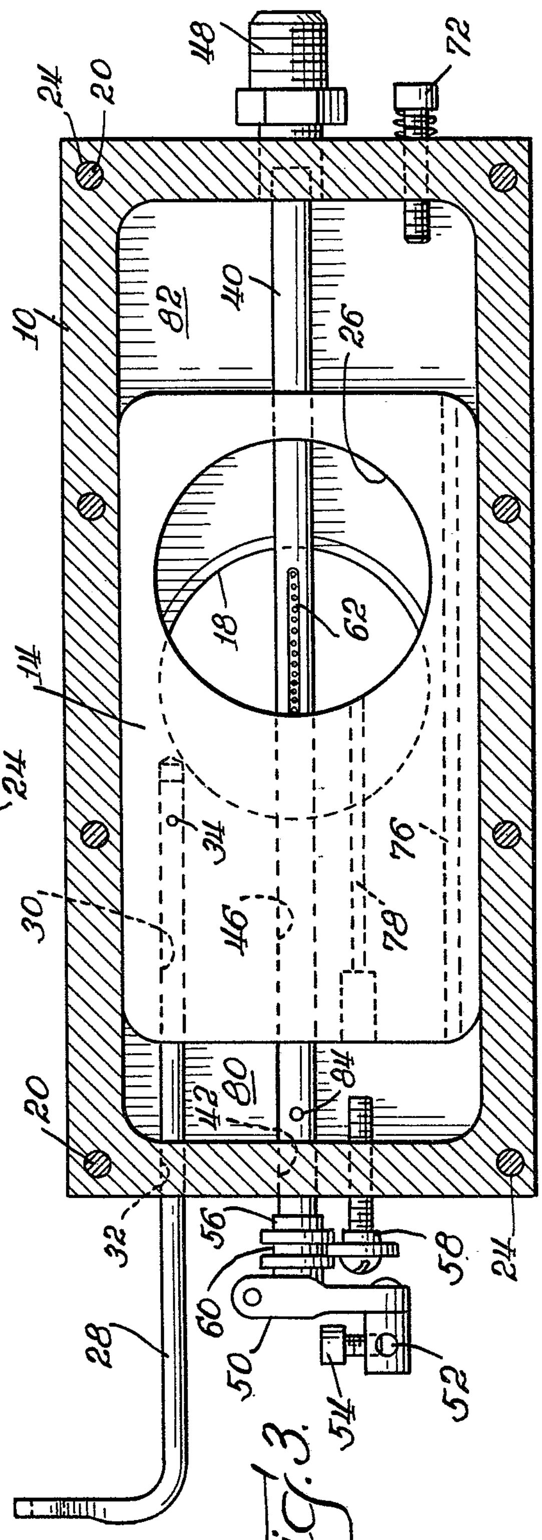

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Fig. 3.

