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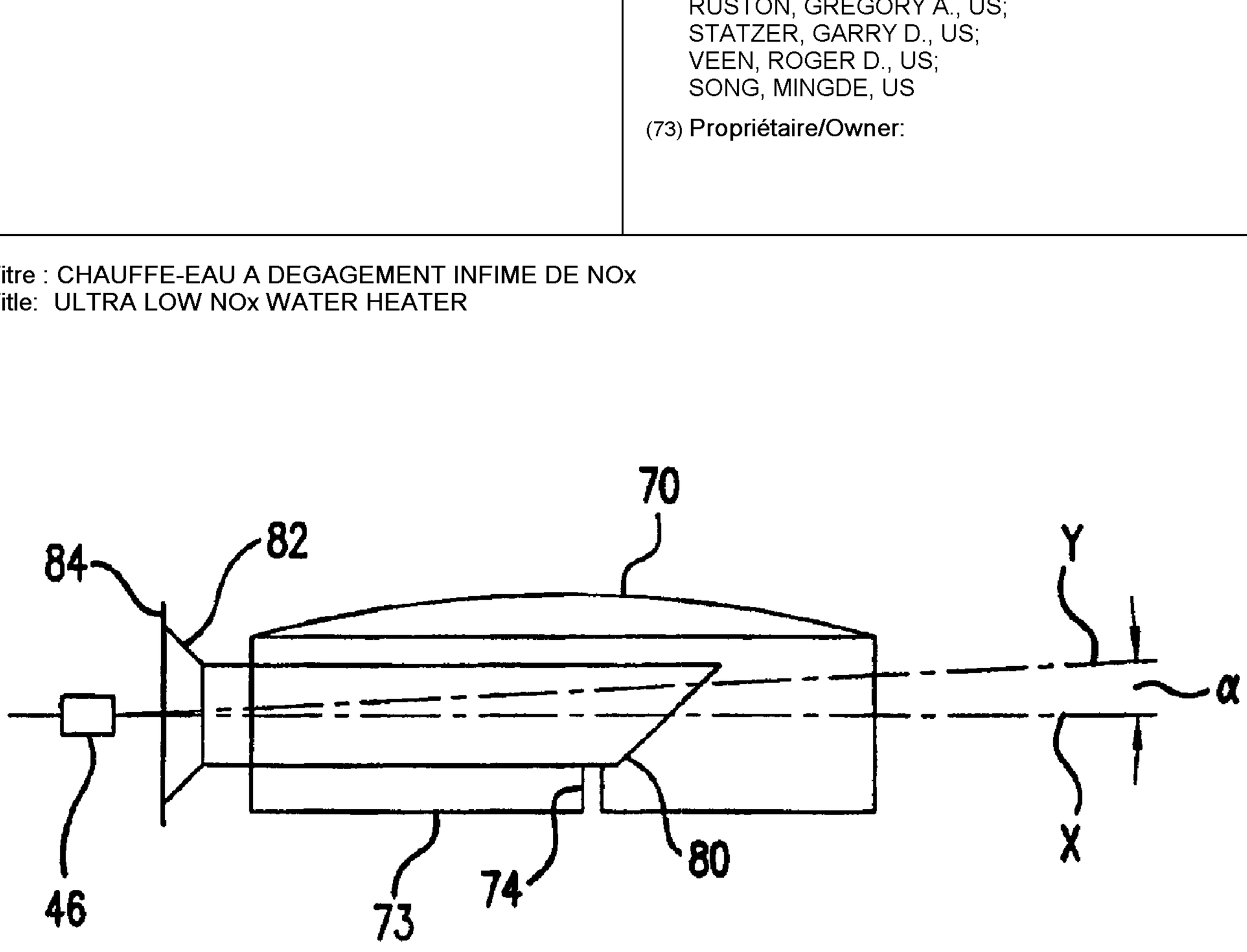
(54) Title: ULTRA LOW NOx WATER HEATER



(57) Abrégé/Abstract:
A low NO_x water heater including a water container; a combustion chamber adjacent the water container having an opening covered with an open flame arrestor; a burner associated with the combustion chamber and arranged to combust fuel to heat water in the water container, the burner including a plenum chamber having a combustion surface and a fuel/air conduit adapted to receive fuel and air and extending between and sealed to the plenum and a wall of the combustion chamber; and a heat resistant acoustic absorber positioned on the wall.

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Abstract

A low NO_x water heater including a water container; a combustion chamber adjacent the water container having an opening covered with an open flame arrestor; a burner associated with the combustion chamber and arranged to combust fuel to heat water in the water container, the burner including a plenum chamber having a combustion surface and a fuel/air conduit adapted to receive fuel and air and extending between and sealed to the plenum and a wall of the combustion chamber; and a heat resistant acoustic absorber positioned on the wall.

ULTRA LOW NOx WATER HEATER

Technical Field

The technology in this disclosure relates to water heaters, particularly to ultra low NO_x gas-fired water heaters.

Background

Reducing polluting emissions from gas-fired water heaters, such as NO_x emissions, continues to be an important objective. Water heater manufacturers have attempted to reduce NO_x emissions through a variety of approaches, one approach utilizing radiant screen-type burners. However, there have been issues associated with simultaneously achieving: 1) the low NO_x goal, 2) providing a water heater that is resistant to build up of lint, dirt, oils and the like or that can shut itself off when too much of a build-up occurs, 3) manufacture of a gas-fired water heater in an economical fashion and 4) producing a water heater that is safe, has excellent lon-gevity and is noise free upon either initial ignition of the burner or during continued combustion of the burner.

Summary

We provide a water heater including a water container, a combustion chamber adja-cent the water container having an opening covered with a flame arrestor, a burner associated with the combustion chamber and arranged to combust fuel to heat water in the water container, the burner including a plenum chamber having a combustion surface and a fuel/air conduit adapted to receive fuel and air and extending between and sealed to the plenum and a wall of the combustion chamber, and a heat resistant acoustic absorber positioned on the wall.

We also provide a water heater including a water container, a combustion chamber adjacent the water container, a burner associated with the combustion chamber and arranged to combust fuel to heat water in said water container, the burner having a combustion surface and a fuel/air conduit extending from the plenum and adapted to receive fuel, and a fuel nozzle posi-tioned to supply fuel into the fuel/air conduit at an angle that is between about 1.5° and about 2.5° out of horizontal relative to a horizontal plane extending along a central axis of the fuel/air conduit.

We further provide a water heater including a water container, a combustion chamber adjacent the water container, a burner associated with the combustion chamber and arranged to combust fuel to heat water in the container, the burner having a combustion surface and adapted to receive fuel, and a fuel/air conduit sealed between a wall portion of the combustion chamber and the plenum, wherein an end portion of the conduit adjacent the wall portion is substantially conically shaped.

