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(54) **HIGH EFFICIENCY RADIANT BURNER**

HOCHLEISTUNGSSTRAHLUNGSBRENNER

BRÛLEUR RADIANT À RENDEMENT ÉLEVÉ

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(73) Proprietor: **Cascade Designs, Inc.**
Seattle, Wa. 98134-2301 (US)

(72) Inventors:
• **STEPHENS, Redwood, D.**
Seattle, WA (US)

• **PORENSKY, John**
Seattle, WA 98107 (US)

(74) Representative: **Carter, Stephen John et al**
Mewburn Ellis LLP
City Tower
40 Basinghall Street
London EC2V 5DE (GB)

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Description

[0001] The present invention relates to controlled combustion and more particularly to pressurized hydrocarbon gas burners and most particularly to a liquid pressurized gas (LPG) stove/cookware system that includes a high efficiency heat exchanger working in conjunction with a fully aerated radiant burner.

[0002] Conventional gas combustion apparatus use partially aerated burners and require introduction of relatively large quantities of secondary air for complete combustion to occur. This dilution of the combustion gases reduces flame temperatures and heat transfer efficiencies into a heat transfer surface, such as a fluid container in a cooking system, e.g., a pot. Generally, the volume of introduced secondary air is dependent on natural convection and diffusion of the combustion gasses, which limit the driving pressure of the gases and excess air to pressures that can be attained only by the buoyancy effect of the hot rising gases. Thus, heat transfer values for forced convection are much larger than values for free convection. Currently a number of companies (Cascade Designs Inc. and JetBoil, Inc.) offer gas combustion apparatus with heat exchangers that boost efficiency from conventional stove and pot combinations (35% - 55%) to (45% - 65%). Because these apparatus are limited by free convection heat transfer coefficients and dilution of the combustion gases with secondary air, higher efficiency values for apparatus of these designs are limited.

[0003] While manufacturers of combustion-based heat transfer apparatus continually strive for increased combustion and heat transfer efficiencies, they must also address environmental concerns relating to combustion by-products. One such combustion byproduct, nitrous oxides (NO_x), is of particular concern with respect to domestic gas water heaters. Initial combustion of gases in natural convection heaters occurs at high temperatures which are conducive to nitrous oxide formation. The combustion gases are diluted by freely convecting air where some additional combustion occurs but gas departure and velocities drop. US 4,639,213 provides a confined space infrared burner system. US 4,437,829 provides a roll-out flame detector for swimming pool heater fuel gas control. KR10-2004-0040577 provides a premix type knitted metal fiber mat gas burner. JP10-185126 provides a burner element for surface combustion burner. GB 907,061 provides a radiant gas heater.

[0004] Accordingly, the present invention provides a fuel gas burner as set out in claim 1. The present invention utilizes a radiant gas burner and optional heat exchanger arrangement to achieve high heat transfer values to containers through forced convection and hotter undiluted combustion gases, which increase over all efficiency of the system from (70% to 85%), without adding excessive heat exchanger surface area. The burner also greatly lowers the temperature at which complete combustion occurs, thereby greatly reducing nitrous oxide emissions.

A feature of the invention is that as power output is increased, the driving pressure for forced convection with the optional heat exchanger is also increased, and thus heat transfer efficiency is generally constant over a wide range of power outputs. The result of this arrangement provides for a radiant burner that is highly fuel efficient, that has increased resistance to the deleterious effects of wind on the burner, that greatly increases the safety of operation of the radiant burner, and that significantly reduces the output of nitrous oxides. When used in combination with the optional heat exchanger, fuel efficiency is further increased and emissions further decreased.

[0005] The radiant burner comprises a generally enclosed cavity defined, at least in part, by a fuel gas impermeable surrounding and a lower surface of a fuel gas permeable burner element, wherein the cavity has at least one opening exposed to an oxidizer source. Sealingly coupled to the at least one opening is a mix tube that defines a longitudinal axis, and has a first end and a second end wherein the first end occupies the at least one opening and the second end extends into and is exposed to the pressure cavity. As those persons skilled in the art will appreciate, any structure capable of mixing a gaseous fuel with a gaseous oxidizer can be used as a mix tube, and therefore such structures are considered as an equivalent. A fuel gas injector, which during use of the burner is in fluid communication with a source of fuel gas, is positioned to introduce fuel gas into the mix tube, preferably at or proximate to the first end, thereby encouraging momentum transfer of the oxidizer into the fuel gas stream when the oxidizer is also introduced at or proximate to this location.

[0006] Because of the porosity of the burner element, a pressure gradient exist between the cavity and an upper surface of the burner element. Consequently, pre-combustion gasses diffuse from the lower surface of the burner element to the upper surface. Pre-combustion gasses at the upper surface may then be ignited, such as by an igniter that is associated with the burner, whereupon combustion takes place.

[0007] In one series of embodiments, a plurality of openings is present in the pressure cavity. A corresponding number of cylindrical mix tubes are fluidly coupled to the openings, and are exposed to the ambient environment at their first end and to the cavity at their second ends. Thus, the ambient environment provides the oxidizer source, i.e., oxygen. A corresponding number of fuel gas injectors are preferably positioned at the first end of the mix tubes such that the fuel gas, when introduced into the mix tubes, entrains a volume of air and mixes the two gasses to form a pre-combustion gas. The pre-combustion gasses are further mixed and turbulence imparted into the pre-combustion gas stream by a plurality of static mixing posts. The mixing posts also serve to radiate heat that may accumulate in the burner housing through exposure to the cool pre-combustion gasses.