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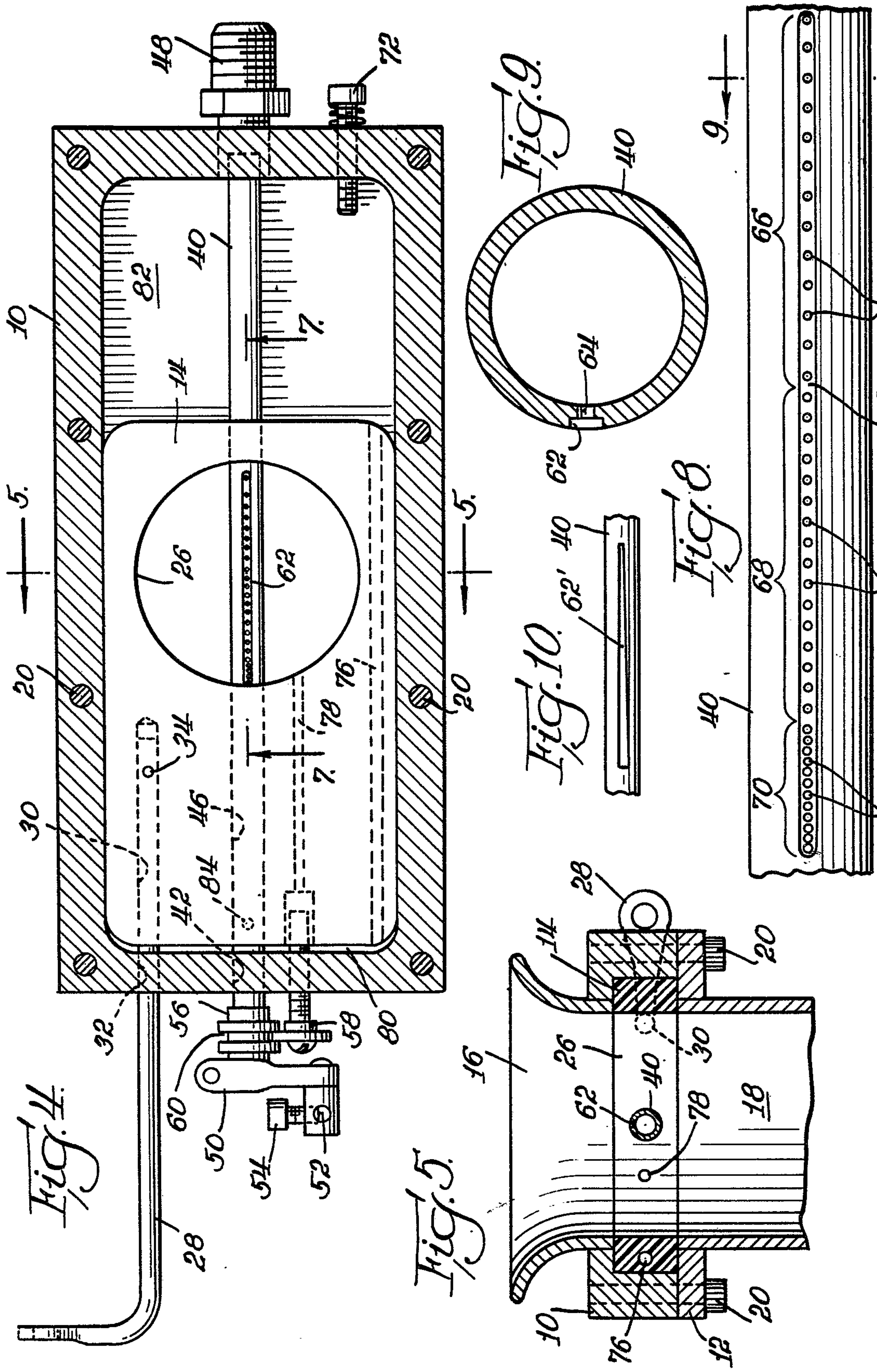
Fig. 4.
Fig. 5.
Fig. 8.
Fig. 9.
Fig. 10.
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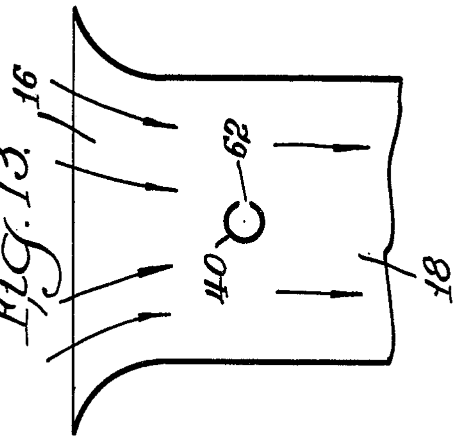

Fig. 13.

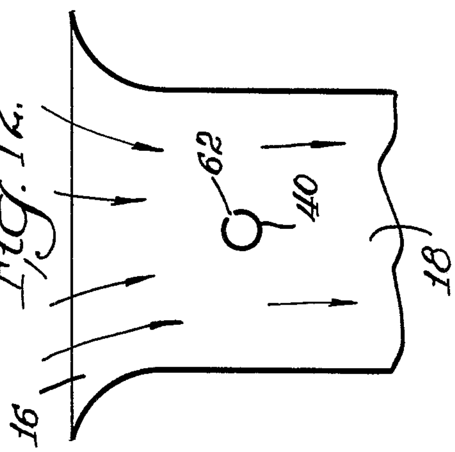

Fig. 12.