Brief Description of the Drawings

Fig. 1 is a schematic partial sectional view of a water heater which emphasizes selected features of the water heater proximate the combustion chamber and omits others for ease of understanding.

Fig. 2 is a schematic top plan view of a combustion chamber of the water heater shown in Fig. 1.

Fig. 3 is a front elevational view of a combustion chamber and burner taken from Fig. 1.

Fig. 4 is a schematic perspective view of a burner taken from Fig. 1 sealed to a com-bustion chamber door.

Fig. 5 is a schematic perspective view of the burner and door of Fig. 4 connected to a fuel supply line.

Fig. 6 is a schematic perspective view of a fuel nozzle.

Fig. 7 is a front elevational view of a venturi.

Fig. 8 is a side elevational view of the venturi shown in Fig. 7.

Fig. 9 is a schematic side elevational view of a burner, a venturi and a fuel nozzle.

Detailed Description

It will be appreciated that the following description is intended to refer to specific aspects of the structure selected for illustration in the drawings and is not intended to define or limit the disclosure, other than in the appended claims.

Turning now to the drawings generally and Figs. 1 and 2 in particular, a water heater 10 is shown. It includes a water tank/container 12 having a water inlet 14 and a water outlet 16. A flue 18 extends upwardly through the tank and outwardly from the top of water heater 10. Tank 12 is surrounded by insulation 20 and a jacket 21. Such insulation may be made from a number

of known foam type insulations and/or fiberglass insulation such as around the lower portion of the water heater. Various substitutions may be made.

A combustion chamber 22 is located below tank 12 and formed by tank bottom 24, substantially vertically oriented skirt 26 and bottom pan 28. Bottom pan 28 sits on legs 30. A burner 32 formed from a plenum 68 is positioned in combustion chamber 22. Burner 32 is also positioned to receive fuel from fuel line 34, which connects to gas valve 36, which connects to a fuel supply line 38 connected to a fuel supply that is not shown.

Burner 32 is positioned within combustion chamber 22 and above an opening 40 shown in Fig. 2 in bottom pan 28. Burner 32 is a so-called "low NO_x" burner which is more spe-cifically shown in other Figures and described later herein in detail. It is, however, possible to utilize other types of low NO_x burners having different sizes, shapes and modes of combustion in accordance with selected aspects of this disclosure. Other such burners are known and need not be discussed herein.

Opening 40 may be covered with an air inlet/flame trap/flame arrestor such as an air inlet/flame trap/flame arrestor 42 of the type as disclosed in any of US Patents 5,797,355; 6,142,106; 6,085,699 or the like, for example. However and in any event, the flame arrestor should have about 30% or more open surface area. Such flame arrestors will hereinafter be referred to as an "open flame arrestor." Combustion air enters combustion chamber 22 through opening 40 and open flame arrestor 42. Although Fig. 2 shows combustion chamber 22 having an opening 40 and open flame arrestor 42 positioned at a particular location in bottom pan 28, it is possible to construct water heater 10 such that opening 40 and open flame arrestor 42 have dif-ferent locations with respect to combustion chamber 22 and burner 32.

Fuel line 34 connects to a fuel nozzle 46 fixed to door 44 such that the end of fuel line 34 is held in a selected position by mounting bracket 31 proximate an opening 48 in the end of a venturi 50. Fuel exits nozzle 46 and flows directly into opening 48. Pilot fuel line 35 extends between gas valve 36 and a pilot burner (not shown). Venturi 50 connects directly between plenum 68 and door 44. Venturi 50 is substantially air-tightly sealed to door 44 and plenum 68.

Combustion chamber 22 also contains heat resistant acoustic absorber 27. Absorber 27 is substantially a belt of heat resistant acoustic absorption-type material. It is preferably made of fiberglass. One example of a suitable absorber material is Sewn E-glass®. Other types of acoustically absorbing material may be used. An adhesive may be employed to adhere absorber 27 to the interior surface of skirt 26. Also, a metallic backing layer 29 may be applied to the surface of absorber 27. Backing layer 29 provides stiffness and further heat resistance.

In operation, fuel is supplied through nozzle 46 to venturi 50 and ambient combustion air is mixed at opening 48 of venturi 50 and the mixed fuel/air flows into plenum 68 and may further be mixed and distributed by a type of diffuser if desired. The air and fuel mixture is then combusted along the surface of screen 70 in the usual manner. Primary combustion air is introduced solely through opening 48 in venturi 50. Secondary air flows through opening 40 and open flame arrestor 42.

Fig. 3 shows burner 32 in one possible position relative to skirt 26 and opening 60 in skirt 26. Burner 32 is sized and shaped to be removable from combustion chamber 22 through opening 60. Burner 32 is preferably rectangular in shape and sized slightly smaller than opening 60, although it need not be so shaped and/or sized. Door 44 (not shown in Fig. 3) is removably sealed to skirt 26, typically by screws (not shown) which extend through holes 62 in skirt 26.

Burner 32, including rectangularly-shaped plenum 68, has a substantially flat or plan-ar bottom 73. Burner 32 has a combustion surface 70 as shown in Figs. 4 and 5 which is most preferably in a curved configuration although any shape, including flat or substantially flat, is possible. The surface is porous and preferably Inconel® screen, most preferably having portions of the screen formed into reinforcing ribs.

As previously noted, burner 32 and plenum 68 may have a construction completely different from that shown in the figures and may be a shape other than the burner 32 and plenum 68 illustrated herein. In any event, in essentially all burners and plenums suitable for use in connection with liquid or gaseous fuel, such burners have a combustion surface of some type wherein a multiplicity of ports are present on the surface itself or are located at or around the edge of that surface that permit egress of fuel and/or combustion air for formation of a flame adjacent such multiple holes or ports. Those ports/holes are typically arranged in a generally planar manner, typically in a generally horizontal orientation. Nonetheless, such burners and plenums may be utilized in accordance with this disclosure and fall within the scope of the appended claims.

Plenum 68 has an opening 72 sized and shaped to receive venturi 50 in a substantially sealed manner. The length of venturi 50 may be adjusted as desired. A small rib 74 may be manufactured into the bottom of plenum 68 to provide an attachment point for the inwardly extending end portion of venturi 50 as shown in Fig. 9. The inwardly extending end portion of venturi 50 should extend about three-quarters of the length of plenum 68. As shown in Fig. 9, venturi 50 extends about three-quarters of the length of plenum 68 as shown from the left side to the right side of that figure. Also, venturi 50 has an angled portion 80 at its distal end. The top portion of the venturi extends the furthest to the right side with the bottom portion of the venturi extending less far. Angled portion is formed at about a 45° angle.

