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(54) LIQUID OSCILLATOR DEVICE.

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US-A-3 432 102
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Description

The present invention is related to a liquid oscillator particularly for a windshield washer system according to the preamble of claim 1.

In US—A—4,157,161, 4,184,636, 4,151,955, 4,052,002, FR—A—2352591 and *Engineering World*, December 1977, Vol. 2, No. 4 Page 1, liquid oscillator systems are disclosed in which a stream of liquid is cyclically deflected back and forth, and in the case of US—A—4,157,161 and *Engineering World* the liquid is a cleaning liquid compound directed upon the windshield of an automobile system. In those which have the coanda effect wall attachment, or lock-on (Engineering World and FR—A—2352591, for example) there is a dwell at the ends of the sweep which tends to make the fan spray heavier at ends of the sweep than in the middle. Such system works very well where a single nozzle is used to provide a fan spray from the center of the windshield as in the system disclosed in Engineering World system.

The basic object of the present invention is to provide a liquid oscillator which produces a fan spray in which the liquid is relatively uniform throughout the fan spray thereby resulting in a more uniform dispersal of the liquid.

This object is solved within a liquid oscillator of the preamble of claim 1 according to the invention by the characterizing features of claim 1. By means of this inventive oscillator a vortex aided power jet control is provided eliminating wall attachement and a boundary layer effects and consequently dwell of the jet at its extreme positions. When used in a windshield washer system, a very uniform fan spray pattern can be reached.

For example, in a preferred embodiment, the liquid is a windshield washer fluid which is sprayed on an automobile windshield and the uniform droplets provide a better cleaning action. In addition, the oscillator in the present invention retains the desirable low pressure start features of the prior art as well as cold weather start characteristics of the oscillator.

The preferred embodiment of the invention is carried out with an oscillator constituted by a generally rectangular chamber having at the upstream end an inlet aperture for a powder nozzle, an outlet aperture or throat coaxially aligned with the power nozzle or inlet aperture, the outlet aperture also having a pair of short boundary walls which have an angle between them of approximately the desired fan angle of liquid to be issued. The fan angle, as disclosed in the prior art referred to above, is related to the distance between the power nozzle and the outlet throat. A pair of spaced walls extending downstream of the power nozzle and spaced therefrom terminate in a pair of bulbous protuberances or deflectors which define the downstream ends of vortex forming spaces and the deflectors also define the vortex controlled entranceways to the inlets of a pair of liquid passages, the exits for the passages being at opposite sides of the power nozzle. While it is not critical for the proper operation of the present invention, one of the upper and/or lower walls bounding the oscillation chamber is tapered to assure cold weather oscillation.

Brief description of the drawings

The above and other objects advantages and features of the invention will become more apparent when considered with the accompanying drawings wherein:

Figure 1a is a silhouette of a preferred form of the oscillator, and Figure 1b is a sectional side elevational view of Figure 1a.

Figure 2 is a view similar to Figure 1a, but wherein legends have been applied and some of the numbering deleted for clarity and there is shown the positions of three of the vortices and the location of the power jet at a particular instance during operation thereof,

Figures 3a—3h diagrammatically illustrate a sequence of vortex formation and movement and resulting flow conditions in an oscillator incorporating the invention.

Detailed description of the invention

The invention will be described in relation to automobile windshield washer assemblies, the oscillator of the present invention is constituted by a molded plastic body member 10 which would typically be inserted into a housing or holder member 11 (shown in section Figure 2) which has a fitting 12 which receives tubing 13 connection to the outlet of the windshield washer pump (not shown). Liquid washing compound is thus introduced to the device via power nozzle inlet 14 which thus issues fluid through power nozzles 15. The liquid issues from the power nozzle 15 which at its exit EP has a width W, the liquid flowing initially past the exit ports 16 and 17 of liqiud passages 18 and 19 respectively. Elements 20 and 21 basically form the boundaries of the interaction chamber and the liquid passages 18 and 19, respectively. This chamber structure is defined by a pair of walls 20N and 21N which are normal to the central axis through the power nozzle 15 and outlet throat 24, which connect with wall elements 20-P and 21-P which are parallel to the direction of fluid flow, the normal and parallel wall elements being joined by curved section 20C and 21C respectively so that the liquid passages from the inlets 18-I and 19-I respectively are of substantially uniform width and about equal to the width W of the power nozzle. An important feature of the invention are the bulbous protuberances or projections 20-B and 21-B at the downstream ends of parallel portions 20-P and 21-P which preferably have smoothly rounded surfaces. Protuberances 20-B and 21-B with outer wall portions 36 and 37 define the entranceways 38 and 39 to inlets 18-I and 19-I respectively. The outlet throat 24 has a pair of very short diverging fan angle limiting walls 26-L and 26-R, which in this embodiment are set at an angle of about 110° and which thereby defines the maximum fan angle.