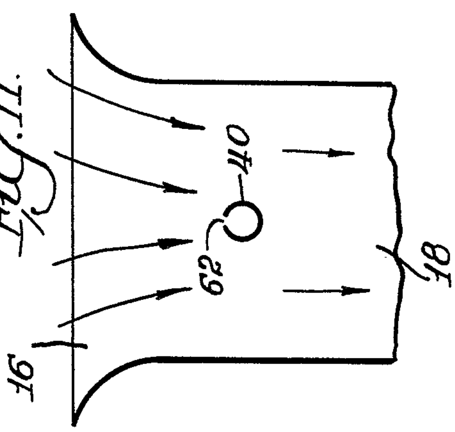

Fig. 11.

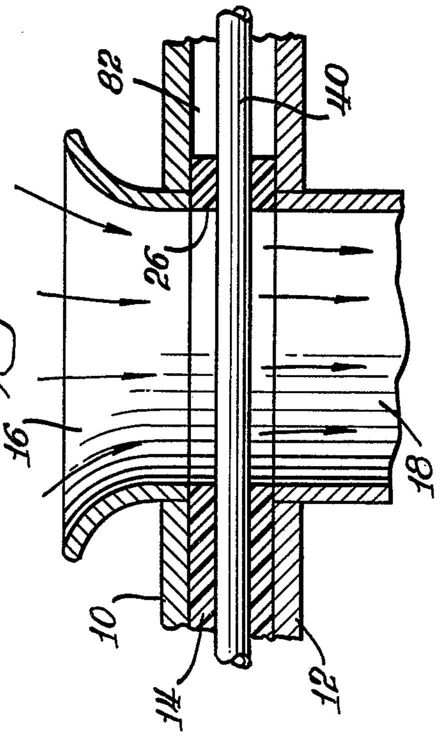

Fig. 7.

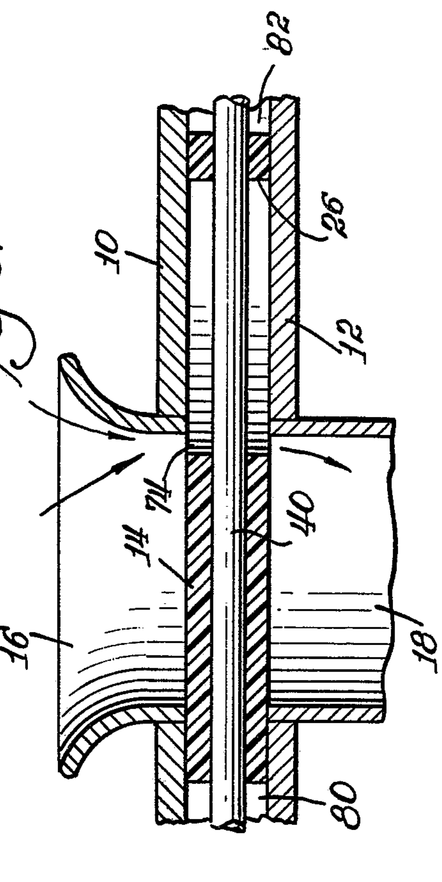

Fig. 6.