Venturi 50 has a barrel portion 86 and a substantially conical portion 82 that extends outwardly from barrel portion 86. The distal most portion of conical portion 82 has a flange 84 that is sealed to outer door 44. As better shown in Figs. 7 and 8, venturi 50 comprises a barrel portion 86, substantially conical portion 82, flange 84 and radius portion 88. Utilization of ven-turi 50 in conjunction with plenum 68 at a length of about three-quarters of the length of plenum 68 and the angled portion 80, helps facilitate complete combustion to reduce NO_x emissions.

Also, referring back to Fig. 9 and in conjunction with Figs. 1 and 6, a schematic rep-resentation of nozzle 46 is shown. Nozzle 46 has a central bore 47 extending from an inlet side 49 to an outlet side 51. Threads allow fuel nozzle 46 to be sealingly fixed to fuel supply line 34. Fig. 9 particularly shows a dashed axis "X" that extends longitudinally through venturi 50 as a center axis. A dashed line "Y" is angled out of horizontal from axis "X" at angle α. Angle α should be between about 1.5° and about 2.5°, preferably about 2°. Dashed line "Y" forms the angle at which a central axis extending through nozzle 46 should be tilted out of horizontal to further enhance complete combustion of fuel emanating from nozzle 46 to further reduce NO_x emissions. Although we are not entirely sure of the mechanism behind this phenomenon, we dis-covered that the normal horizontal introduction of fuel into venturi 50 does not produce the same combustion completion efficiency as does the about 1.5° – about 2.5° range. We also discovered that increasing the angle to as much as 3% results in degradation of combustion efficiency back to the horizontal levels.

Conventional wisdom has suggested that achieving lowered levels of NO_x emissions for radiant screen burners necessitates that the combustion air and fuel should be primarily pre-mixed and passed through the venturi. This required that a flammable vapor arrestor located in the bottom of the combustion chamber be blocked off or only very small amounts of secondary air be

allowed in the chamber through small, tightly controlled areas or flapper doors. However, such arrangements exhibited unacceptable start-up (rumbling) and operational noise (100+ dB scream) due to a standing wave forming in the combustion chamber and passing up the flue. Additionally, burners in such arrangements were subject to flash back and pilot burner outages occurring due to the main burner starving the pilot burner for air. Also, the burner tended to be potentially affected by lint, dust and oil contamination under certain particular circumstances. This was indicated by the system producing higher levels of CO at relatively low levels of contamination due to incomplete combustion while lacking secondary air.

We found that, by using an open flame arrestor, the start up rumble was eliminated and operational noise reduced. An open flame arrestor is a flammable vapor resistant structure that has about 30 percent or more of the available burner surface as open area. It was found that less than about 30 percent compromises both the acoustic levels and resilience to resist flash back. We also found that the pilot burner was also relatively unaffected by burner operation since it was easily able to draw sufficient secondary air through such a large volume opening.

We also discovered that improving air flow characteristics of the burner to allow for an adequate amount of primary air is helpful. Previously, burners had enough air flow restriction within their mixing bodies that additional draft was needed to overcome such restriction. We minimized internal burner restriction and vastly improved internal flow characteristics of the bur-ner. This allows full exposure to secondary air while continuing to introduce adequate amounts of primary air, thus allowing the use of a open flame arrestor.

Use of open flame arrestor 42 permits burner 32 to operate without the noise com-monly associated with radiant burners. The secondary air is also relatively free to flow where needed within combustion chamber 22 to aid in more complete combustion. This feature makes the

water heater much more resilient to lint, dirt and oil contamination. When burner ports begin to clog from dirt accumulating on screen 70, this reduces the amount of fuel/air mixture that can flow through the ports, which usually reduces the amount of air available to complete combustion. With secondary air present on the other side of the burner screen surface, this reduction of air is compensated for and complete combustion occurs. This provides a distinct advantage over systems that only can allow a small amount of secondary air to enter. The open flame arrestor 42 deals with the problem of start up rumble, which is caused by the initial ignition pressure wave pulse, because it is allowed to escape the chamber. It also aids in keeping the burner contaminant resistant by shocking surface build up and slowing total contaminant build up. It also reduces the high-pitched operation noises of burner 32. In fact, in normal operating conditions, most combustion noise is eliminated.

Open flame arrestor 42 also allows air to travel to the pilot burner independently of venturi 50. This allows the pilot burner to remain lit when burner 32 consumes the main source of air.

Open flame arrestor 42 also eliminates potential flash back to nozzle 46 when it becomes slightly air deprived. Burner 32 no longer seeks air from venturi 50 when abundant air is available on the other side of the burner screen 70 due to open flame arrestor 42. In fact, extraordinary measures must be induced to force a flash back. Open flame arrestor 42 also allows condensation produced in heating cold water to safely drain away from combustion cham-ber 22 without affecting combustion performance and minimizing chamber corrosion over a long period.

Open flame arrestor 42 also allows water heater 10 to operate during a flammable vapor incident and coordinate with burner 32 to combust the flammable vapors present in the incoming air at a

much higher rate. This tends to keep the unburned hydrocarbons at a lower level throughout the event.

Open flame arrestor 42 also allows burner 32 to operate in a mode more compatible with basic water heater design because it provides more convection heat transfer by allowing greater airflow. This helps in transferring heat to surfaces not exposed directly to the infrared radiation, such as flue 18. Water heaters are designed to have a great deal of the heat transfer occur through convection. We found that this system flows between about 10 and about 20 per-cent more air than a conventional water heater of the same size and BTU input while having comparable or less exhaust outlet temperatures.

We discovered that, while the above-mentioned system eliminated operational noise during normally encountered conditions, a small and barely audible tone may be induced in unpredictable conditions. We found that a heat resistant, acoustic absorber 27, mounted along skirt 26 inside combustion chamber 22, has substantially completely eliminated operational acoustics under all conditions. Absorber 27 is used in conjunction with burner 32/venturi 50/open flame arrestor 42 to be substantially completely noise free. Acoustic pads tested in closed chamber systems did not address start up rumble and did not completely address operational acoustics in various conditions. Burner 32 and absorber 27 together make a very quiet operating system. Sewn E-glass® is particularly resistant to heat and is non-respiring during the lifetime of the material. Metallic backing 29 mounts facing combustion chamber 22 to add stiffness to the pad and speed the assembly process. Adhesive may be applied to selected areas of the metallic backing 29 to assist not only in assembly, but during shipping. Also, it was found that absorber 27 provided thermal insulation to chamber 22, thereby enhancing the efficiency and making surfaces that are normally hot during operation completely cool to the touch.

Although this disclosure has been described in connection with specific forms of water heaters and associated components, it will be appreciated that a wide variety of equivalents may be substituted for the elements described herein without departing from the spirit and scope of this disclosure as described in the appended claims.