[0008] A feature of the burner is the incorporation of a thermal fuse (trip filter) disposed between the fuel gas

source and the gas injector(s). This fuse may be constructed from any material that will be predictably responsive to heat such that when exposed to heat higher than a certain temperature for an established period of time, the material changes form, which operates to interrupt fuel flow to the gas injector(s). In one series of embodiments, the filter is a eutectic metal such as cadmium, lead tin alloy, which is formed into a washer that operatively keeps a check valve in the open position. Thus, in the event of a light back or thermally derived malfunction, the increased temperature will cause the washer to liquefy, and thereby permit the check valve to close and isolate the fuel gas from the thermal condition that caused the melting of the thermal fuse.

[0009] In order to increase the efficiency of systems employing the radiant burner, containment vessels, such as pots, can be specially adapted to exploit the quantity and quality of heat output by the radiant burner. A primary mode of adaptation involves the use of heat exchanging structure at or near the bottom of the containment vessel, which preferably comprises a plurality of fins, either as fin elements integral with the vessel or as fin bodies attachable to the vessel, arranged to maximize radiant and convective heat transfer of combustion gasses from the burner. Each relevant containment vessel will have a bottom surface and a lower side surface that is linked to the bottom surface by a shoulder. The intention of the heat exchanging structure is to increase the duration of the vessel's exposure to the burner output, thereby further increasing the efficiency of the system employing the radiant burner.

[0010] The described and illustrated burners provide a user with exceptional efficiency and significantly decreased undesirable combustion byproducts. For example, CO emissions are about 8 times less than a comparably sized conventional stove. Similarly, nitrogen oxides are significantly reduced (approximately 80-93%) when compared to commercially available competing stoves.

BRIEF -DESCRIPTION OF THE DRAWINGS

[0011]

Fig. 1 is an elevation view of an assembled burner and heat exchanger equipped pot system;

Fig. 2 is a cross section elevation view of a burner,

Fig. 2A is a detailed cross section of a thermal fuse/trip that can be used in the embodiment shown in Fig. 2;

Fig. 3 is a cross section plan view of the burner of Fig. 2;

Fig. 4 is a cross section elevation view of a first heat exchanger equipped pot;

Fig. 5A is a perspective view of the first heat exchanger equipped pot wherein post pot manufacture fin elements are attached to the bottom of the pot and external covers and rings are removed for clarity;

Fig. 5B is a perspective view of the first heat exchanger equipped pot wherein fin bodies are integrated into the bottom of the pot during manufacture of the pot and external covers and rings are removed for clarity;

Fig. 6 is a cross section elevation view of second heat exchanger equipped pot wherein a peripheral heat exchanger ring is employed to increase the surface area available for heat transfer; and

Fig. 7 is a perspective view of a peripheral heat exchanger ring segment for use with the embodiment of Fig. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] The following discussion is presented to enable a person skilled in the art to make and use the invention. Various modifications to the preferred embodiment will be readily apparent to those skilled in the art, and the generic-principles herein may be applied to other embodiments and applications

[0013] Thus, the present invention is not intended to be limited to the embodiment show, but is to be accorded the widest scope consistent with the principles and features disclosed herein.

[0014] Unless otherwise noted herein, all parts of burner 10 and heat exchanger 90 are constructed from metal. Depending upon the part's application, the metal may be aluminum, steel, copper, brass or similar conventional metal. The selection of metal is primarily driven by thermal transfer considerations, although resistances to corrosion and high temperatures, as well as weight considerations are also valid criteria for material selection. In a preferred embodiment, burner element 60 comprises a porous metal foam material sold under the trademark METPORE by Porvair Advanced Materials, Inc. of Hendersonville, North Carolina. However, those persons skilled in the art will appreciate that other gas porous, heat resistant materials can be used, such as ceramics and metal-ceramic composites.

[0015] Turning then to Figs. 2 and 3, a burner embodiment of the invention is shown in cross section elevation and plan views, respectively. Burner 14 comprises metallic base 12, which provides fuel delivery infrastructure 30 (discussed below) and which partially defines cavity 24. Cavity 24 is further defined by metal surround 14 and burner element 60. As will be described in more detail below, cavity 24 is generally sealed from the environment with two major exceptions. First, mix tubes 50a and 50b are sealingly attached to surround 14 and are exposed to the environment proximal ends 52a and 52b (see Fig.

3). Second, burner element 60 is porous to gasses (see Fig. 2). As a result of this arrangement, gasses introduced at proximal ends 52a and 52b of mix tubes 50a and 50b travel the length of the mix tubes until expelled into cavity 24 at distal ends 54a and 54b. Because burner element 60 is highly porous, a gas pressure gradient exists between cavity 24 and the environment at outer surface 64 such that gasses present in cavity 24 will diffuse through burner element 60 towards outer surface 64.

