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(54) **Large capacity air-powered smokeless flare.**

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Description

Background of the Invention

1. Field of the Invention

This invention lies in the field of the smokeless burning of waste gases by means of flares.

Still more particularly, this invention relates to the construction of flares for the burning of very large flows of waste gas, of size 90718 kilograms (200,000 pounds) per hour or greater.

Still more particularly, it concerns an improved type of construction for flares to burn large quantities of gas smokelessly with reduced expenditure of energy for pressurization of the primary combustion air.

2. Description of the Prior Art

In the prior art large high-powered flares for the smokeless burning of waste gas have been built, up to the size of about 45359 kilograms (100,000 pounds) per hour, using the power of pressurized air for smokeless combustion. Such prior art devices were constructed in such a form that the primary combustion air was pre-pressured and pre-mixed with the waste gas in such a way that the total flow was in the form of a solid vertical cylinder of rapid upflowing gas and air, such that there was a large induction of secondary air around the outer periphery of this column of flame and gas.

Because of the surface area limitation to the flow of induced secondary air into the outer wall of the rising column of gas, and the necessity for the secondary air to penetrate to the center of the column in order to avoid incomplete and smoky combustion, there was a practical limit of the order of 45359 kilograms (100,000 pounds) per hour for such flares. Such applications that had larger flows than this would require a duplication of two or more such flares to handle a total flow capacity.

By the present invention it is now possible to provide combustion of 90718 kilograms (200,000 pounds) per hour in a single flare, or less with reduced expenditure of electrical energy for pressurizing the primary combustion air.

However, there is another serious problem in the smokeless combustion of hydrocarbons where the hydrogen to carbon ratio (H/C-R) is low. Ventings from an ethylene facility (principally olefinic, or unsaturated compounds) provides gases for smokeless flare burning where the H/C weight ratio can be as low as 0.166, and difficulty with smoky burning increases as the H/C ratio decreases. For example, consider methane (H/C = .333) makes no smoke as it burns at the flare; ethane (H/C = .25) makes faint trailing smoke, and propane (H/C = .222) smokes relatively heavily. Smoke density increases as the H/C falls below .222, and difficulty in smoke suppression will vary as the potential smoke density increases. Thus, as the H/C-R decreases, means must be provided to increase the rate of induction of secondary air to

provide smokeless combustion. With this invention it is possible to flare burn without smoke, large flows of waste gases, which are combustible, and which have H/C-R in the range of 0.333 down to 0.083 (acetylene).

Prior art is represented by DE—A1—2,725,202 and GB—A—695477 and U.S.—A—3817695 of which this invention distinguishes as set forth herein below.

DE—A1—2 725 202 discloses a flare for smokeless combustion of large volumes of vented waste gases. GB—A—695477 discloses a burner having an inner vertical conduit for the upward flow of gases under a selected pressure, plus an outer, larger vertical conduit forming an annular passage through which primary combustion air is flowed upwardly under a selected velocity. US—A—3817695 recognizes the necessity to break up a single column of gas to allow excess of air to the centre of the burning.

An object of this invention is to provide a smokeless combustion of flare-vented gases for the burning of large flows of waste gases with a minimum expenditure of electrical power for pressurizing the primary combustion air.

According to the present invention a flare for smokeless combustion of waste gases being vented under a selected pressure having an inner vertical conduit of diameter D1, for the upward flow of waste gases for burning, an outer vertical conduit of diameter D2 larger than D1, substantially coaxial with the first conduit, forming a first annular passage between the two conduits and connected at the bottom with an air mover which forces primary combustion air at greater than atmospheric pressure through said first annular passage, an igniter being arranged at the top of the second annular passage is characterized in that an annular volume of refractory material in the form of an annular cylinder extends from the outer surface of the inner conduit out to a diameter equal to D3, a closed cylindrical obstacle, having an upwardly curved bottom, the obstacle being of diameter D3A greater than D1 but less than D2, supported axially above the top of the inner conduit by a selected distance and forming a second annular passage of diameter D2A less than D2 between the obstacle means and the outer conduit the upwardly curved bottom surface located below the top of the outer conduit at a point where a vena contracta of air flow is formed in the second annular passage whereby the mixture of gas and air flowing up the second annular passage will continue upwardly as an annular wall of gas and flame and, because of its high velocity, will induce radial flow inwardly to the outer surface, of secondary air from the outside and will induce a downward flow of air inside of the annular wall, to flow radially outwardly into the inner surface of the annular flow.