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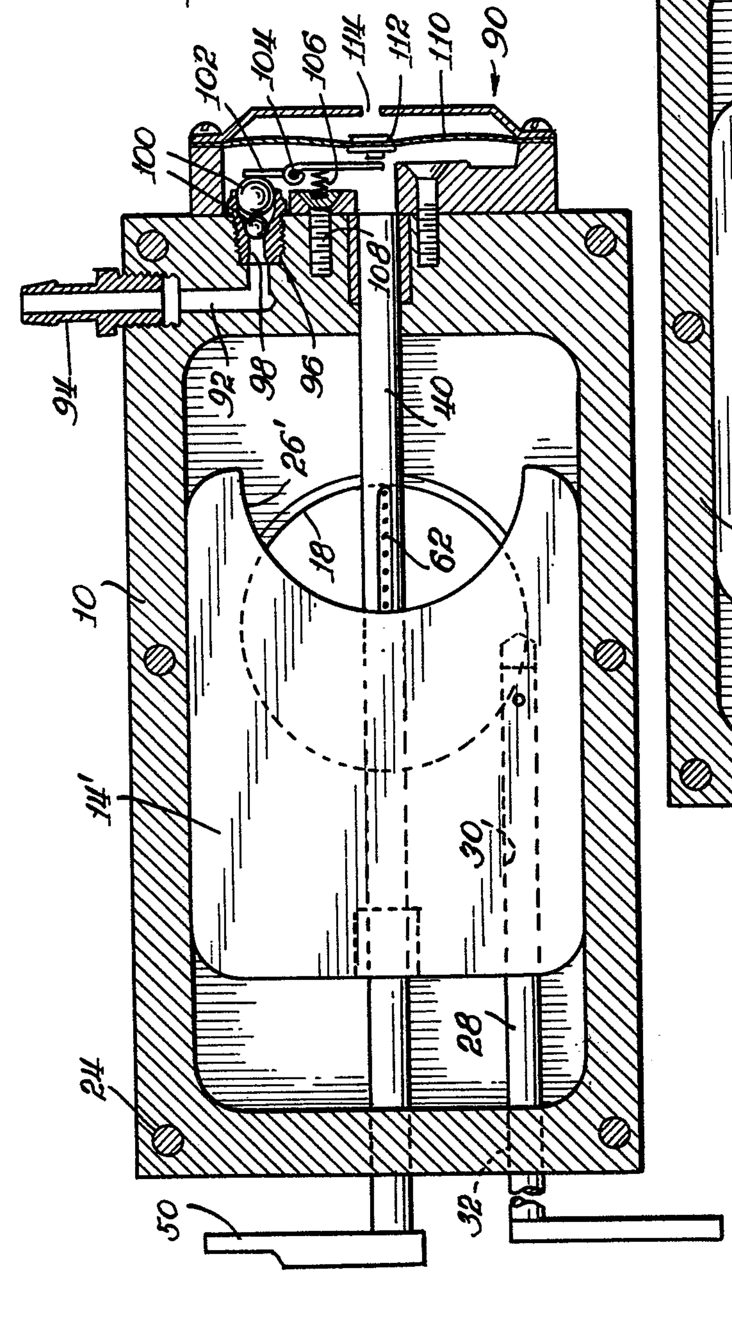

FIG. 14.