While the basic structural features of the invention have been described above in relation to the invention; the following description relates to the functional characteristics of each of the major components of the invention.

Power nozzle

Figure 1a shows that in the device the walls WP of the power nozzle, are not parallel to the power jet centerline, but converge increasingly all the way to the power nozzle exit EP, so that the power jet stream will continue to converge (and increase velocity) until the internal pressure in the jet overrides and expansion begins.

The main oscillator chamber

The main oscillator chamber MOC includes a pair of left and right vortex supporting or generating volumes which vortices avoid wall attachment and boundary layer effects and hence avoids dwell of the power jet at either extremity of its sweep; the chamber is more or less square. The terms "left" and "right" are solely with reference to the drawing and are not intended to be limiting.

Feedback passages

Exits (16, 17)

The feedback passage exits 16 and 17 (Figures 1a, b and 2) are not reduced in flow area. A reduction in flow area is sometimes used in prior art oscillators to increase the velocity of feedback flow where it interacts with the power jet; to restrict entrainment flow out of the feedback passage; or as part of an RC feedback system to determine power jet dwell time at an attachment wall. In the preferred embodiment of the invention, the feedback passage exits 16 and 17 of the oscillator are the same size as the passages 18 and 19. No aid to wall attachment is necessary because there are no walls on which attachment might occur.

Inlet (18-I and 19-I)

The feedback inlets in many prior art oscillators are sharp edged dividers placed so that they intercept part of the power jet flow when the power jet is at either the right or left extreme of its motion. The dividers used in prior art oscillators at the feedback inlet direct a known percentage of the flow to the feedback exit (or feedback nozzle in some cases) in order to force the power jet to move or switch to the other side of the device. The feedback passages sometimes contain "capacitors" to delay the build-up of feedback pressure in order to lengthen the time the power jet dwells at either extreme. In contrast the feedback inlets 18-I and 19-I of this invention are rotated 90° relative to the usual configuration, and thus do not intercept any power jet flow. In fact, as will be described later under the heading "Method of Oscillation", there is no power jet flow in the feedback passages 18 and 19.

Deflectors (protuberances 20-B and 21-B)

The partition that separates feedback passage from the main chamber MOC of the oscillator may also be seen in Figure 2, this partition is terminated at the feedback passage inlet by rounded protrusion or deflector members 20-B and 21-B. This part of the partition has three functions; to deflect the power jet stream; to provide a downstream seal for the vortex generation chamber; and to form part of the feedback passage inlet.

Method of oscillation

Initially as the supply pressure applied to the inlet 14 of the oscillator is increased, the power jet leaving via EP becomes turbulent. Liquid from the power nozzle EP issues therefrom toward the outlet throat and expands to fill the oscillation chamber MOC. The turbulence which begins on the free sides of the jet causes some entrainment of local fluid in the main chamber MOC, and eventually sufficient instability in the pressure surrounding the jet to cause it to be begin to undulate. This movement increases with increased pressure until the jet impacts the deflectors and then the normal oscillation pattern for this device begins.

In this invention there are four places where vortexes can exist. These locations (30, 31, 32, 33), may be seen in Figures 1 and 2. However, only three vortexes exist during most of the cycle, only two during the feedback portion of the cycle, and never four at the same time.

Assuming the power jet has just arrived at the left side of the device in Figures 2 and 3a, the vortex formation in left vortex generation chamber has just begun. The deflector 20-B has formed a seal between the power jet and the rest of the chamber, so that the only place chamber MOC can get a supply of flow to relieve the low pressure generated there would be from the feedback passage. With normal feedback this would occur because the feedback inlet would be receiving flow at a rate greater than the entrainment flow of the feedback exit, and the power jet would move toward the opposite side. However, in this invention the inlet 18-I to the feedback passage is sealed by a strong vortex at entranceway 38. This vortex at entranceway 38 was larger (like the one at entranceway 39) until it was confined in the feedback inlet by the power jet. Being suddenly reduced in size, its rotational speed increased, enhancing its ability to seal the feedback inlet 18-I and to deflect the power jet toward the outlet device to ambient. Meanwhile, since the vortex forming in the left vortex chamber has no flow to relieve the low pressure but the power jet, it builds in intensity. The increasing pressure unbalance across the power jet and the motion of the vortex cause the power jet to move further left (Figures 3b, 3c and 3d) and to begin to impact the deflector 20-B more on the upstream side. As this condition increases the power jet deflects off the deflector at a more shallow angle permitting the vortex 32 at entranceway 38 to expand. Thus, the outlet stream begins to move before feedback begins.

As the power jet moves into the left vortex chamber if flows right across the lower end of the partition forming the feedback passage exit 16 following the contour of the partition 20-P and at the same time, by aspiration, greatly reducing the pressure in feedback passage 18. The continual lowering of the pressure in the feedback passage, combined with the loss in energy of the vortex 32, results in the vortex suddenly being "swallowed" (Figure 3e) into the feedback passage 18 and dissipating there.