[0016] Fuel gas, such as Liquid Pressurized Gas (LPG), is delivered to burner element 60 in the following manner. An LPG bottle (not shown) is rotationally coupled to inlet 30, as is best shown in Figs. 2 and 2A. To permit such coupling, inlet 30 includes threaded portion 32, preferably conforming to the B-188 standards to ensure wide compatibility with gas bottle suppliers. Once securely coupled, probe 36 opens a valve in the LPG bottle and pressurized gas travels through probe 36 and into chamber 26. Chamber 26 is generally defined by inlet housing 27 and seat 28. Within chamber 26 are ball 29 and compression spring 25. Compression spring 25 provides an outward bias to ball 29, which is prevented from translational movement by seat 28 reacting against outlet housing 31 via thermal fuse body 38. LPG occupies both chamber 26 and area 26', which is in fluid communication with outlet conduit 40 via port 39. Outlet conduit 40 then permits LPG to discharge into regulator 42.

[0017] A feature of the disclosed arrangement is directed towards a thermal LPG interrupt that functions to autonomously stop the flow of gas from the container to the burner. As briefly described above and as best shown in Fig. 2A, seat 28 functions to prevent ball 29 from extending into contact with sealing surface 41. In turn, seat 28, which is in a compression mode through the bias imparted by spring 25 to ball 29, reacts against outlet housing 31 via thermal fuse 38. But for the presence of fuse 38, seat 28 would be urged to translate away from compression spring 25, thereby permitting ball 29 to come in sealing contact with sealing surface 41, and thereby occlude further gas passage into outlet conduit 40. Therefore, fuse 38 is intentionally constructed to loose structural cohesion at or above a general temperature to prevent potentially explosive conditions such as might be encountered during a "light back" or reverse ignition propagation event. While the ultimate determination of the appropriate temperature is a matter of design consideration, the disclosed embodiment contemplates thermal conditions of between about 146°C to 200°C as being candidate temperatures for a thermal trip.

[0018] While those persons skilled in the art will appreciate the broad selection of candidate materials, particularly satisfying results have been objected when Ultra-High Molecular Weight (UHMW) plastics are chosen, or eutectic alloys. A benefit of using eutectic alloys concerns both the precise nature of their phase conversion and the very sharp transition provided by them. This second characteristic is of importance to the operational life of the burner; because the thermal fuse is in an axial com-

pression mode, mechanical creep can occur, particularly at higher temperatures, thereby potentially decreasing the performance of the arrangement during normal conditions. One alloy that has yielded favorable results comprises cadmium - 18.2% wt.; lead - 30.6% wt.; tin - 51.2% wt. This alloy has a melting point of about 145°C ± 1.5°C.

[0019] Upon passing thermal fuse 38, the compressed gas is directed towards regulator and valve assembly 42 for pressure and volume regulation. Control handle 44 provides functionality to assembly 42 as is appreciated by those persons skilled in the art. Regulated gas is then directed to both gas jets 48a and 48b via distribution manifold 46, which in turn direct fuel gas into mix tubes 50a and 50b. Entrainment of an oxidizer, in this case oxygen bearing air, occurs at the injector and throughout the length of the mix tube by drawing air into the mix tube at openings 16a and 16b, which represents the only major openings within pressure cavity 24. Those persons skilled in the art will appreciate that other forms of oxidizer introduction could take place via the same or different structure. However, the present embodiment represents an efficient and cost-effective approach to the production of a combustible gas. Because the described method and related structure rely upon momentum transfer (a Venturi effect is established at opening 16a and 16b, which creates a localized area of low pressure, thereby drawing in ambient air to aid in combustion), mixing of the fuel gas with an oxidizer is accomplished efficiently and inexpensively. Moreover, because there are no moving parts, reliability and longevity are increased.

[0020] To optimize the introduction of air as an oxidizer and minimize the effects of the environment (primarily wind for portable burner operations), surrounding 14 is coaxially surrounded by perforated housing 18. Consequently, a generally annular space is created between surrounding 14 and housing 18, from which air is drawn into openings 16a and 16b. In this manner, any wind impacting perforated housing 18 is diffused prior to entering opening 16a and 16b.

[0021] The fuel gas and oxidizer combination (pre-combustion gas) exits from ends 54a and 54b of mixing tubes 50a and 50b and enters cavity 24, where upon it impinges static mixing and heat transfer posts 56. As intimated by its name, static mixing and heat transfer posts 56 perform a dual function: Because posts 56 are thermally coupled to base 12, heat generated by burner 10 and transferred to base 12 by radiation, conduction and/or convection is partially removed by contact between posts 56 and incoming cool pre-combustion gas. Beneficially, this drawing of heat from base 12 increases the heat content of pre-combustion gas, which promotes more efficient combustion thereof. Posts 56 also beneficially function to increase mixing of pre-combustion gas prior to combustion and aid in uniform distribution of pre-combustion gas by decreasing the gas velocity so that diffusion of pre-combustion gas through burner element 60 occurs more uniformly.

[0022] As noted earlier, during operation of burner 10,

a pressure gradient exists between upper surface 64 of burner element 60, which is exposed to ambient conditions, and lower surface 62 of burner element 60, which is exposed to slightly pressurized pre-combustion gas. After transport of pre-combustion gas from cavity 24 to upper surface 64, piezoelectric igniter 66 may be operated to initiate combustion of pre-combustion gasses, in a manner well known in the art. Upon ignition, combustion migrates to just below upper surface 64 of burner element 60, and is prevented from further propagation by the low bulk thermal conductivity and small pore size of burner element 60. At this point, burner 10 becomes a radiant burner with no perceptible freely convective frame.