The velocity of flow of the primary combustion air is preferably in the range of 15.25 to

61 metres per second in the second annular passage.

The refractory material may be supported by a metal sheath on its outer surface, the sheath being supported by the inner conduit.

A plurality of equally spaced baffles may extend across the flow of air gas mixture in the second annular passage adjacent the top of the outer conduit; these baffles may include at least one opening whose axis is parallel to the axis of the outer conduit.

Brief Description of the Drawings

These and other objects and advantages of this invention and a better understanding of the principles and details of the invention will be evident from the following description taken in conjunction with the appended drawings in which:

FIGURE 1 is a vertical section of one embodiment of this invention.

FIGURES 2 and 3 are cross-sectional views taken respectively across the planes 2—2 and 3—3 of FIGURE 1.

FIGURES 4 and 5 show plan and cross-sectional views of a modification of FIGURE 1.

FIGURES 6 and 7 show details of the modification of FIGURES 4 and 5.

Description of the Preferred Embodiment

Referring now to the drawings and, in particular, to FIGURE 1, there is shown one embodiment of this invention illustrated in cross-section, indicated generally by the numeral 10.

The waste gases flow from their source, through the conduit 11 and up to the conduit 12 in accordance with arrows 14. Conduit 12 is of diameter D1.

There is a second larger, outer conduit 16 of diameter D2, which is closed at the bottom around the inner conduit 12, into which primary combustion air is flowed under selected pressure by means of blower 17, in accordance with arrow 19. The air flow from the blower flows into the bottom of the annular space 18, between the inner and outer conduits. The annular space 18 between the inner 12, and outer 16, conduits is designated as the first annular space.

The air flow 19 from the blower 17 may enter the space 18, axially or radially, in which case it will flow vertically in the first annular space in accordance with arrows 20. Alternatively, the blower can be mounted tangentially to the conduit 16, in which case the air will flow upwardly in the form of a helix in accordance with arrow 19A. The helical flow adds turbulence, which assists in the mixing of air and gas.

The second conduit 16 slopes at 22 into a reduced diameter conduit 24 above a point 23 to a diameter D2A, for the purpose of increasing the velocity of the upward flow of air in the space 25.

Above the top of the inner conduit 12 there is

a closed cylindrical object or obstacle 34, which has a curved bottom surface 35 and a curved top surface 36. It is supported by pipe 38, which is supported by spacers 40, inside of, and coaxial with the inner conduit 12. There is a vertical gap between the top of the conduit 12 and the obstacle 34 for the outflow of gases in accordance with arrows 15. The obstacle is of outer diameter D3A. It is preferred that the top 36 of the obstacle 34 be above the top of the conduit 24.

A shroud 26 of outer diameter D3 is substantially, not necessarily dimensional, equal to D3A of the obstacle 34 and is fastened to the outer surface of the conduit 12, and the space between the conduit 12 and the shroud 26 is filled with a refractory material 30. The top surface of the refractory material defines a conical passage 32 leading from the inside of the conduit 12, out into the second annular space 25 at a point substantially at the vena contracta of the air flow between the obstacle 34 and the top portion of the outer conduit 16. The approximate vena contracta is shown by dotted line 28. This second annular space is of selected inner and outer diameter, such that under the rapid flow of the primary combustion air 20, mixing with the outwardly flowing gases 15, there will be a rising annular column 44 of gas and air substantially vertically from the second annular space in accordance with arrows 42. Means such as 48 are provided for igniting the gas. Therefore, there will be flame and hot air and gas rising above the top of the flare.

The purpose of the shroud 26 is to decrease the radial width of the second annular space 25 to increase the flow velocity of primary air 42 prior to mixing with the gas flow 15.

The preferred value of the ratio D2/D1 is approximately 1—7. It can be larger or smaller depending on the desired flow velocity of the gas-air mixture in the second annular passage. The preferred value of flow velocity is 23 m (75 ft.)/sec., but can be as high as 61 m (200 ft.)/sec. or more or as low as 15.25 m (50 ft.)/sec., depending on the composition of the waste gas and its hydrogen to carbon ratio.