What is claimed is:

1. A low NO_x water heater comprising:

a water container;

a combustion chamber adjacent the water container;

a burner associated with the combustion chamber and arranged to combust fuel to heat water in the water container, the burner having a combustion surface and a fuel/air conduit extending from a plenum and adapted to receive fuel; and

a fuel nozzle positioned to supply fuel into the fuel/air conduit at an angle that is between about 1.5° and about 2.5° out of horizontal relative to a horizontal plane extending along a central axis of the fuel/air conduit.

2. The water heater defined in claim 1, wherein the angle is about 2°.

3. The water defined in claim 1, wherein an end portion of the fuel/air conduit extending from the plenum is sealed to a wall portion of the combustion chamber.

4. The water heater defined in claim 3, wherein the wall portion is a door sealed to an opening in the combustion chamber.

5. The water heater defined in claim 1, wherein the fuel/air conduit extends into the plenum a distance of about ¾ of the length of the plenum.

6. The water heater defined in claim 5, wherein a distal portion of the fuel/air con-duit extending into the plenum is angled at about 45°.

7. The water heater defined in claim 1, wherein the angle is less than 3% out of horizontal relative to the horizontal plane extending along the central axis of the fuel/air conduit.

8. The water heater defined in claim 6, wherein a top portion of the distal portion of the fuel/air conduit extends further into the plenum than a bottom portion of the distal portion of the fuel-air conduit.

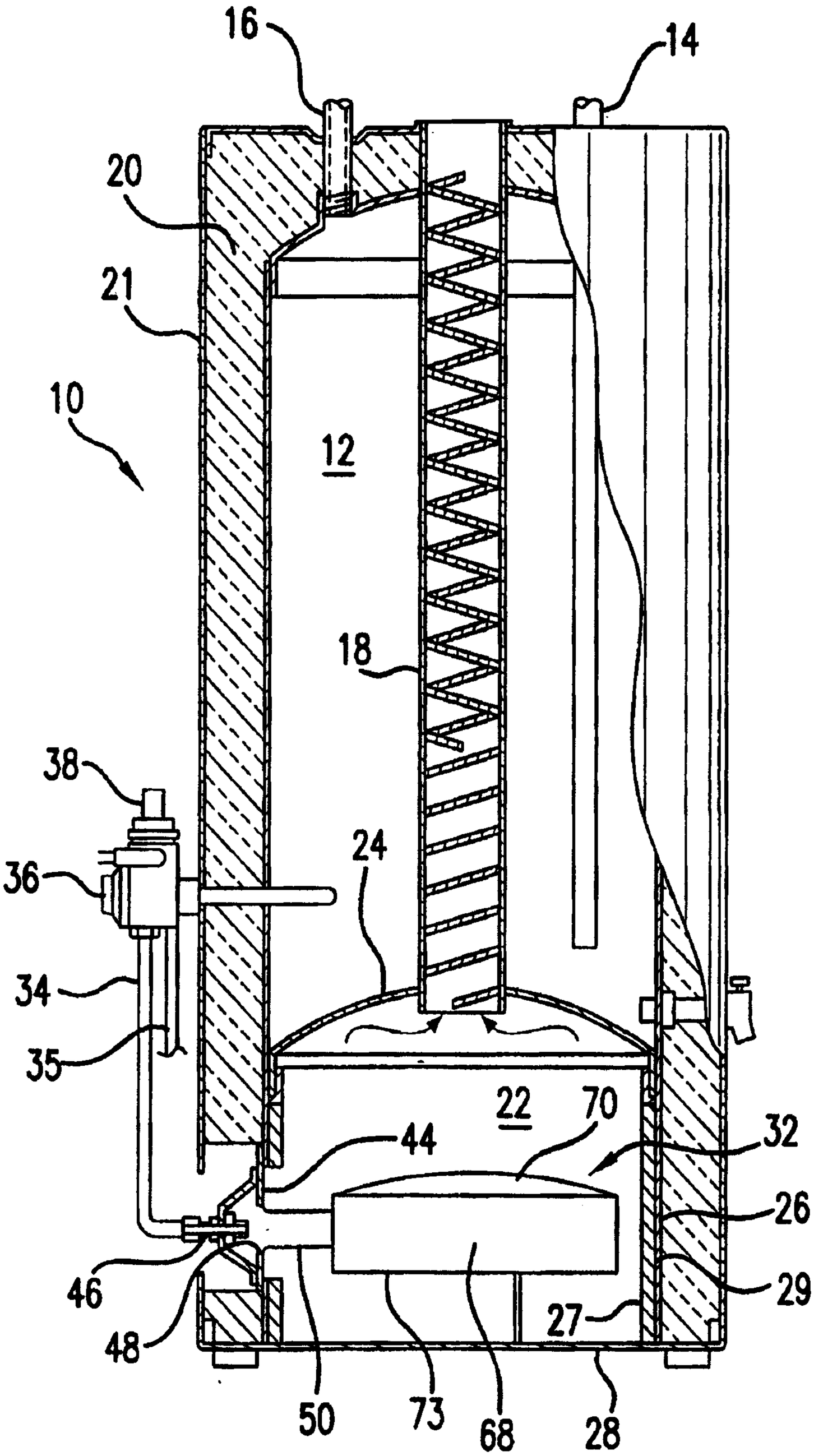
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FIG.1