[0023] Screen 20 is provided as a safety feature to prevent unintentional physical contact with burner element 60 and to serve as an interface with cookware employing a heat exchanger as described in detail below. Both screen 20 and perforated housing 18 are secured to burner 10 by way of screen retainer ring 22. Should maintenance of burner 10 become necessary, a user need only remove retainer ring 22 to expose upper surface 64 of burner element 60, or through removal of burner element 60, base 12.

[0024] While radiant burner 10 represents a significant advance in heating technology with respect to efficiency, safety and reliability, further advances have been achieved when this technology is used in conjunction with a heat exchanger purposefully adapted to extract the maximum amount of heat from burner 10. As best shown in Figs. 1 and 4-7, heat exchanger 90 can be integrated into a fluid vessel, and more particularly vessel or pot 70. The purpose of heat exchanger 90 is to efficiently extract heat generated by burner 10 by taking advantage of its combustion mode. In this respect, the mass flow and temperature attributes of heat generated by burner 10 are considered in the design of heat exchanger 90.

[0025] As shown in the several drawings, the constitution of heat exchanger 90 can take many forms. The ultimate selection of one form over another may be driven by design considerations such as the volume of vessel 70, the nature of the liquid to be heated, the fluid dynamic properties of the combustion gasses, and similar factors. Thus, the presently illustrated embodiments are intended to show several variations, but are by no means representative of an exhaustive inventory of available heat exchangers. However, the presently illustrated embodiments all attempt to maximize the surface area exposed to the radiant heat and combustion gasses of burner 10 without significantly minimizing the benefits achieved through convection heating. Thus, the illustrated embodiments employ a plurality of channels having relatively unobstructed exit paths where the channels maximize the distance the combustion gasses must travel from burner element 60 to the ambient environment

[0026] Turning first to Fig. 5A, a weld-on heat exchanger arrangement is shown. Here, a plurality of fin elements 80 are formed separately from pot 70, and subsequently attached to pot 70 such as by spot welding, brazing or

similar heating techniques to create a plurality of channels 86 through which combustion gasses may travel. Fin elements 80 are preferably constructed from aluminum by stamping or similar high volume creation means.

Fin elements 80 are preferably formed for placement on bottom surface 78 of pot 70 in a spiral or involute pattern to maximize exposure time of the combustion gasses with the elements. Fig. 5B shows a similar pattern of fin bodies 82 formed on bottom surface 78 of pot 70, however, fin bodies 82 are integral with bottom surface 78. In this embodiment, fin bodies 82 may be formed by machining the desired pattern in bottom surface 78 or during casting of bottom surface. While the thermal transfer rates from fin bodies 82 to pot 70 and overall durability are greater than the thermal transfer rates from fin elements 80 to pot 70 due to the more robust association of the former with the pot, manufacturing costs are higher.

[0027] In addition to machining or casting methods for creating suitable fin bodies, a preferred means of manufacturing integral fin bodies is by impact extrusion processes. These processes provide the benefits of exceptional thermal conductivity (superior to that of casting), desirable surface finish for the cooking surface (superior to that of casting or machining), low weight (superior to that of casting and machining, which also generates avoidable waste) and low cost (superior to that of machining and welding). While there are size limitations using these processes, they are not material to the form factors commonly used in backpacking cookware.

[0028] It should also be noted that bottom surface 76 need not be planar or flat. Again depending upon design parameters, bottom surface 78 can be conical or frusto-conical like, with the apex at the center of the vessel. Such a geometry will not only beneficially modify the residency of any combustion gasses during operation of a burner, but when used in conjunction with a burner such as burner 10 having screen 20, will restrict properly mate with the burner to the exclusion of other cookware. Alternatively, a plurality of surface features such as convex or concave features can be established in or on bottom surface 78 to alter the egress of combustion gasses to the environment.

[0029] The embodiment of Fig. 6 illustrates a perimeter heat exchanger arrangement that can be used in conjunction with the heat exchanges of Figs. 5A and 5B, or with other arrangements. By linking a plurality of perimeter elements 64 as shown in Fig. 7, for example, and surrounding the perimeter of pot 70 with such elements, waste heat exiting from channels 86, for example, impinge upon perimeter elements 84 and is redirected along reduced diameter portion 74 of pot 70. In this manner, additional surface area for heat exchange is created at both perimeter elements 84, which are thermally linked to heat exchanger 90, as well as directly to pot 70. To prevent the unintentional migration of fluid in pot 70 from entering heat exchanger 90, drip ring 76 is provided above reduced diameter portion 74.