Because of the high velocity of the rising air/gas mixture 44, secondary combustion air will be induced radially inwardly and outwardly, in accordance with arrows 46 into the outer surface 50 of this annular column 44. Also, there will be a reduced pressure directly above the obstacle 34, which will cause a downflow of atmospheric air 54, which will then be deflected outwardly into the inner surface 52 of this annular wall of gas. Because of the relatively large diameter of the obstacle 34 and the outer conduit 24 there will be a very large surface area for contact and mixing between the induced secondary air 46 and the rising column 44. Also, there will be a large contact area of the inner surface 52, which will likewise be receiving and mixing with the induced secondary air 54.

Because of the relatively narrow radial dimension of the annular column the penetration depth required of the atmospheric air in order to contact the entire volume of gas in the annular wall will be very much less than that required when the rising column of gas is in the form of a solid cylinder. Consequently, the efficiency of induction and contact of secondary air with the rising column of gas and primary air, will make this embodiment very efficient in the smokeless combustion of very large flows of waste gases, without substantial increase in the amount of electrical energy required to provide the pressurized primary air.

Because of this greater efficiency of mixing of the primary air with the waste gases and the more efficient induction and mixing of secondary air, the embodiment shown in FIGURE 1 is more efficient than the prior art devices and, therefore, can handle much larger flows of gas with the same amount of energy required for pressurizing the primary air. Experience shows that primary air flow in the quantity of about eight to ten per cent of the total stoichiometric flow is adequate to provide smokeless combustion of very large flows of gas.

Referring now to FIGURES 2 and 3, there are shown two views in cross-section taken across the planes 2—2 and 3—3, respectively, of FIGURE 1. The drawings are self-explanatory and identical numerals are used to identify identical parts.

An improvement in the first embodiment shown in FIGURE 1 is illustrated in FIGURES 4—7. The improvement lies in the use of a plurality of circumferentially spaced radial baffles 60 across the second annular passage 25. While four such baffles are shown, there can be any desired number. The baffles 60 are flat bars (Fig. 6) which extend from the outer conduit 24 transverse to the air-gas flow, up to the wall of the obstacle 34 or they can be angular 62, 64 (Fig. 7). They can be attached, as by welding 68 to outer conduit 24, or to both 24 and 34. Air-gas flow in passage 25, which is not covered by baffles, is unimpeded, but the gas-air flow velocity is increased by the reduction of cross-section.

The purpose of the baffles is to cause accelerated indraft or induction of secondary air 70, FIGURES 4 and 7, to the area above the obstacle for enhancing burning. The air 70 moving inwardly over the baffles adds to the flow of secondary air 54.

This induction effect exists because when a baffle such as those shown in FIGURES 3—7 is transverse to (or blocks) flow, as in passage 25, where the flow 42 is at significant velocity, the pressure above the baffle is reduced according to $V^2/2g$ flow energy of 42. If the pressure of air immediately adjacent to the top of 24 is atmospheric, the low-pressure at the upper surface of the baffle causes air flow 70, and since the pressure above obstacle 36 is equally low, the air thus induced flows to the area above 36

to add to 54.

The baffles may be either solid, or may be perforated with closely adjacent ports 66, which are substantially aligned as in FIGURE 6 for continuous ignition across the baffle because of air travel to their vicinity. The baffles 60 through which gas and air 24A travel may be perpendicular to the wall of the outer conduit or at a selected angle upwardly or downwardly to the horizontal.

The length of the reduced diameter D2A portion 24 above point 23 is very short as compared to the length of conduit 16 in order to minimize the distance travelled by the high velocity air flow 42 and thus minimize linear pressure drop within the annular space 25. This reduces the energy demand that would otherwise be necessary to overcome excessive pressure drop. In a typical field service situation the length of portion 24 is about 0.9 metres (three feet) while the length of conduit 16 can be upwards of 61 metres (200 feet). The flow velocity of air in space 18 is but a fraction of the velocity as the air passes the orifice 23 23 metres (75 feet) per second preferred) into space 25, the ratio being a function of D2A to D2.