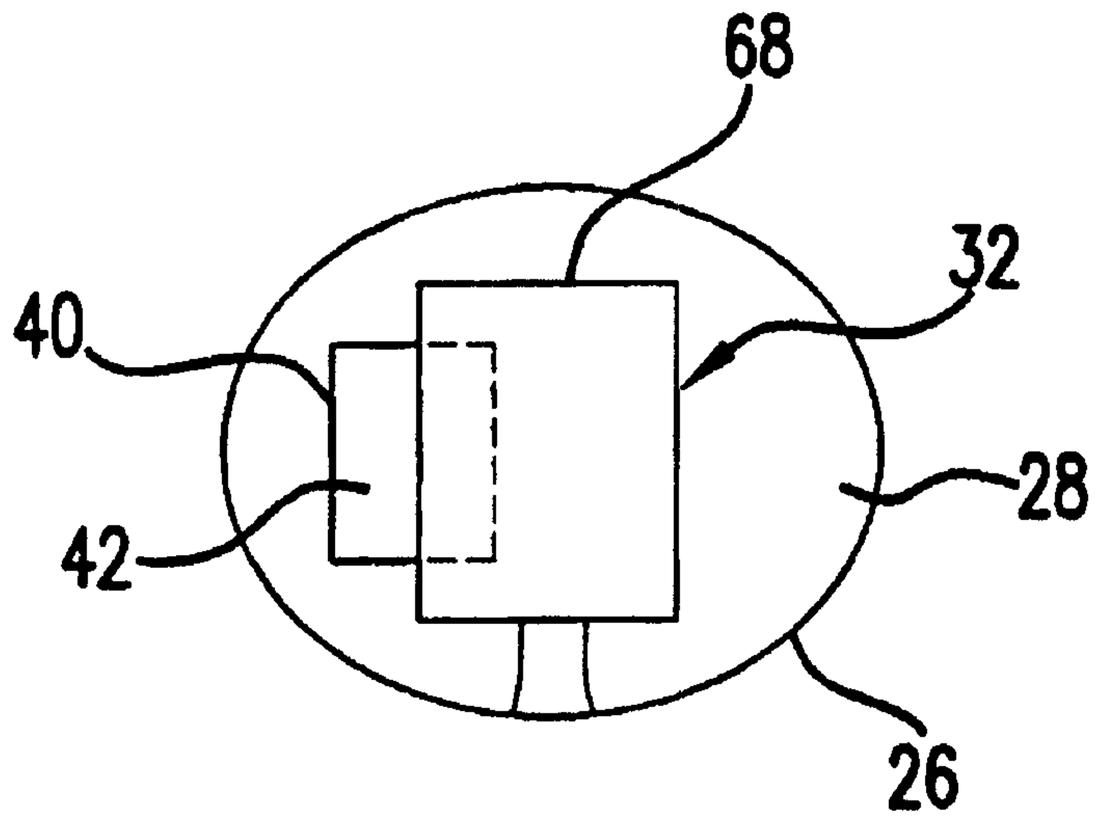


FIG.2

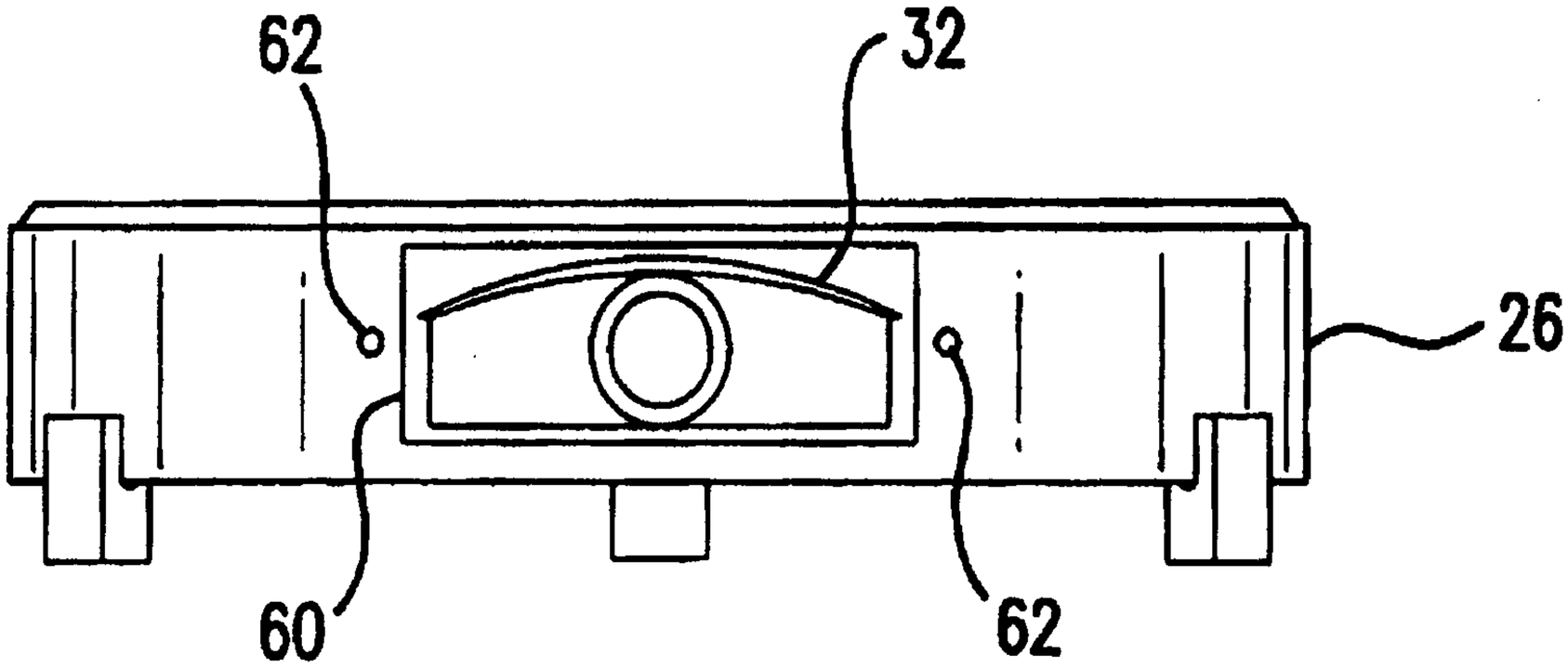


FIG.3

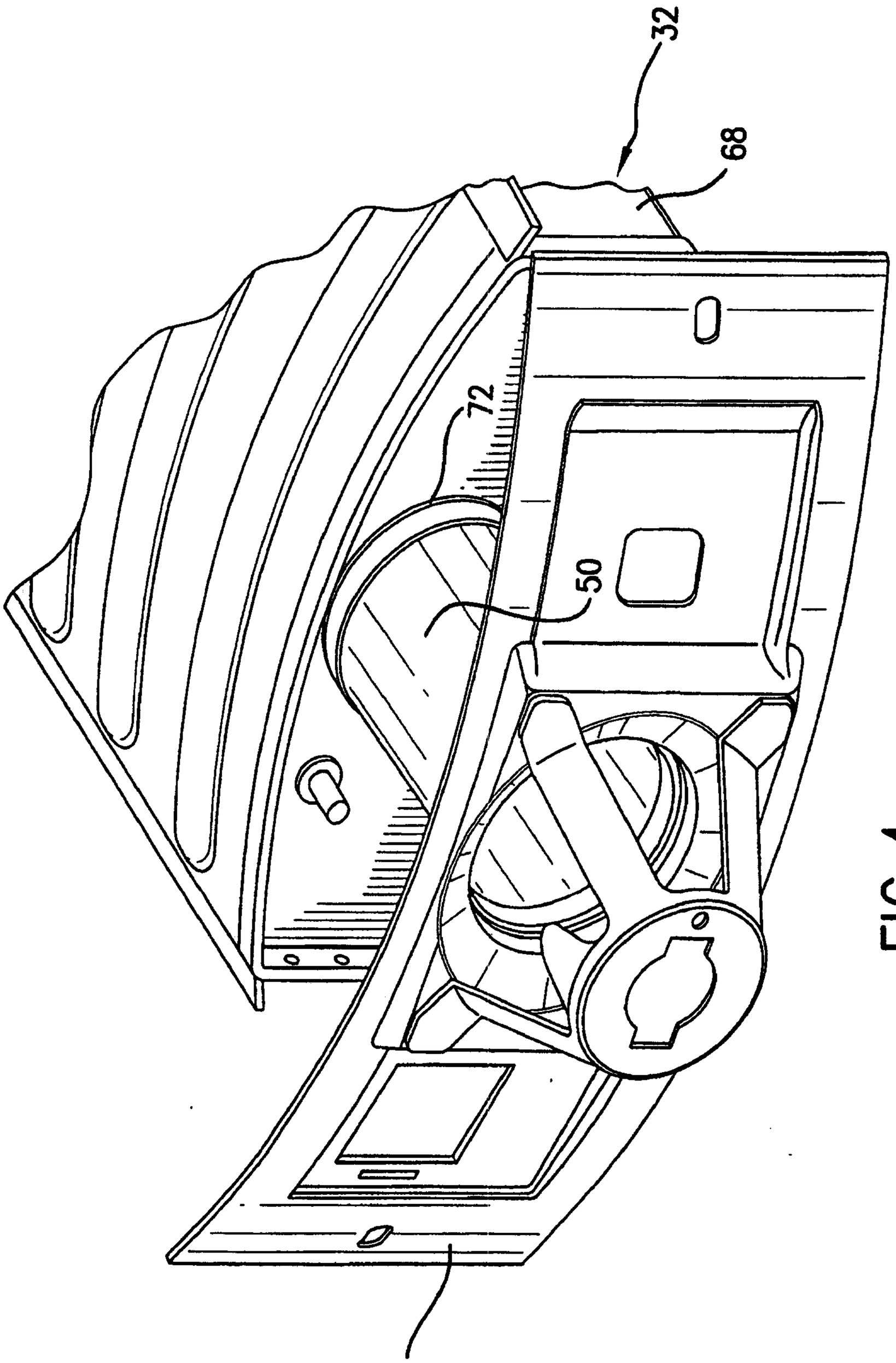