Claims

1. A fuel gas burner (10), for use with a source of fuel gas, comprising:

a cavity (24) defined, at least in part, by a fuel gas impermeable surrounding (14) and a fuel gas permeable burner element (60) having an interior surface exposed to the cavity (24) and an exterior surface (64) exposed to the environment, wherein the fuel gas impermeable surrounding (14) has at least one opening (16); a mixing element (50) having a first end (52) and a second end (54), wherein the first end (52) is fluidly coupled to the at least one opening (16) and the second end (54) is fluidly coupled to the cavity (24); and

a fuel gas injector (48) operatively coupled to the source of fuel gas and positioned at or proximate to the first end (52) of the mixing element (50) for injecting fuel gas into the mixing element (50), whereby introduction of pressurized fuel gas by the injector (48) into the mixing element (50) and entrainment of an oxidizer from the first end (52) of the mixing element (50) creates a volume of pressurized pre-combustion gas within the cavity (24) by means of a Venturi effect established at the opening (16), which diffuses from the interior surface (62) of the burner element (60) to the exterior surface of the burner element (60);

said fuel gas burner (10) **characterized in that** it further comprises:

at least one heat transfer post (56) thermally linked to at least part of the fuel gas impermeable surrounding (14).

2. The burner (10) of claim 1 further comprising a portable bottle of fuel gas.
3. The burner (10) of claim 1 wherein the at least one heat transfer post (56) is disposed in the path of the pre-combustion gas exiting from the mixing element (50).
4. The burner (10) of claim 1 further comprising a non-planar shielding element (20) proximate to the burner element (60).
5. The burner (10) of claim 1 further comprising a thermal fuse (38) for occluding a fuel gas passage between the source of fuel gas and the fuel gas injector (48).
6. The burner (10) of claim 5 wherein the thermal fuse (38) comprises a eutectic alloy.

7. The burner (10) of claim 5 wherein the thermal fuse (38) is radially constrained.

8. The burner (10) of any one of claims 1 to 7 wherein the first end (52) of the mixing element (50) is sealing coupled to the at least one opening of the fuel gas impermeable surrounding (14).

9. The burner (10) of any prior claim wherein the surrounding (14) is coaxially surrounded by a permeable housing (18) that fluidly couples the at least one opening (16) with the environment.

Patentansprüche

1. Brenngasbrenner (10) zum Einsatz mit einer Brenngasquelle, umfassend:

einen Hohlraum (24), der mindestens teilweise definiert ist durch eine brenngasundurchlässige Umgebung (14) und ein brenngasdurchlässiges Brennelement (60) mit einer Innenfläche, die dem Hohlraum (24) ausgesetzt ist, und einer Außenfläche (64), die der Umwelt ausgesetzt ist, wobei die brenngasundurchlässige Umgebung (14) zumindest eine Öffnung (16) aufweist; ein Mischelement (50) mit einem ersten Ende (52) und einem zweiten Ende (54), wobei das erste Ende (52) mit der zumindest einen Öffnung (16) fluidverbunden ist und das zweite Ende (54) mit dem Hohlraum (24) fluidverbunden ist; und wobei

ein Brenngaseinspritzer (48), der mit der Brenngasquelle wirkverbunden und auf dem oder nahe des ersten Endes (52) des Mischelements (50) angeordnet ist, um das Brenngas in das Mischelement (50) einzuspritzen, wobei durch Einspritzen von unter Druck stehendem Brenngas durch den Einspritzer (48) in das Mischelement (50) und Mitnahme eines Oxidationsmittels vom ersten Ende (52) des Mischelements (50) aufgrund eines an der Öffnung (16) eintretenden Venturieffekts, ein Volumen von unter Druck stehendem Prä-Verbrennungsgas im Hohlraum (24) erzeugt wird, das sich von der Innenfläche (62) des Brennelements (60) bis zur Außenfläche des Brennelements (60) erstreckt;

dadurch gekennzeichnet, dass der Brenngasbrenner (10) ferner Folgendes umfasst:

mindestens einen Wärmeübertragungsstab (56), der mit mindestens einem Teil der brenngasundurchlässigen Umgebung (14) thermisch verbunden ist.

2. Brenner (10) nach Anspruch 1, ferner umfassend

eine tragbare Brenngasflasche.

3. Brenner (10) nach Anspruch 1, wobei der zumindest eine Wärmeübertragungsstab (56) auf dem Pfad des aus dem Mischelement (50) austretenden Prä-Verbrennungsgases angeordnet ist. 5
4. Brenner (10) nach Anspruch 1, ferner umfassend ein nichtplanares Abschirmelement (20) nahe des Brennelements (60) umfasst. 10
5. Brenner (10) nach Anspruch 1, umfassend eine thermische Sicherung (38) zum Verschließen eines Brenngasdurchlasses zwischen der Brenngasquelle und dem Brenngaseinspritzer (48). 15
6. Brenner (10) nach Anspruch 5, wobei die thermische Sicherung (38) eine eutektische Legierung umfasst.
7. Brenner (10) nach Anspruch 5, wobei die thermische Sicherung (38) radial begrenzt ist. 20
8. Brenner (10) nach einem der Ansprüche 1 bis 7, wobei das erste Ende (52) des Mischelements (50) mit der zumindest einen Öffnung der brenngasundurchlässigen Umgebung (14) dichtungsverbunden ist. 25
9. Brenner (10) nach einem der vorangegangenen Ansprüche, wobei die Umgebung (14) von einem durchlässigen Gehäuse (18) coaxial umgeben ist, das die zumindest eine Öffnung (16) mit der Umwelt fluidverbindet. 30