Claims

1. A flare for smokeless combustion of waste gases being vented under a selected pressure having an inner vertical conduit (12) of diameter D1, for the upward flow of waste gases for burning, an outer vertical conduit (16) of diameter D2 larger than D1, substantially coaxial with the first conduit (12), forming a first annular passage (18) between the two conduits (12 and 16) and connected at the bottom with an air mover (17) which forces primary combustion air at greater than atmospheric pressure through said first annular passage, an igniter (48) being arranged at the top of the second annular passage (25) characterized in that an annular volume (30) of refractory material in the form of an annular cylinder extends from the outer surface of the inner conduit (12) out to a diameter equal to D3, a closed cylindrical obstacle (34), having an upwardly curved bottom, the obstacle being of diameter D3A greater than D1 but less than D2, supported (38) axially above the top of the inner conduit by a selected distance and forming a second annular passage (25) of diameter D2A less than D2 between the obstacle means and the outer conduit the upwardly curved bottom surface (35) located below the top of the outer conduit (24) at a point (28) where a vena contracta of air flow is formed in the second annular passage (25) whereby the mixture of gas and air (42) flowing up the second annular passage (25), will continue upwardly as an annular wall of gas and flame (44) and, because of its high velocity, will induce radial flow inwardly to the outer surface, of secondary air (46) from the outside and will induce a downward flow of air

(52) inside of the annular wall (52), to flow radially outwardly into the inner surface of the annular flow.

2. A flare according to claim 1, characterized in that the velocity of flow of the primary combustion air (20) is in the range of 15.25 to 61 metres per second in the second annular passage (25).

3. A flare according to claim 1, characterized in that the refractory material (30) is supported by a metal sheath (26) on its outer surface, the sheath (26) being supported by the inner conduit (12).

4. A flare according to claim 1, characterized in that it includes a plurality of equally spaced baffles (60) extending across the flow (42) of air gas mixture in the second annular passage (25) adjacent the top of the outer conduit (24).

5. A flare according to claim 4, characterized in that the baffles (60) include at least one opening (66) whose axis is parallel to the axis of the outer conduit (24).

Revendications

1. Une torchère pour la combustion sans fumée de gaz perdus ventilés sous une pression sélectionnée, comprenant une conduite verticale intérieure (21) de diamètre D1 pour le flux montant de gaz perdus à brûler, une conduite verticale extérieure (16) de diamètre D2 plus grand que D1, substantiellement coaxiale avec la première conduite (12), formant un premier passage annulaire (18) entre les deux conduites (12 et 16) et reliée à sa base avec un souffleur d'air (17) qui force l'air de combustion primaire à une pression plus grande que la pression atmosphérique à travers ledit premier passage annulaire, un allumeur (48) étant disposé au sommet du second passage annulaire (25), caractérisé en ce qu'un volume annulaire (30) de matériau réfractaire en forme d'un cylindre annulaire s'étend à partir de la surface extérieure de la conduite intérieure (12) jusqu'à un diamètre égal à D3, en ce qu'un obstacle cylindrique fermé (34) avec un fond courbé vers le haut, de diamètre D3A plus grand que D1 mais plus petit que D2 est supporté (38) axialement à une distance sélectionnée au-dessus du sommet de la conduite intérieure et forme un second passage annulaire (25) de diamètre D2A plus petit que D2 entre les moyens d'obstacle et la conduite intérieure, la surface de base courbée vers le haut (35) étant située en dessous du sommet de la conduite extérieure (24) en un point (28) où une vena contracta du flux d'air est formée dans le second passage annulaire (25), de sorte que le mélange de gaz et d'air (42) coulant vers le haut dans le second passage annulaire (25) continue de monter comme une paroi annulaire (25) de gaz et de flamme (44) et qu'il induit, en raison de sa grande vitesse, un flux radial d'air secondaire extérieur (46) vers l'intérieur de la surface extérieure de la paroi annulaire et un flux d'air (52)

vers le bas, à l'intérieur de la paroi annulaire (44) s'écoulant radialement vers l'extérieur dans la surface intérieure du flux annulaire.

2. Une torchère selon la revendication 1, caractérisée en ce que la vitesse du flux d'air de combustion primaire (20) est dans le domaine de 15,25 à 61 mètres par seconde.

3. Une torchère selon la revendication 1, caractérisée en ce que le matériau réfractaire (30) est supporté par un manchon métallique (26) à sa surface extérieure, le manchon (26) étant supporté par la conduite intérieure (12).

4. Une torchère selon la revendication 1, caractérisée en ce qu'elle comprend une pluralité de chicanes également espacées (60) s'étendant à travers le flux (42) du mélange d'air et de gaz dans le second passage annulaire (25), près du sommet de la conduite extérieure (28).

5. Une torchère selon la revendication 4, caractérisée en ce que lesdites chicanes (60) comprennent au moins une ouverture (66) dont l'axe est parallèle à l'axe de la conduite extérieure (24).