When the vortex 32 is "swallowed", flow can take place in passage 18. The motivation for this flow is not from the usual positive pressure at the feedback inlet, generated by splitting off part of the lower jet, but it is due to a low pressure in the feedback passage 18 generated by the high velocity power jet aspirating fluid from passage 18 at exit 16. The effect of the feedback flow is:

1. Permits the power jet to receive entrained flow (through passage 18), so it can begin to move away from the partition at 16.

2. The additional flow (power jet plus entrained flow) tends to push the vortex 30 in the left vortex chamber downstream.

3. The flow through passage 18 to exit 16 creates a low pressure at inlet 18-I thus initiating a circulating flow from exit 16 to inlet 18-I on the chamber side of the partitions 20-P with the return through passageway 18 (Figures 3e, and 3g).

4. The fluid motion described above, generates a pressure difference across the vortex 30 in the left vortex chamber. This push-pull effect causes the vortex 30 to cross-over deflector 20-B and to move into the low pressure zone at entranceway 38 (Figures 3e, 3g, and 3h).

5. The inlet 18-I is thus sealed once more upon the arrival of the vortex 32 (Figure 3h). Feedback flow exists only during that period of time from the annihilation of the vortex at inlet 18-I until the next vortex, from 30, moves into 18-I. During the remainder of the oscillator's cycle there is essentially no net flow through passage 18.

6. As the vortex 30 generated in the left vortex chamber moves across deflector 20-B, it forces the power jet to the right side (Figure 3g) where the power jet encounters the vortex 33 at entranceway 39 and the deflector 21-B.

7. The motion of the "new" vortex 32, as it crosses over deflector 20-B, and the motion of the "old" vortex 33 at entranceway 39 cause the power jet to bend sharply and exit to the left. (Opposite to the condition shown in Figure 2).

8. When the power jet encounters the deflector 21-B (Figure 3h), a vortex 31 begins to form at the right vortex generation chamber (inlet 19-I is sealed by the "old" vortex 33) and the entire process described above is repeated.

The movement of the outlet stream is depicted in Figures 3a through 3h. As is shown in these figures, the outlet stream begins to move or sweep in an opposite direction by virtue of generation and movement of the vortices 30 and 31 and hence before fluid flow in the feedback passages. Therefore; the motion and position of the outlet stream is not entirely dependent on feedback, whereas the opposite is true, in astable multivibrators. The angular relationship (sweeping motion) of the output stream versus time is more closely related to sinusoidal oscillation than it is to astable oscillation. This is evidenced by the fact that the output stream does not "linger" at either extreme of its angular movement.

The power nozzle design purposely generates turbulence in the power jet stream prior to the nozzle exit, rather than attempt to generate a "low" turbulence nozzle design with a controlled and stable velocity profile. Moreover, the power nozzle allows the power jet flow within the power nozzle to "hug" one or the other of the power nozzle's sidewalls in order to cause a closer interaction between the power jet and the exits 16 and 17 of the feedback passages 18 and 19, thus, enhancing the generation of very low pressures in the feedback passages.

The feedback passage exits 16 and 17 are unrestricted so there is no RC storage (e.g. capacitance or resistance effects) and permit maximum flow from the feedback passage. The large exits 16 and 17 also permit maximum aspiration to occur as a result of the power jet flowing across the exits. The feedback passages 18 and 20 are at a "low pressure-no flow" condition for most of the oscillator cycle.

Feedback is controlled by low pressure and vortex movement rather than intercepting a portion of the power jet. In fact, there is no power jet flow in the feedback passage. The entranceways 38 and 39 to feedback passage inlets 18-I and 19-I are designed to provide containment of a vortex for sealing the inlet to the feedback passage against flow.

The vortices produced in left and right vortex generation chambers dominate the process of oscillation and also provide a new vortex that moves into the inlet of a feedback passage to terminate each feedback occurrence.

It is the vortex aided power jet control (as opposed to boundary layer or stream interaction) which is the dominant oscillatory mechanism controlling all major aspects. When a vortex moves across one of the deflectors, it forces the power jet toward the opposite deflector. In addition, the vortex, with help from a counter rotating vortex on the other side of the power jet, causes the power jet to bend sharply around the first vortex.

Since there is no wall lock-on or coanda effect utilized, there is essentially no dwell, a uniformity of fan pattern is achieved at the relatively wide angle (in the disclosed embodiment 110° to 120° however, it is to be understood that the fan angle can be any value from 30° to 160°) needed for good wetting, for example of a windshield, especially where separate driver and passenger nozzles are used. The fan is in the direct line vision. At the same time, the device retains the low threshold pressure for initiation of oscillation so in the case of a windshield washer assembly for automobiles, there is no need to increase pump sizes for cold weather operation when the viscosity and surface tension of the liquid has increased. If desired, the oscillation chamber can have the top (roof) and bottom (floor) walls thereof diverging from each other in the direction of the outlet throat so as to expand the power jet in cold weather but it is not necessary in regards to the present invention.