FIG. 4

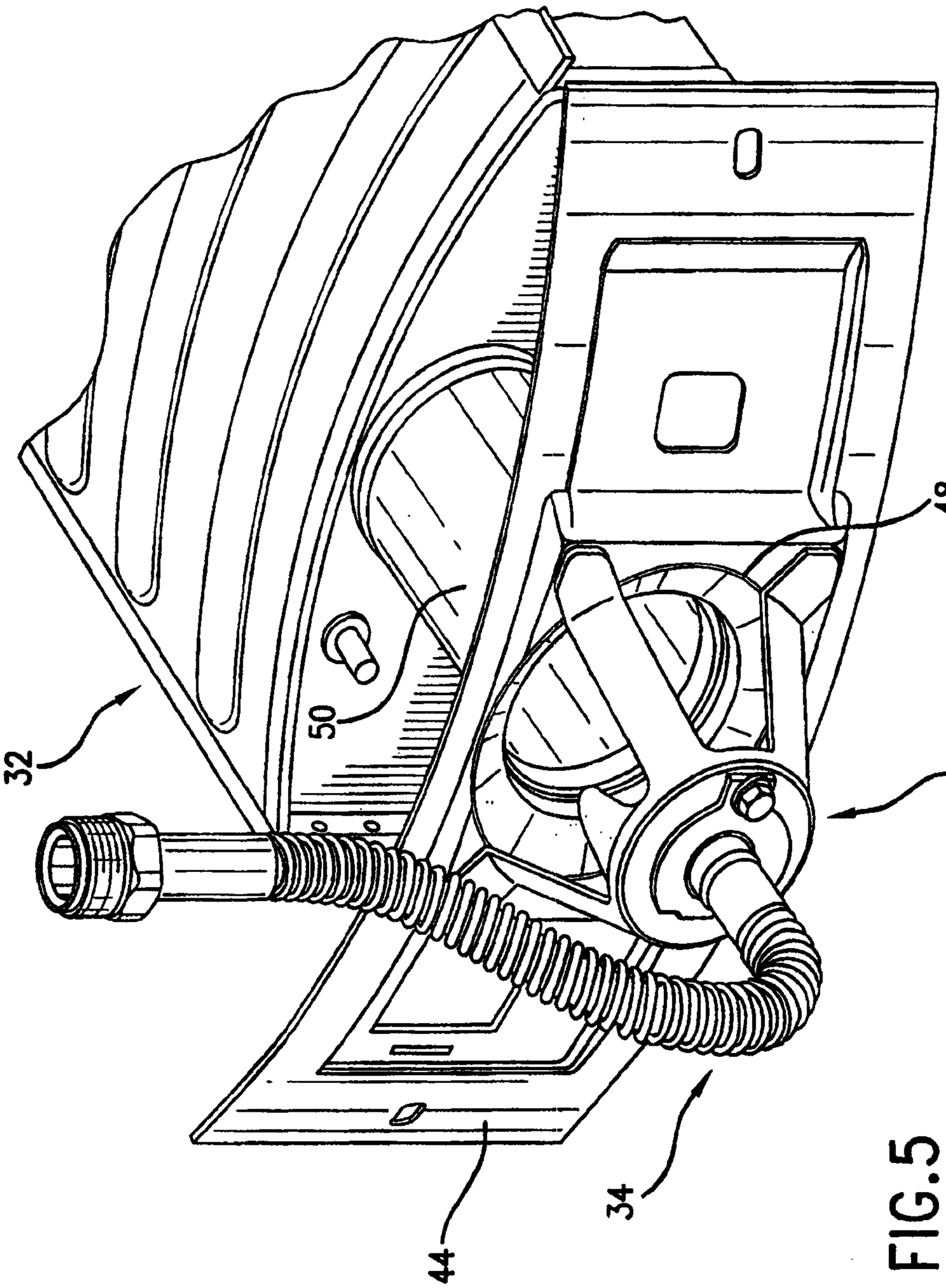


FIG.5

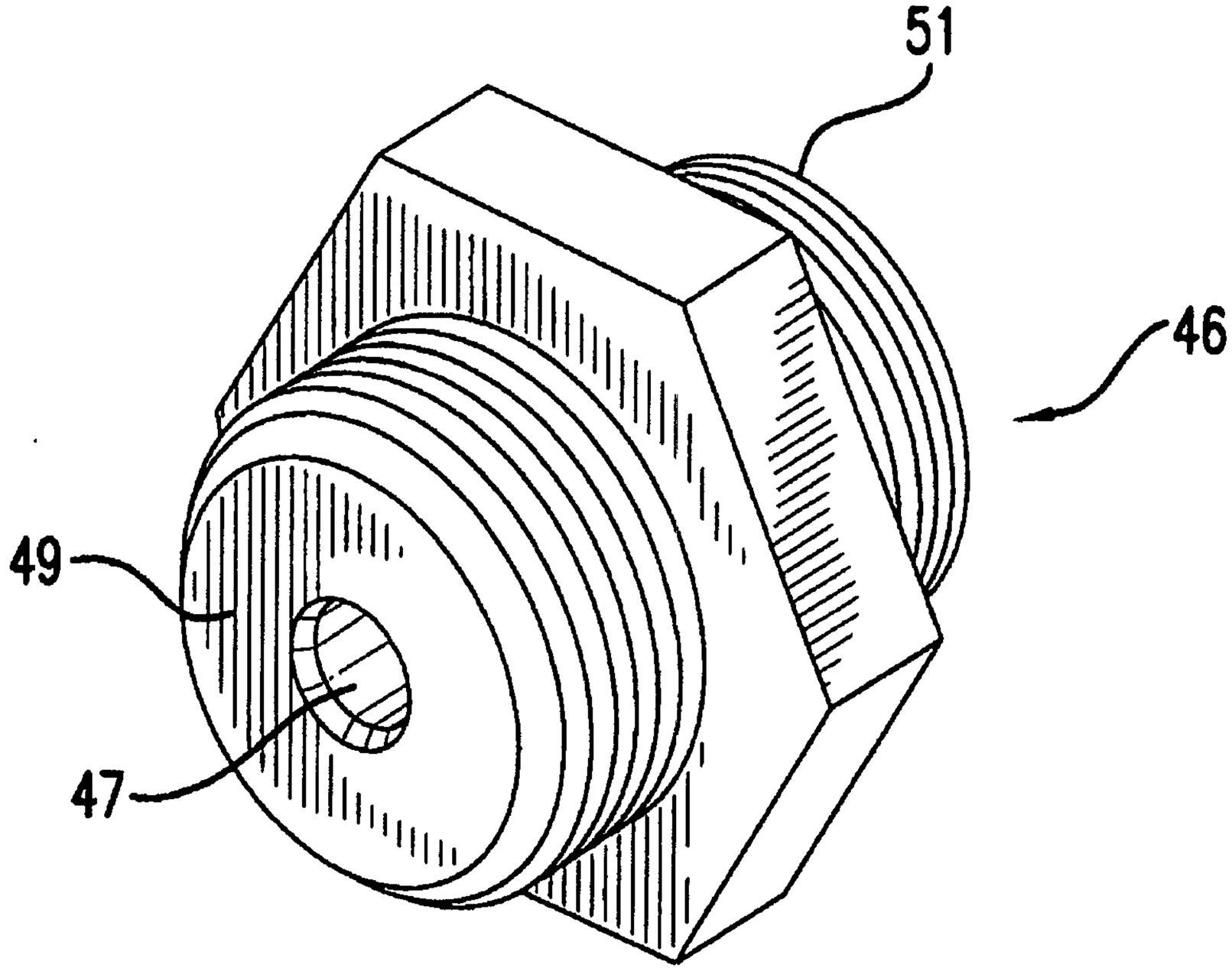