Patentansprüche

1. Fackelrohr zur rauchlosen Verbrennung von Abgasen, die mit bestimmtem Druck abgelassen werden, mit einer inneren vertikalen Leitung (12) vom Durchmesser D1 zum Aufwärtsleiten der zu verbrennenden Abgase, einer äusseren vertikalen Leitung (16) vom Durchmesser D2 der grösser ist als D1, im wesentlichen coaxial zur ersten Leitung und die einen ersten, ringförmigen Durchgang (18) zwischen den zwei Leitungen (12 und 16) bildet und die unten mit einem Ventilator (17) verbunden ist, der Primär-Verbrennungsluft mit einem über atmosphärischem Druck liegenden Druck zwangsweise durch den genannten ersten Durchgang zuführt, und mit einer Zündvorrichtung (48), die oben am zweiten ringförmigen Durchgang (25) angeordnet ist, dadurch gekennzeichnet, dass ein ringförmiger Körper (30) aus feuerfestem Material in Form eines Zylinders von der äusseren Oberfläche der inneren Leitung (12) bis zu einem Durchmesser gleich D3 auswärts ragt, dass eine geschlossene zylindrische Schikane (34) mit aufwärts gekrümmtem Boden und mit einem Durchmesser D3A grösser als D1, aber kleiner als D2 axial über dem oberen Ende der inneren Leitung in bestimmtem Abstand gestützt (38) ist und einen zweiten ringförmigen Durchgang (25) vom Durchmesser D2A kleiner als D2 zwischen der Schikane und der äusseren Leitung bildet, wobei die aufwärts gekrümmte Bodenfläche (35) sich unterhalb dem oberen Ende der äusseren Leitung (24) an einer Stelle (28) befindet, wo eine vena contracta des Luftstroms im zweiten ringförmigen Durchgang (25) gebildet wird, wobei das Gemisch von Gas und Luft (42), das im zweiten ringförmigen Durchgang (25) aufwärts fliesst, als ringförmige Gas- und Flammenwand (44) weiter aufwärts strömt

und infolge seiner hohen Geschwindigkeit einen Zustrom von Sekundärluft (46) von aussen gegen die äussere Oberfläche sowie eine abwärts gerichtete Luftströmung (52) innerhalb der ringförmigen Wand (52) die radial auswärts in die innere Oberfläche der ringförmigen Strömung strömt, bewirkt.

2. Fackelrohr nach Anspruch 1, dadurch gekennzeichnet, dass die Geschwindigkeit des Primärluftstromes (20) im zweiten ringförmigen Durchgang (25) im Bereiche von 15, 25 bis 61 Metern pro Sekunde liegt.

3. Fackelrohr nach Anspruch 1, dadurch gekennzeichnet, dass das feuerfeste Material (30) an seiner Aussenseite durch einen Metall-

mantel (26) gestützt ist, wobei der Mantel (26) durch die innere Leitung (12) gestützt ist.

4. Fackelrohr nach Anspruch 1, dadurch gekennzeichnet, dass es eine Mehrzahl von in gleichmässigem Abstand angeordneten Schikanen (60), die quer im Strom des Luft-Gasgemisches liegen, im zweiten ringförmigen Durchgang (25) beim oberen Ende der äusseren Leitung (24) aufweist.

5. Fackelrohr nach Anspruch 4, dadurch gekennzeichnet, dass die Schikanen (60) mindestens eine Oeffnung (66) aufweisen, deren Achse parallel zu der Achse der äusseren Leitung (24) liegt.