The device illustrated is an actual operating device. Variations of the output characteristics can be achieved by varying the curvature of protuberances 20-B and 21-B. In addition, the fan angle can be decreased by shortening the distance between the power nozzle 15 and outlet throat 24. In the drawings, the distance between the power nozzle 15 and the outlet throat 24 is about 9W and the distance between side walls 20 and 21 is slightly more than 6W, the distance between protuberances 20-B and 21-B is slightly greater than 4W.

Claims

1. A liquid oscillator, particularly for a windshield washer system having a liquid fan spray nozzle, having an oscillation chamber (MOC), a power nozzle (15) for introducing a liquid power jet into said chamber, an outlet throat (24) downstream of said power nozzle and a pair of passages (18, 19) having inlet openings (18-I, 19-I) to the respective sides of said outlet throat and exit openings (16, 17) adjacent said power nozzle, said oscillation chamber including a pair of mirror image wall surfaces beginning immediately downstream of said exit openings and extending to downstream therefrom, characterized in that said pair of mirror image wall surfaces defines two vortex forming chambers (30, 31) the upstream end of each of said vortex forming chambers being set back from said exit openings (16, 17) sufficient to avoid wall attachment and that the downstream end of each of said mirror image wall surfaces has protrusions (20B, 21B), respectively, having relatively smooth surfaces to guide the vortices formed in said vortex forming chambers thereover and into said inlet openings whereby said liquid power jet is caused to oscillate back and forth in said oscillation chamber.

2. A liquid oscillator according to claim 1, characterized in that said power nozzle (15) has converging sides and said power jet expands in said oscillation chamber (MOC).

3. A liquid oscillator according to claim 1 or 2, characterized in that said oscillation chamber (MOC) has top and bottom walls which diverge relative to each other.

4. A liquid oscillator according to one of claims 1 to 3, characterized in that said power jet creates a suction at the exit opening (16, 17) of the one of said pair of passages (18, 19) having a vortex residing in the inlet opening (18-I, 19-I) thereof.

5. A liquid oscillator according to one of claims 1 to 4, characterized in that said rounded protrusions (20B, 21B) merge into said inlet openings (18-I, 19-I).

6. A liquid oscillator according to one of claims 1 to 5, characterized in that said oscillation chamber (MOC) is preferably generally rectangular in shape.

7. A liquid oscillator according to one of claims 1 to 6, characterized in that the vortex forming chambers (30, 31) are confined by a first pair of walls (20N, 21N) normal to the axis of said power nozzle (15) and located immediately downstream of said exit openings (16, 17) and of a length sufficient to avoid wall attachment, a second pair of walls (20P, 21P) parallel to the axis of said power nozzle connected to said first pair of walls immediately downstream thereof, the pair of spaced apart rounded protrusions (20B, 21B) being connected to the downstream end of said second pair of walls, whereby the liquid of said power jet does not lock-on to any wall surface.

Patentansprüche

1. Oszillator für Flüssigkeiten, insbesondere für ein Windschutzscheiben-Waschsystem mit einer Gebläsesprühdüse für Flüssigkeiten mit einer Oszillationskammer (MOC), einer Treibdüse (15) zum Einführen eines flüssigen Treibstrahls in die Kammer, einem Ausgangsdüsenhals (24) stromabwärts von der Treibdüse und einem Paar von Kanälen (18, 19) mit Eingangsöffnungen (18-I, 19-I) zu den jeweiligen Seiten des Ausgangsdüsenhalses und mit Ausgangsöffnungen (16, 17) in dern Nähe der Treibdüse, wobei die Oszillationskammer ein Paar von Spiegelbildwandoberflächen aufweist, welche unmittelbar stromabwärts von den Ausgangsöffnungen beginnen und sich stromabwärts hiervon erstrecken, dadurch gekennzeichnet, daß das Paar von Spiegelbildwandoberflächen zwei wirbelbildende Kammern (30, 31) begrenzt, deren stromaufwärtiges Ende jeweils in Bezug zu den Ausgangsöffnungen (16, 17) ausreichend zurückgesetzt ist, um Wandberührung zu vermeiden, und daß das stromabwärtige Ende jeder Spiegelbildwandoberfläche jeweils Vorsprüge (20B, 21B) mit relativ glatten Oberflächen aufweist, um die in den wirbelbildenden Kammern gebildeten Wirbel hierüber und in die Eingangsöffnungen zu führen, wodurch der flüssige Treibstrahl veranlaßt wird, in der Oszillationskammer hin und her zu oszillieren.

2. Oszillator für Flüssigkeiten nach Anspruch 1, dadurch gekennzeichnet, daß die Treibdüse (15) konvergierende Seiten aufweist und daß sich der Treibstrahl in der Oszillationskammer (MOC) ausbreitet.