Revendications

1. Brûleur à gaz combustible (10) destiné à être utilisé avec une source de gaz combustible, comprenant :

une cavité (24) définie, au moins en partie, par un environnement imperméable au gaz combustible (14) et un élément de brûleur perméable au gaz combustible (60) ayant une surface intérieure exposée à la cavité (24) et une surface extérieure (64) exposée à l'environnement, dans lequel l'environnement imperméable au gaz combustible (14) a au moins une ouverture (16) ;

un élément de mélange (50) ayant une première extrémité (52) et une seconde extrémité (54), dans lequel la première extrémité (52) est couplée de manière fluide à la au moins une ouverture (16) et la seconde extrémité (54) est couplée de manière fluide à la cavité (24) ; et un injecteur de gaz combustible (48) couplé de manière opérationnelle à la source de gaz combustible et positionné au niveau de ou à proximité de la première extrémité (52) de l'élément

de mélange (50) pour injecter le gaz combustible dans l'élément de mélange (50), moyennant quoi l'introduction du gaz combustible sous pression par l'injecteur (48) dans l'élément de mélange (50) et l'entraînement d'un comburant par la première extrémité (52) de l'élément de mélange (50) crée un volume de gaz de pré-combustion sous pression à l'intérieur de la cavité (24) au moyen d'un effet de Venturi établi au niveau de l'ouverture (16), qui se diffuse de la surface intérieure (62) de l'élément de brûleur (60) vers la surface extérieure de l'élément de brûleur (60) ;

ledit brûleur à gaz combustible (10) étant **caractérisé en ce qu'il** comprend en outre :

au moins un montant de transfert de chaleur (56) relié thermiquement à au moins une partie de l'environnement imperméable au gaz combustible (14).

2. Brûleur (10) selon la revendication 1, comprenant en outre une bouteille portable de gaz combustible.
3. Brûleur (10) selon la revendication 1, dans lequel le au moins un montant de transfert de chaleur (56) est disposé dans la trajectoire du gaz de précombustion sortant de l'élément de mélange (50).
4. Brûleur (10) selon la revendication 1, comprenant en outre un élément de protection non plan (20) à proximité de l'élément de brûleur (60).
5. Brûleur (10) selon la revendication 1, comprenant en outre un fusible thermique (38) pour boucher un passage de gaz combustible entre la source de gaz combustible et l'injecteur de gaz combustible (48). 35
6. Brûleur (10) selon la revendication 5, dans lequel le fusible thermique (38) comprend un alliage eutectique. 40
7. Brûleur (10) selon la revendication 5, dans lequel le fusible thermique (38) est contraint radialement. 45
8. Brûleur (10) selon l'une quelconque des revendications 1 à 7, dans lequel la première extrémité (52) de l'élément de mélange (50) est couplée de manière étanche à la au moins une ouverture de l'environnement imperméable au gaz combustible (14). 50
9. Brûleur (10) selon l'une quelconque des revendications précédentes, dans lequel l'environnement (14) est entouré de manière coaxiale par un boîtier perméable (18) qui couple de manière fluide la au moins une ouverture (16) avec l'environnement. 55