5

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40

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50

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60

65

6



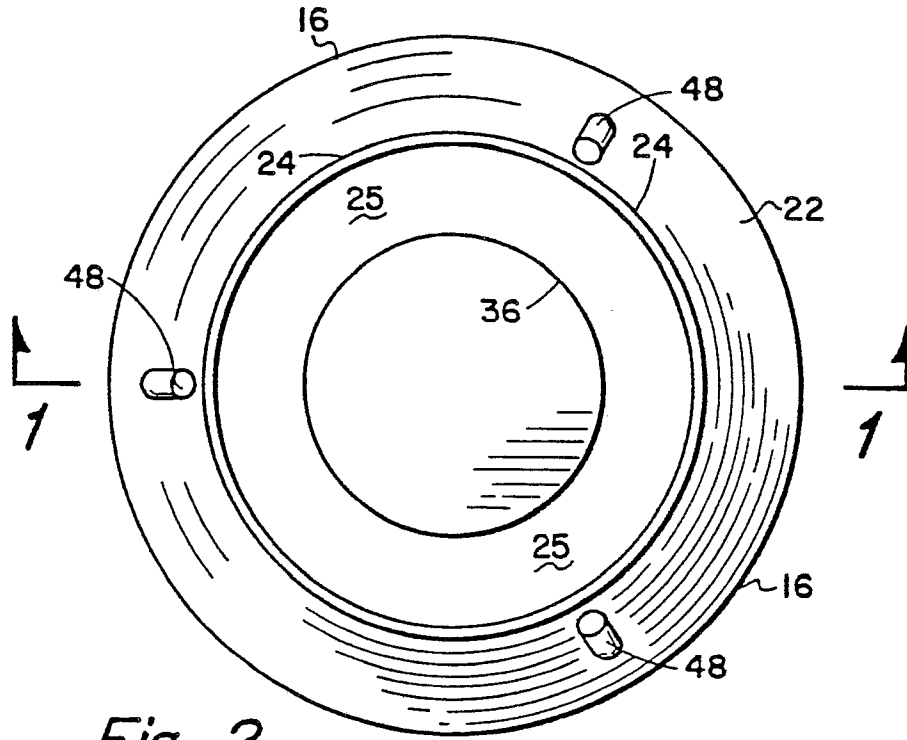


Fig. 2

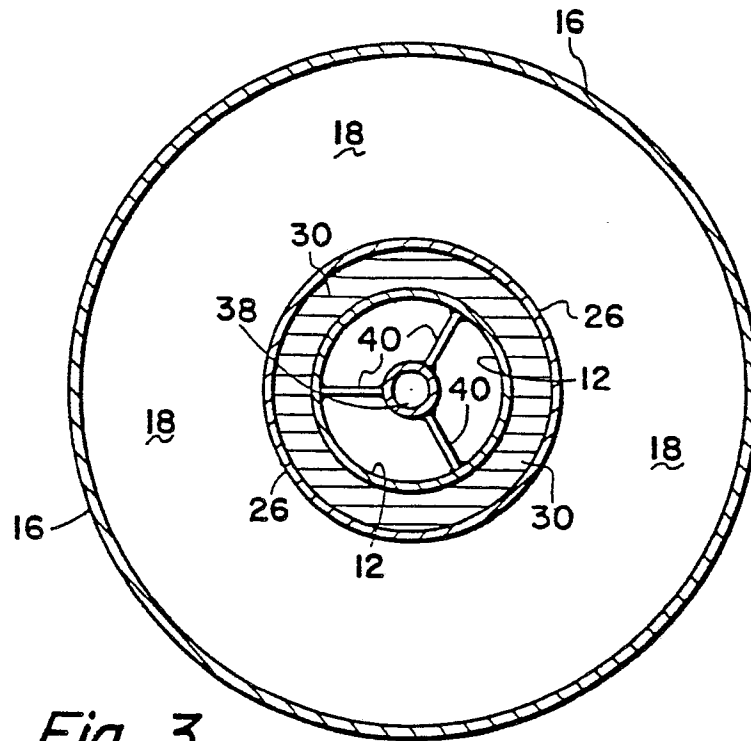