3. Oszillator für Flüssigkeiten nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Oszillationskammer (MOC) obere und unteren Wände aufweist, welche relativ zueinander divergieren.

4. Oszillator für Flüssigkeiten nach einem der

Ansprüche 1 bis 3, dadurch gekennzeichnet, daß der Treibstrahl an der Ausgangsöffnung (16, 17) des einen des Paares von Kanälen (18, 19) einen Sog erzeugt, in dessen Eingangsöffnung (18-I, 19-I) ein Wirbel sitzt.

5. Oszillator für Flüssigkeiten nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß die abgerundeten Vorsprünge (20B, 21B) in die Eingangsöffnungen (18-I, 19-I) münden.

6. Oszillator für Flüssigkeiten nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß die Oszillationskammer (MOC) vorzugsweise allgemein rechteckförmig ist.

7. Oszillator für Flüssigkeiten nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, daß die wirbelbildenden Kammern (30, 31) durch ein erstes Paar von Wänden (20N, 21N), die senkrecht zur Achse der Treibdüse (15) verlaufen und unmittelbar stromabwärts von den Ausgangsöffnungen (16, 17) angeordnet sind und eine ausreichende Länge aufweisen, um Wandhaftung zu vermeiden, und durch ein zweites Paar von Wänden (20P, 21P) begrenzt sind, die parallel zur Achse der Treibdüse verlaufen und mit dem ersten Paar von Wänden unmittelbar stromabwärts von diesen verbunden sind, wobei das Paar von beabstandeten abgerundeten Vorsprüngen (20B, 21B) mit dem Stromabwartigen Ende des zweiten Paars von Wänden verbunden ist, wodurch die Flüssigkeit des Treibstrahls an keiner Wandoberfläche festgehalten wird.

Revendications

1. Oscillateur à liquide, destiné en particulier à une installation de lavage de pare-brise (ou lave-glace) pourvue d'un gicleur produisant un jet de liquide en éventail, comportant une chambre d'oscillation (MOC), un gicleur dynamique (15) destiné à introduire un jet dynamique de liquide dans ladite chambre, un étranglement de décharge (24) en aval du gicleur d'alimentation et deux passages (18, 19) comportant des ouvertures (18-I, 19-I) d'entrée sur les côtés respectifs de l'étranglement de décharge et des ouvertures de sortie (16, 17) adjacentes au gicleur dynamique, ladite chambre d'oscillation comprenant deux surfaces de paroi symétiques l'une de l'autre commençant juste en aval des ouvertures de sortie et s'étendant en aval de celles-ci, caractérisé en ce que les deux surfaces de paroi symétriques délimitent deux chambres de tourbillonnement (30, 31) dont l'extrémité amont de chacune est suffisamment en retrait des ouvertures de sortie (16, 17) pour éviter un effet de paroi, et en ce qui l'extrémité aval de chacune des surfaces de paroi symétrique comporte des saillies (20B, 21B respectivement), présentant des surfaces relativement lisses pour guider les tourbillons formés dans lesdits chambres de tourbillonnement de façon qu'ils les franchissent et passent dans les ouvertures d'entrée, ce qui fait effectuer au jet d'alimentation de liquide des oscillations de sens alternativement opposés dans ladite chambre d'oscillation.

2. Oscillateur à liquide selon la revendication 1, caractérisé en ce que le gicleur dynamique (15) comporte des faces latérales convergentes, et en ce que le jet dynamique s'élargit dans ladite chambre d'oscillation (MOC).

3. Oscillateur à liquide selon la revendication 1 ou 2, caractérisé en ce que ladite chambre d'oscillation (MOC) comporte des parois supérieure et inférieure qui divergent l'une par rapport à l'autre.

4. Oscillateur à liquide selon l'une quelconque des revendications 1 à 3, caractérisé en ce que le jet dynamique produit une aspiration à l'ouverture de sortie (16, 17) de celui des deux passages (18, 19) à l'ouverture d'entrée (18-I, 19-I) duquel réside un tourillon.

5. Oscillateur à liquide selon l'une quelconque des revendications 1 à 4, caractérisé en ce que les saillies arrondies (20B, 21B) aboutissent aux ouvertures d'entrée (18-I, 19-I).

6. Oscillateur à liquide selon l'une quelconque des revendications 1 à 5, caractérisé en ce que la chambre d'oscillation (MOC) a, de préférence, une forme générale rectangulaire.

7. Oscillateur à liquide selon l'une quelconque des revendications 1 à 6, caractérisé en ce que les chambres de tourbillonnement (30, 31) sont délimitées par une première paire de parois (20N, 21N) perpendiculaires à l'axe du gicleur dynamique (15) et situées juste en aval des ouvertures de sortie (16, 17), et d'une longueur suffisante pour éviter un effet de paroi, une seconde pair de parois (20P, 21P) parallèles à l'axe du gicleur dynamique reliées à la première paire de parois juste en aval de celles-ci, les deux saillies arrondies séparées (20B, 21B) étant reliées à l'extrémité aval de la seconde paire de parois, de sorte que le liquid du jet dynamique ne s'attache sur aucune surface de paroi.

