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FOREIGN PATENTS

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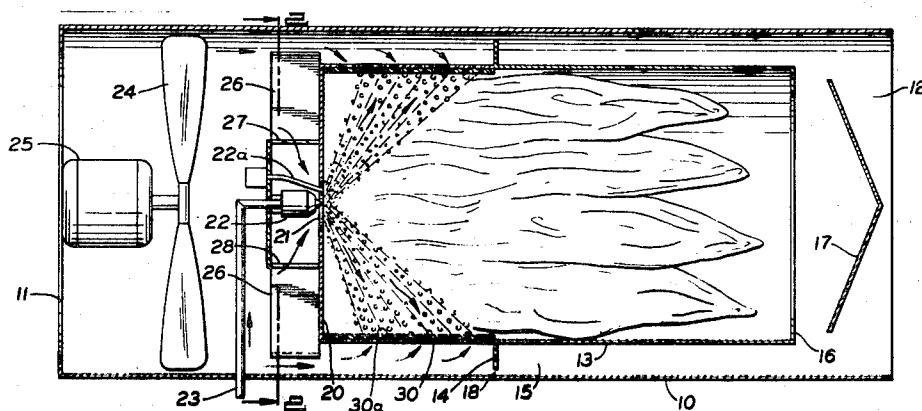
[54] **COMBINATION PRESSURE ATOMIZER AND
 SURFACE-TYPE BURNER FOR LIQUID FUEL**
 1 Claim, 4 Drawing Figs.

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431/170
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 [50] Field of Search..... **431/7, 170,**
326, 352, 351

[56] **References Cited**
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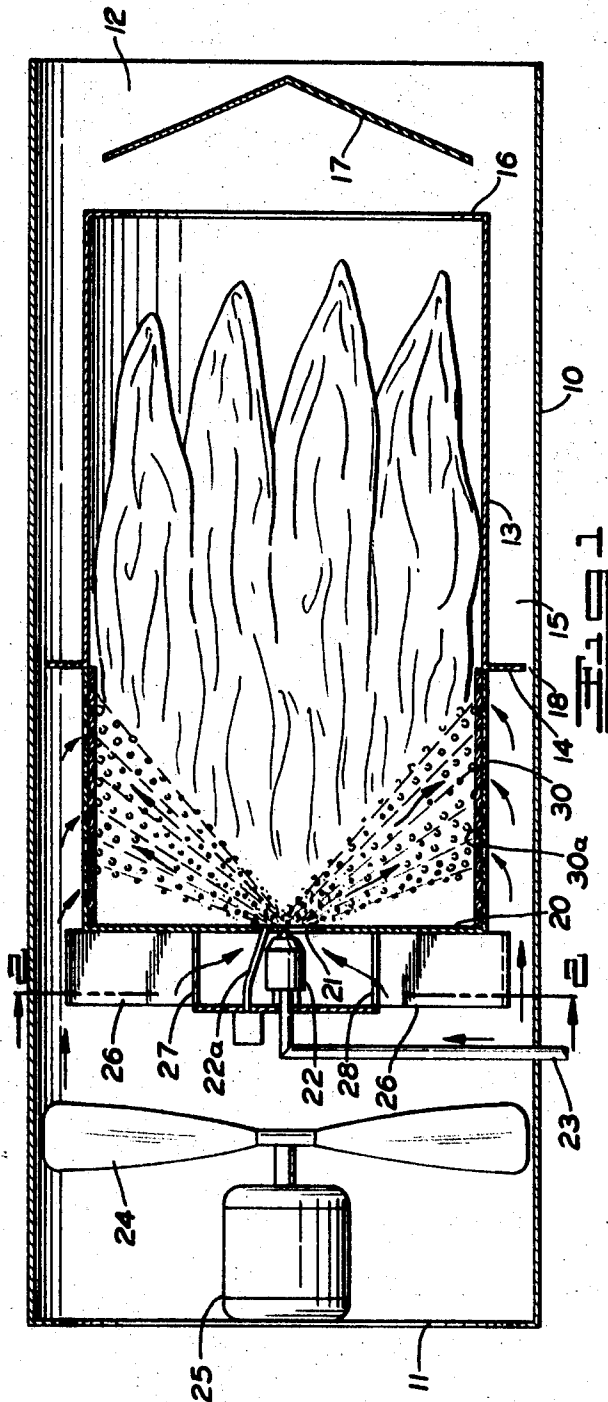
ABSTRACT: A burner for liquid fuel, such as oil, including a centrally disposed atomizing nozzle of the pressure type which receives the liquid fuel and atomizes it under pressure and sprays the atomized droplets forwardly and outwardly causing a substantial proportion of them to impinge against an annular wall of high porosity and of a nature to give a capillary effect so that the droplets are absorbed immediately and the oil thereof is spread throughout the area of the annular wall which serves as the inner wall of the combustion chamber. Primary air for combustion is supplied directly around the centrally disposed pressure-atomizing nozzle and secondary air for combustion is supplied directly through the porous and absorbent annular wall. A substantial part of the atomized oil, that of the smaller droplets, is burned as it passes from the atomizing nozzle and travels toward the surrounding wall in suspension and the remainder, that of the larger droplets, is burned at the exposed inner surface of the annular wall after it reaches it and is absorbed and spread over the area of the wall for evaporation and combustion.