Fig. 3

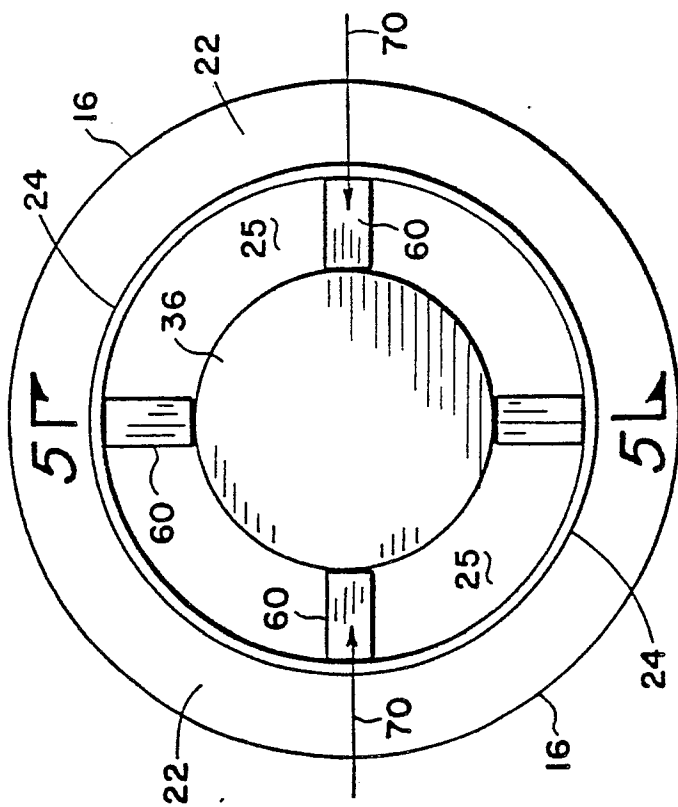


Fig. 4

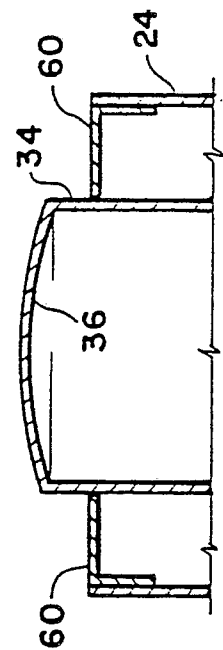


Fig. 5

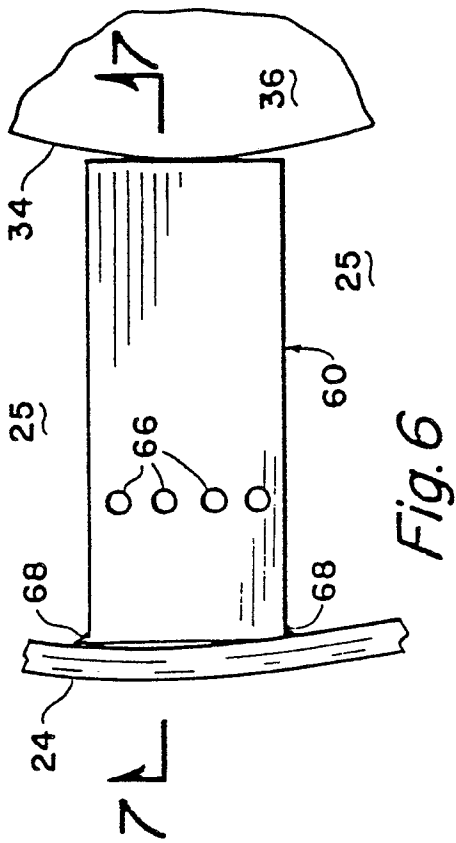


Fig. 6

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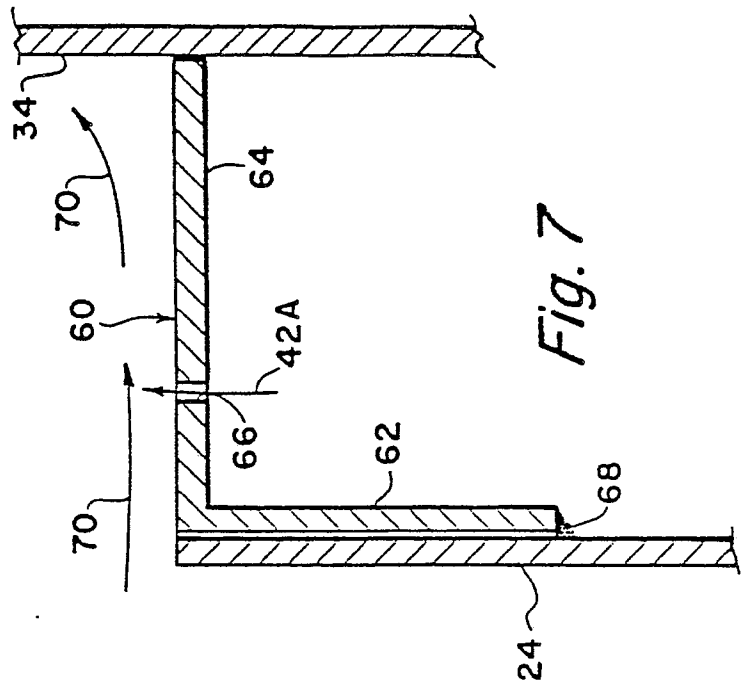


Fig. 7