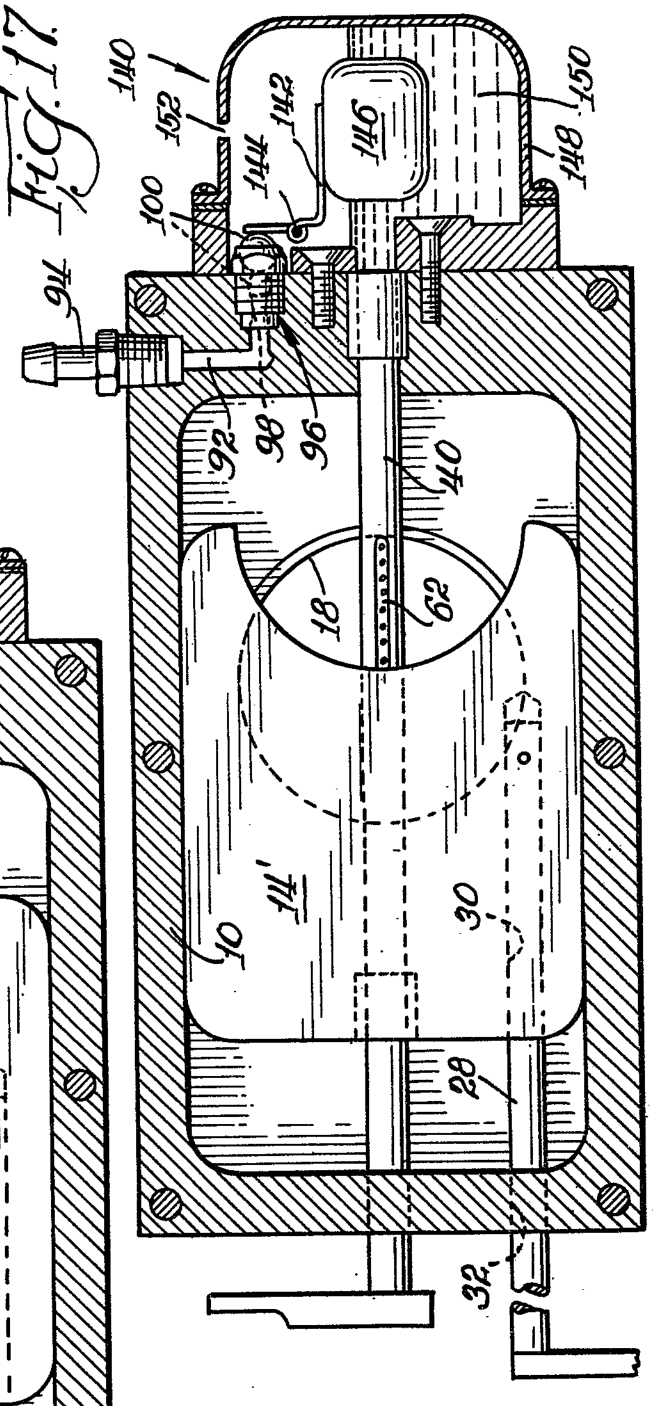

FIG. 17.

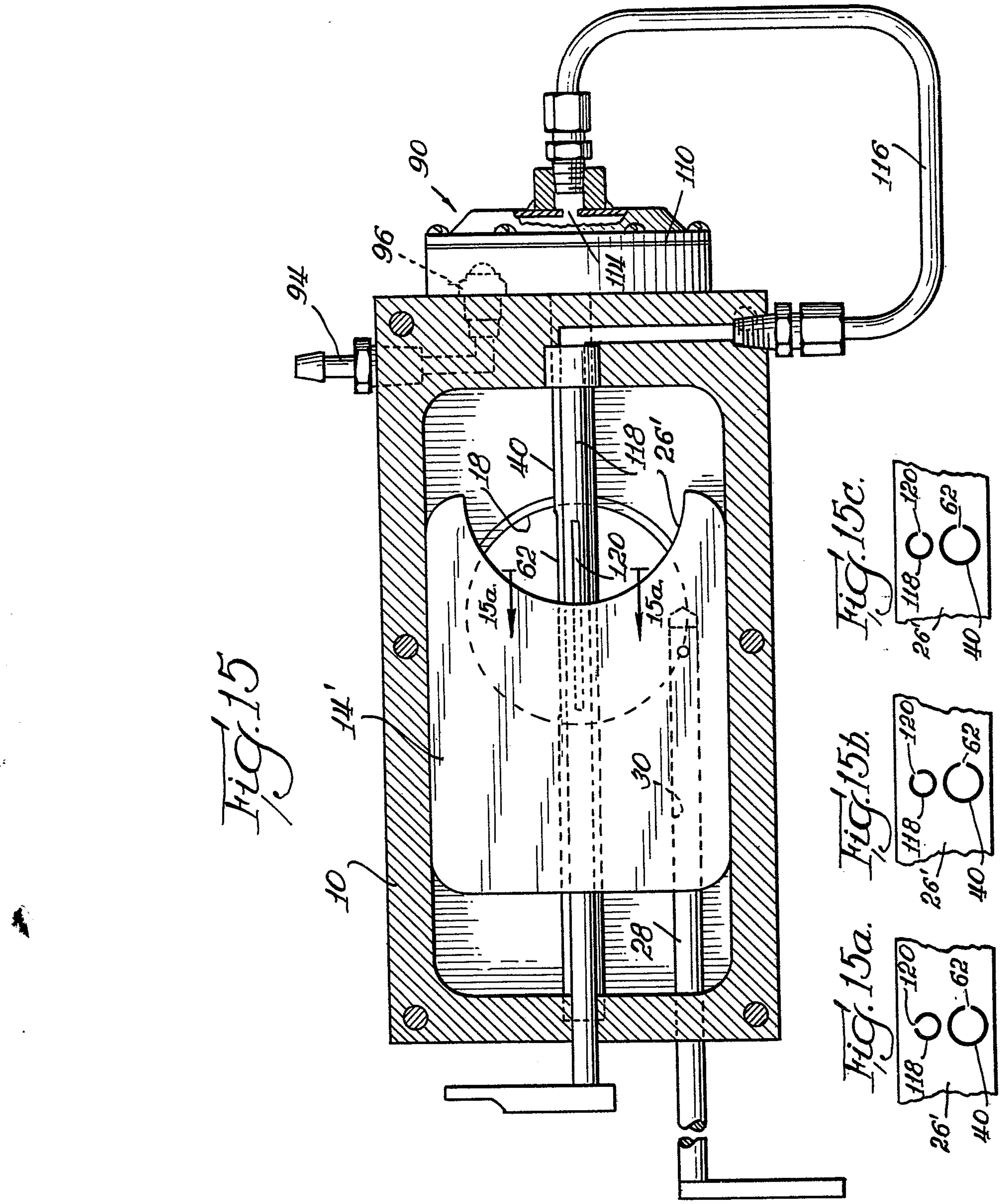

Fig. 15

Fig. 15a.