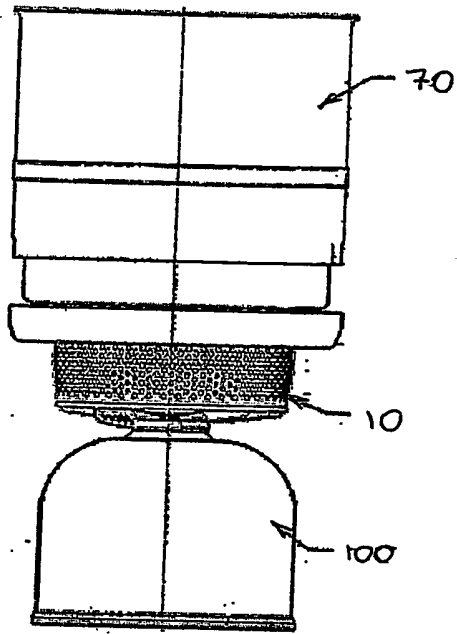


FIG. 1

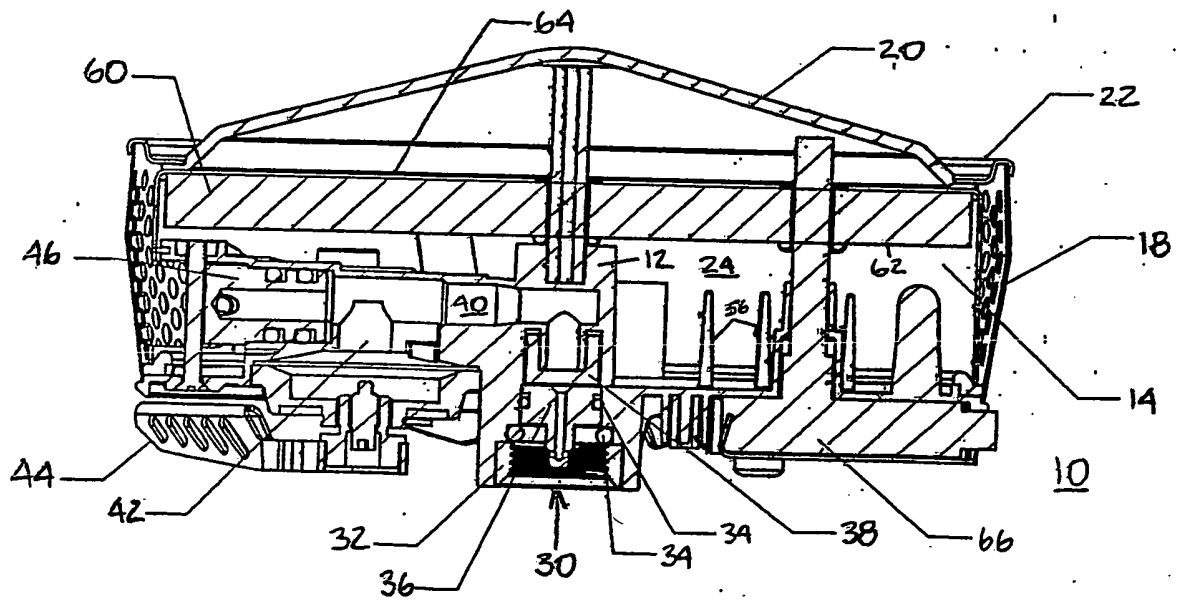


FIG. 2

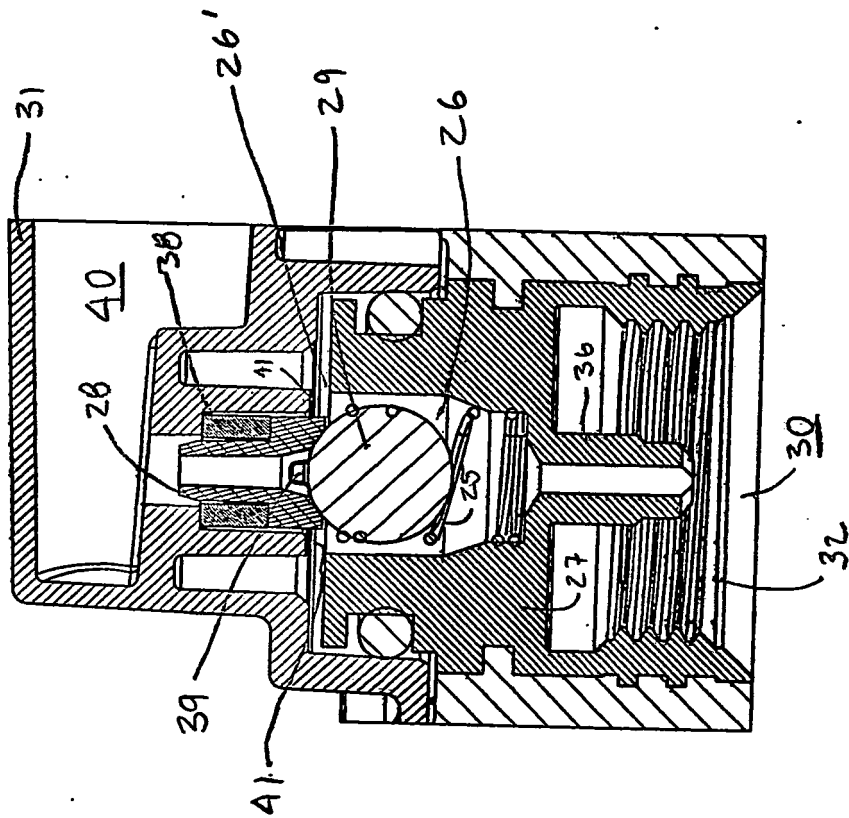
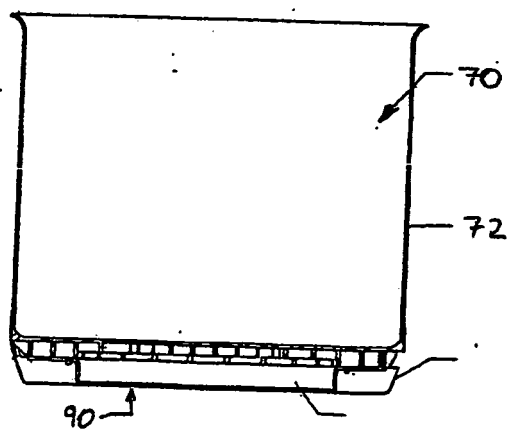
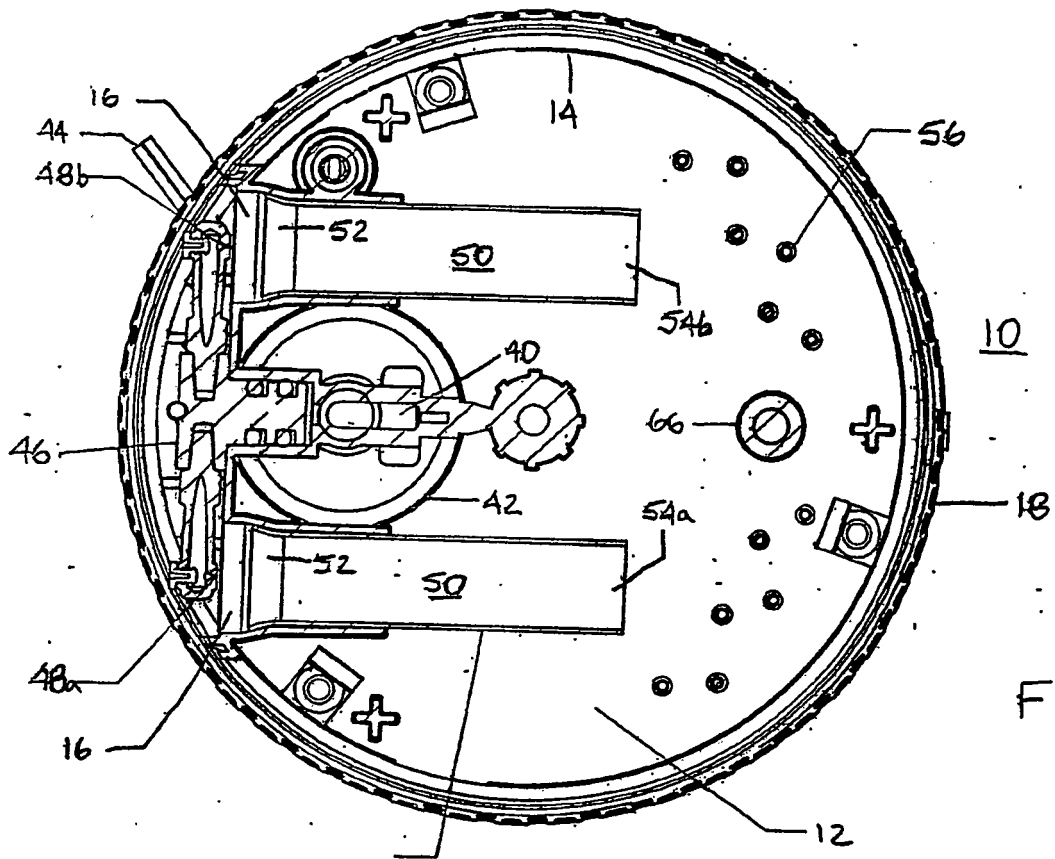
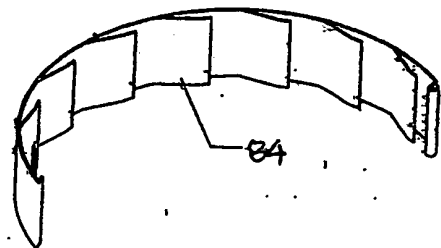