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3,603,711

SHEET 1 OF 2



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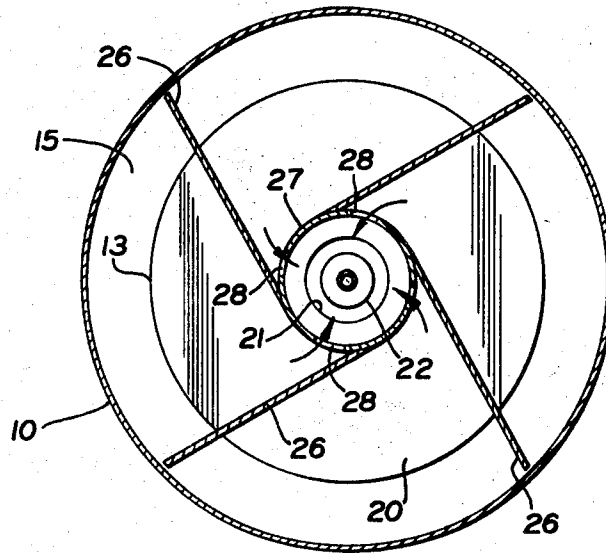


FIG. 2

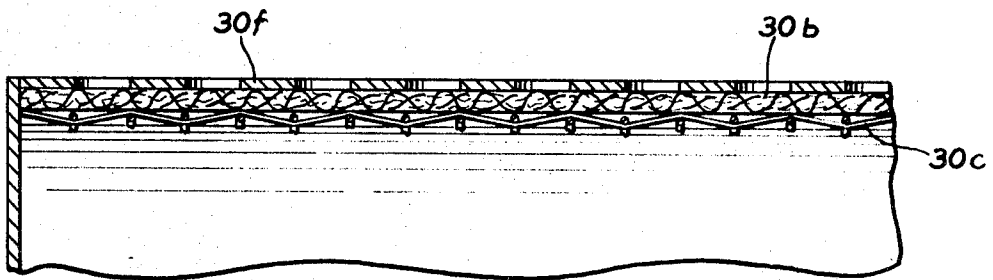


FIG. 3

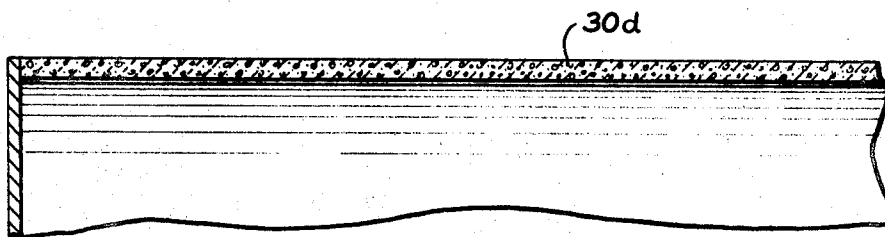


FIG. 4

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COMBINATION PRESSURE ATOMIZER AND SURFACE-TYPE BURNER FOR LIQUID FUEL