Fig. 15b.

Fig. 15c.

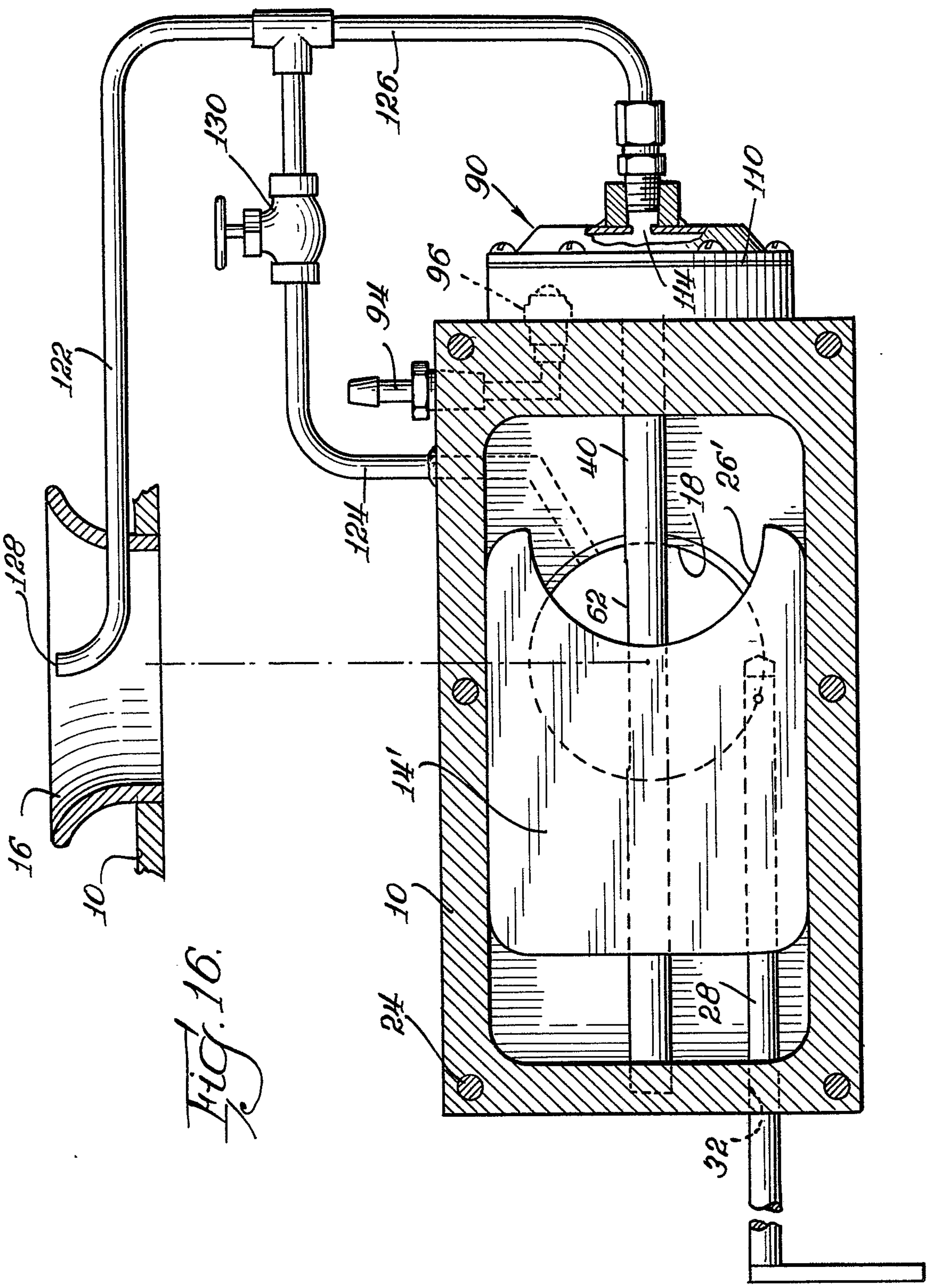

FIG. 16.