FIG 1b

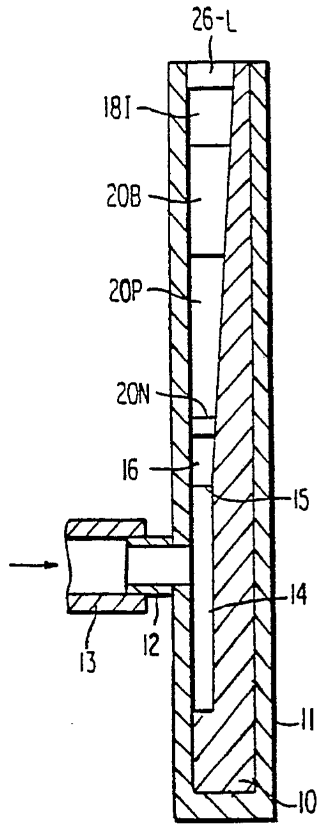
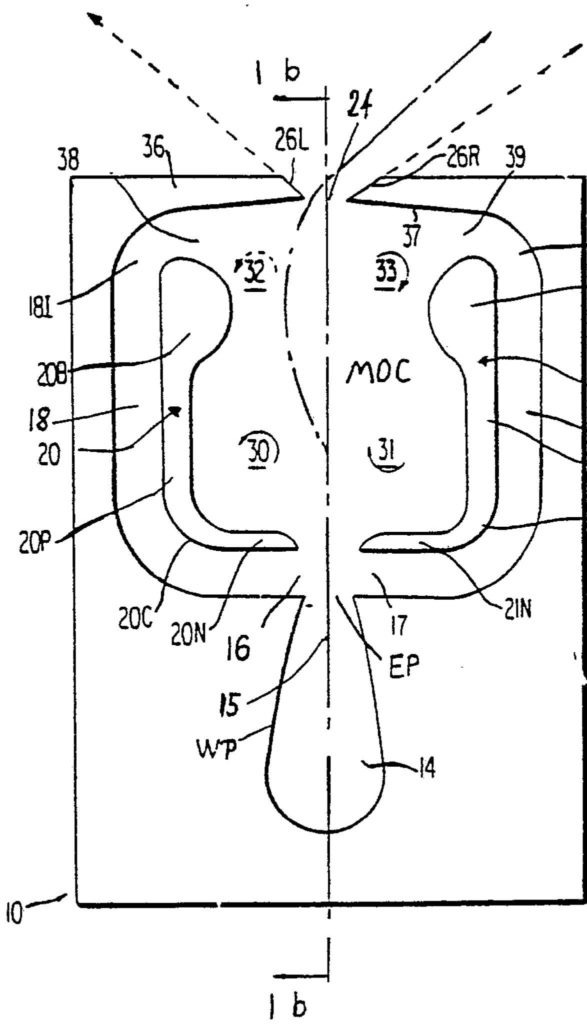

26-L
18I
20B
20P
20N
16
15
14
13
12
11
10

FIG 1a


1 b
24
26L
26R
38
36
39
37
18I
19I
32
33
21B
MOC
20B
21
18
19
20
30
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20P
21C
20C
20N
16
17
21N
EP
15
WP
14
10
1 b