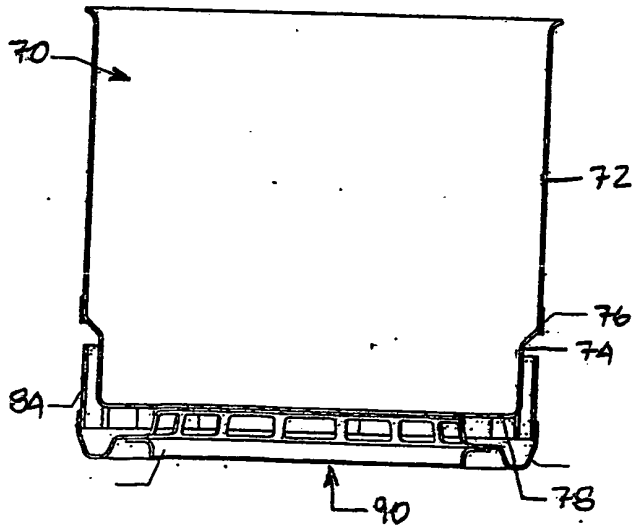
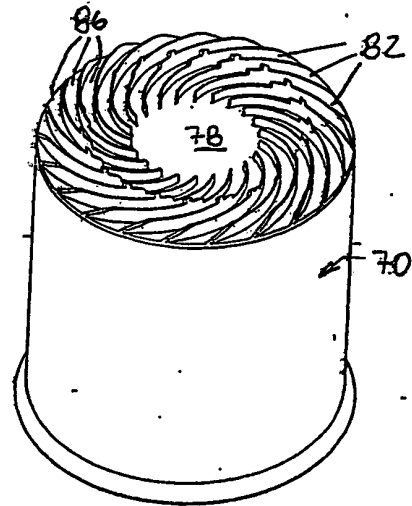
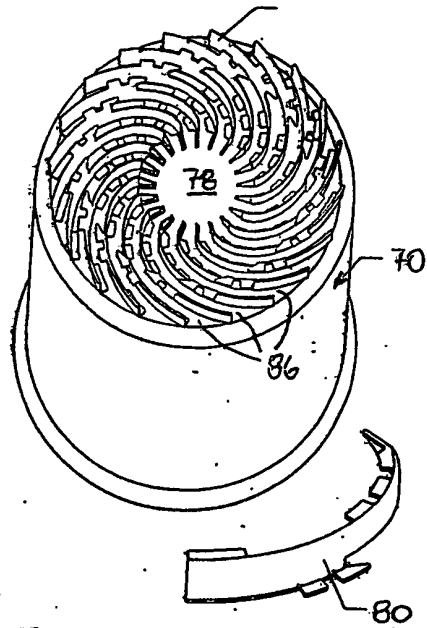


FIG. 2A





REFERENCES CITED IN THE DESCRIPTION

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