FIG.6

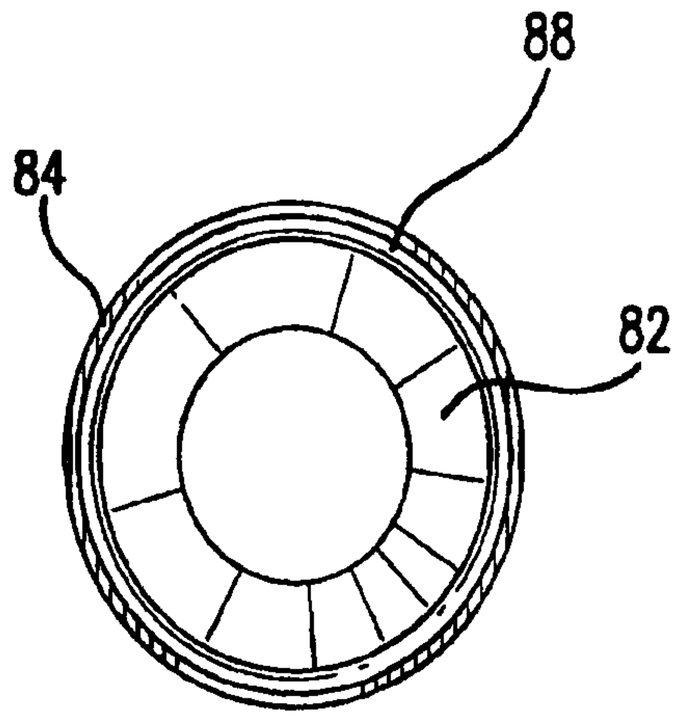


FIG.7

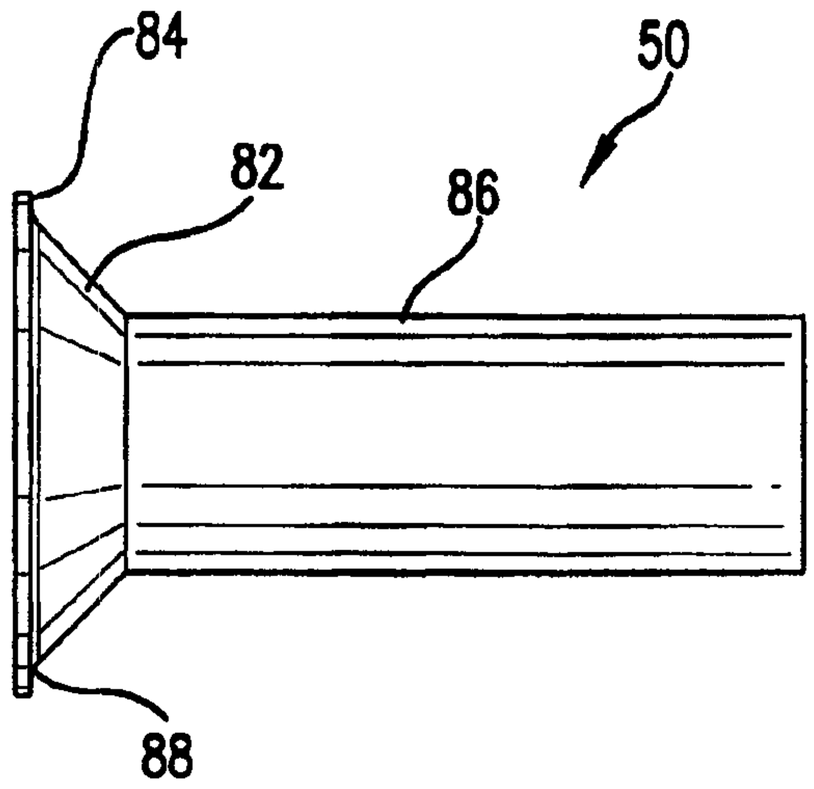


FIG.8