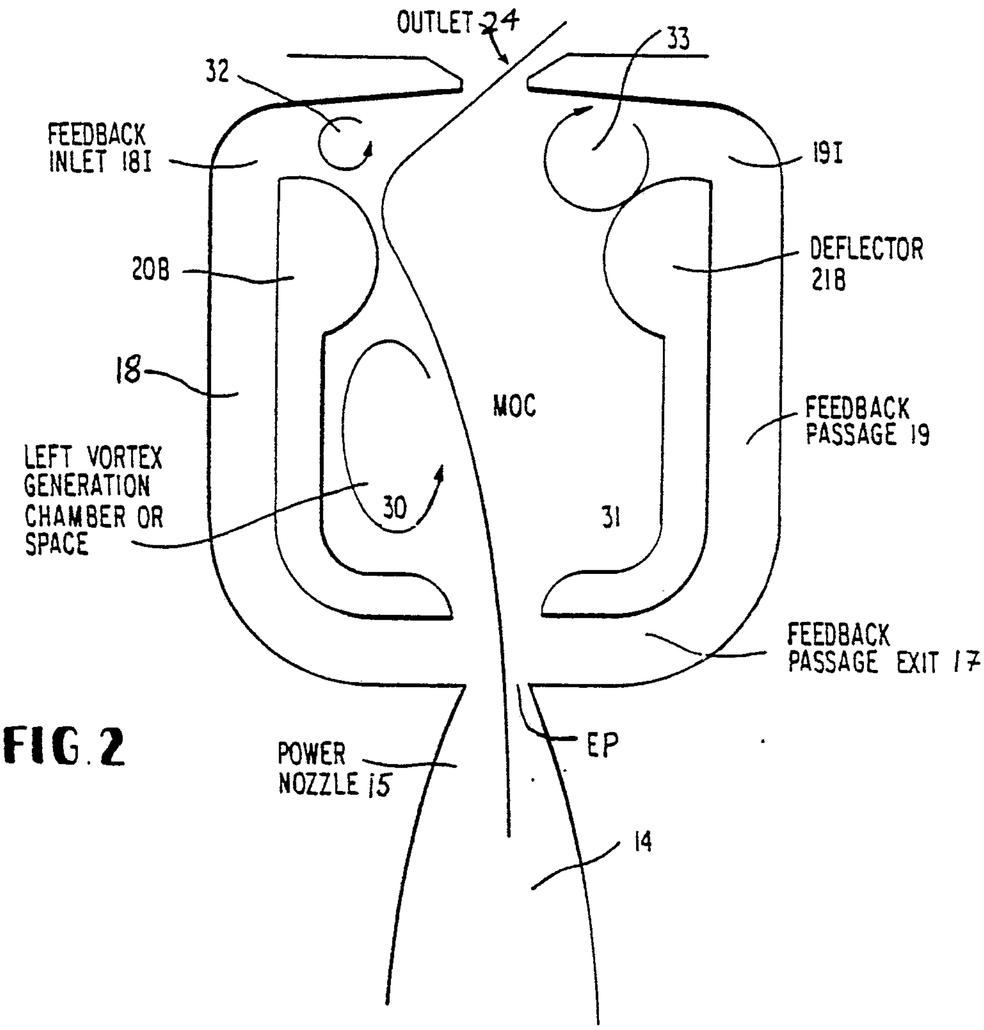
OUTLET 24
32
33
FEEDBACK
INLET 18I
19I
20B
DEFLECTOR
21B
18
MOC
FEEDBACK
PASSAGE 19
LEFT VORTEX
GENERATION
CHAMBER OR
SPACE
30
31
FEEDBACK
PASSAGE EXIT 17
EP
POWER
NOZZLE 15
14