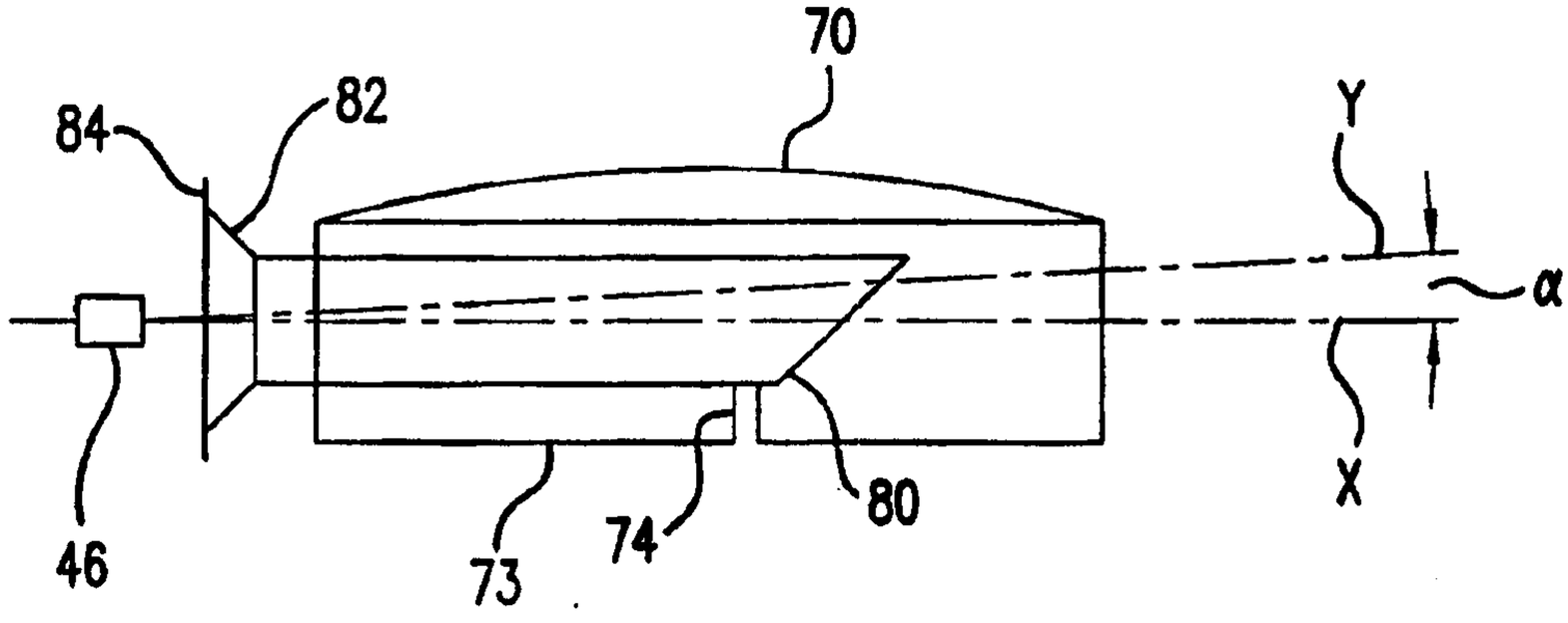
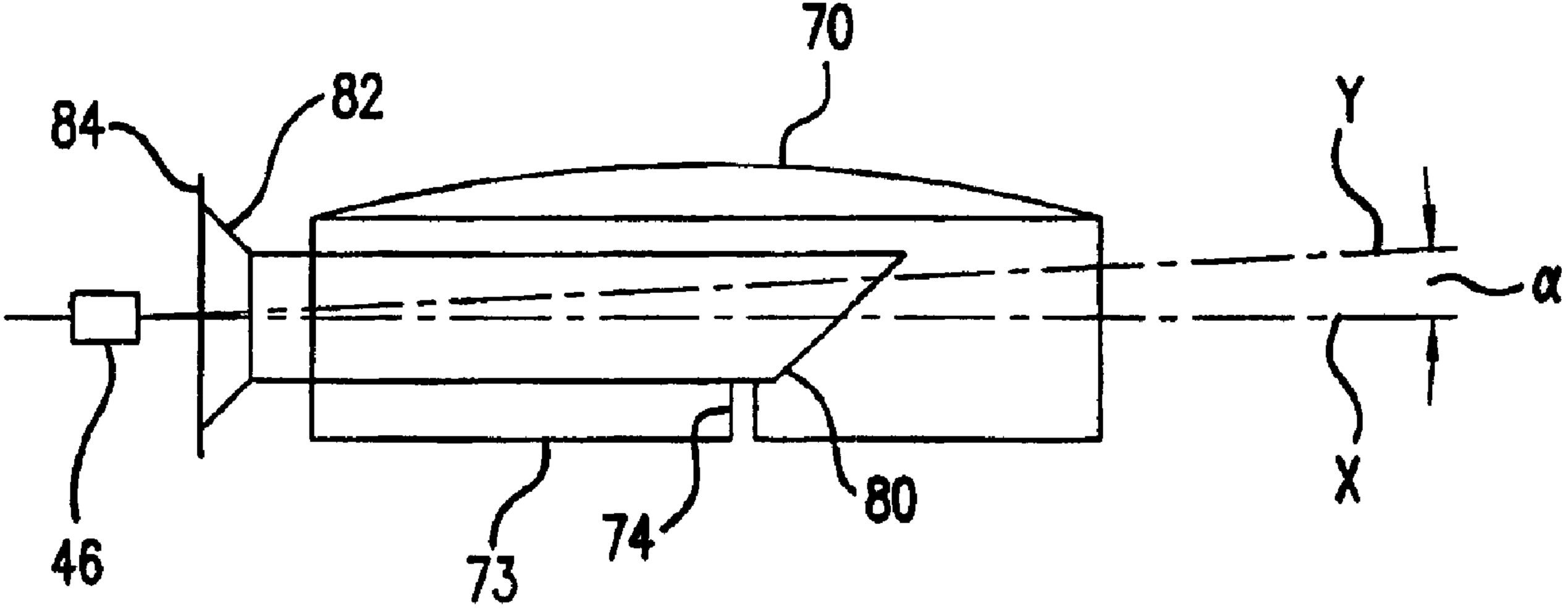


FIG.9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