FIG. 2

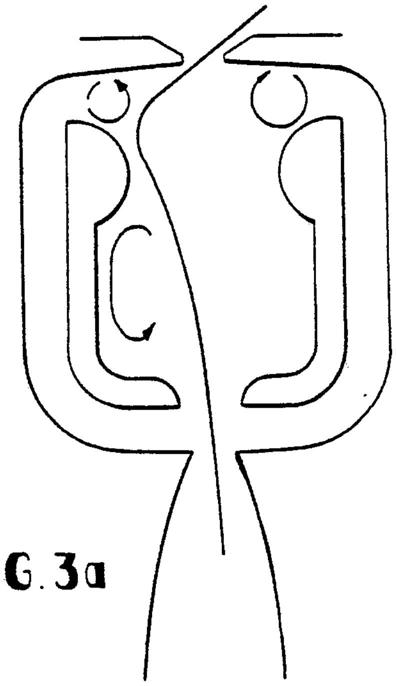

FIG. 3a

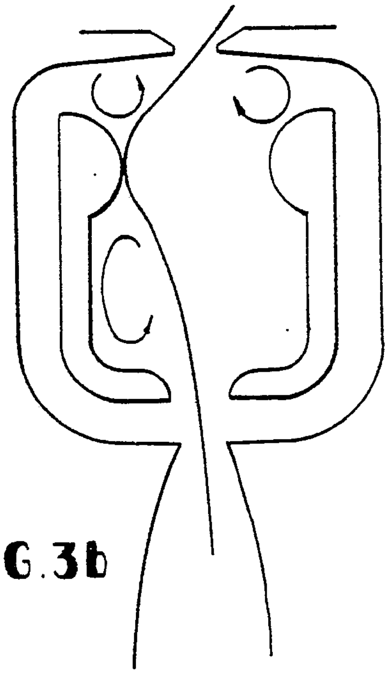

FIG. 3b

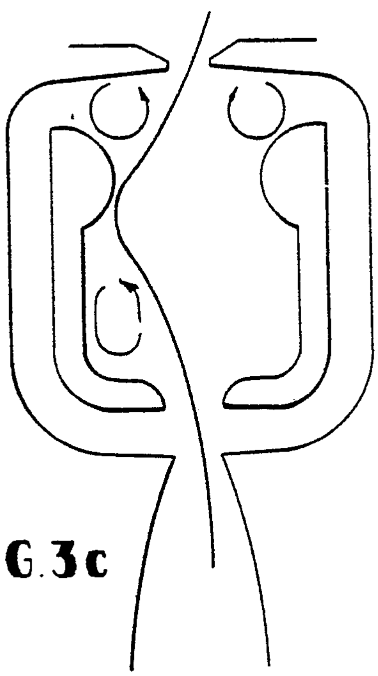

FIG. 3c

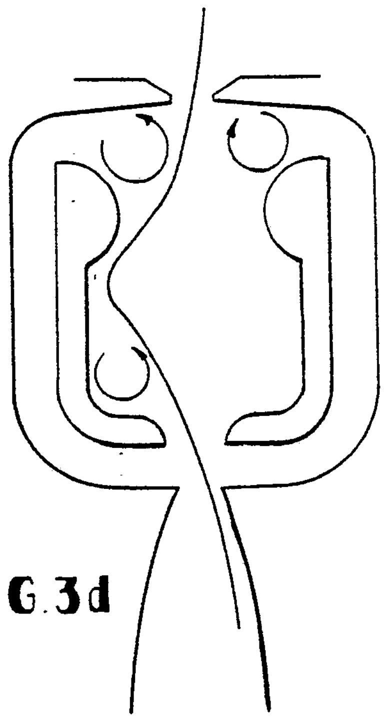

FIG. 3d

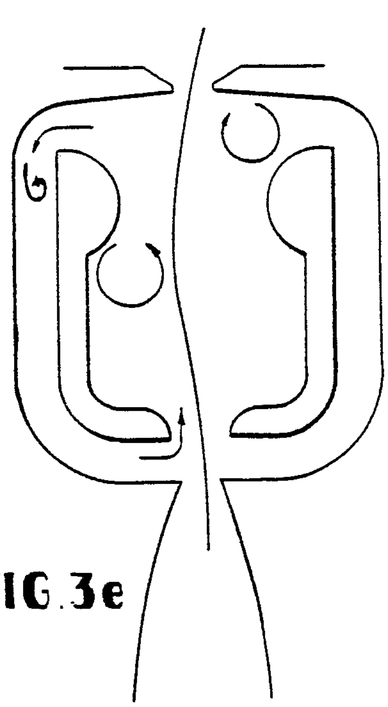

FIG.3e

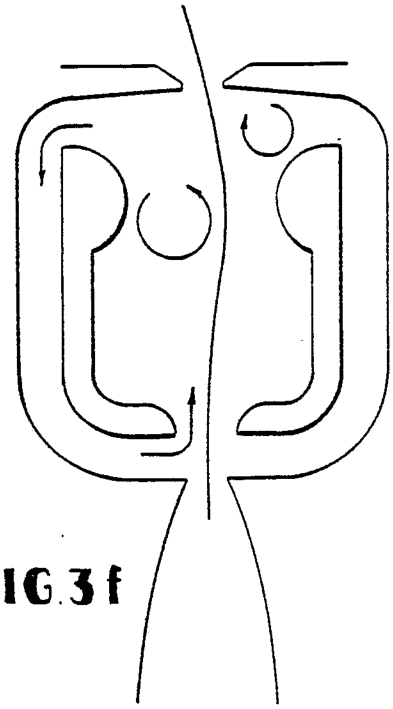

FIG.3f

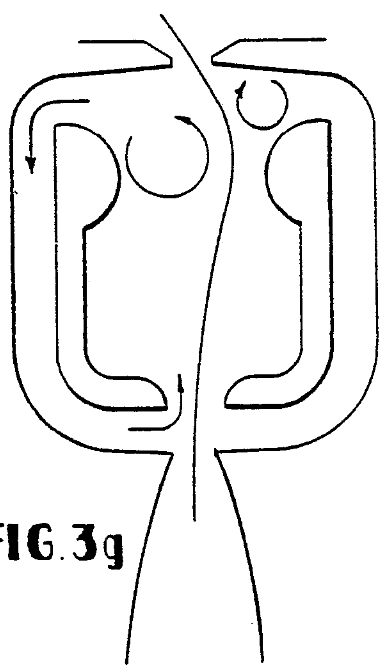

FIG.3g

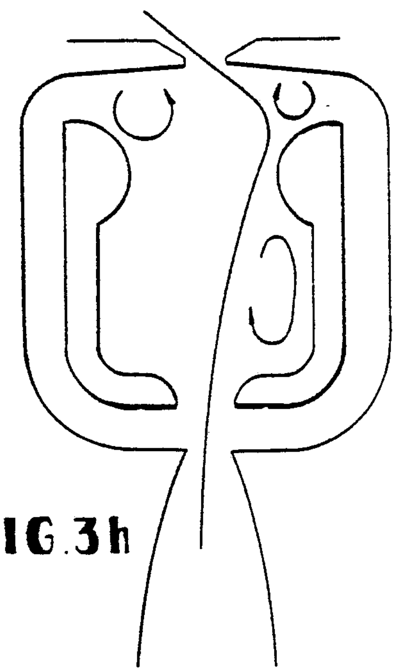

FIG.3h