BACKGROUND OF THE INVENTION

This invention deals with improvements over the general type of rotary atomizing burner and surrounding annular surface burner of the type disclosed in my prior U.S. Pat. Nos. 3,029,863, 3,127,924, 3,176,749 and 3,176,750. All of the those burners operated on the principle of mechanically or physically breaking up the oil by a centrally disposed driven spinner which receives a stream of the oil and produces mechanically a stream of substantially uniform large droplets therefrom by centrifugal force and throws them outwardly against a surrounding annular wall of suitable porosity. This type of burner was effective, but it has been determined in actual practice, that the oil droplets created by the spinner are relatively large and uniform and there is practically no combustion until they contact the annular porous wall and spread over the area thereof so that evaporation and combustion occurs at the surface thereof. Also, with this arrangement, it is necessary to provide a relatively expensive motor and mounting for driving the spinner to create sufficient centrifugal force to produce the oil droplets. As will be apparent later, the objections to this type of burner are overcome according to this present invention by the use of a pressure-type atomizing nozzle in combination with a surrounding porous wall which is of high capillarity and absorbency.

At present, one of the most commonly used burners is the conventional pressure-atomizing oil burner. The rate of burning in this type of burner is determined by the rate of vaporization of the oil droplets released by the atomizing nozzle. This also determines the size of the combustion chamber since no liquid droplets may be permitted to strike the inside walls of the chamber. If they do so, coke will form at the points of impingement. With my improved burner, the liquid droplets are actually caused to impinge on the annular wall of the combustion chamber which, as indicated above, will be porous and preferably of high capillarity and absorbency. Thus, the coking problem of the usual pressure atomizing burner is overcome, since the droplets which reach the annular absorbent combustion wall will completely burn on that wall, due to the fact that the oil is absorbed and spreads throughout the wall and secondary air for combustion is supplied directly through that wall.

In the accompanying drawings, I have illustrated several oil burners which embody the principles of my invention. In these drawings:

FIG. 1 is an axial sectional view illustrating a heater in which my burner is embodied.

FIG. 2 is a transverse sectional view taken along line 2—2 of FIG. 1.

FIG. 3 is an axial sectional view illustrating another type of annular combustion chamber wall structure according to my invention.

FIG. 4 is a similar view illustrating still another type of annular combustion chamber wall structure according to my invention.

With reference to the drawings, and particularly to FIGS. 1 and 2, I have illustrated the burner of my invention embodied in a heater of the small portable horizontal axis-type although it is to be understood that my burner may be mounted in various other type of heaters and with axes vertical or in other positions.

The heater shown for illustration comprises a tubular outer casing 10 which is open at its rear inlet end 11 and at its forward outlet end 12. Within the tubular casing 10 and in concentric relationship therewith and extending axially for a substantial portion thereof is a combustion chamber 13 which is mainly of tubular form and is of smaller diameter than the casing 10 so that an annular air passageway 15 is provided which is also open at both its rear inlet end and forward outlet end. The annular wall forming the combustion chamber 13

may be suitably supported within the casing 10. The forward end of the chamber 13 is provided with an interned flange 16 and spaced forwardly of this flange is a baffle member 17 of conical form.

The rear end of the combustion chamber 13 is substantially closed by a disc wall 20 which, however, has a centrally disposed inlet opening 21. Positioned directly behind this inlet opening and concentric therewith is an atomizing nozzle 22 which receives oil from a suitable source through the line 23. It will be noted that air for combustion, which may be termed primary air, can flow forwardly around the nozzle and through the inlet opening 21 at the same time that oil is sprayed by the nozzle through that opening, as indicated by the arrows in FIG. 1. Suitable ignition electrodes 22a will be associated with the nozzle 22 and preferably be located directly above the nozzle.

For supplying air for combustion under positive pressure a suitable fan 24 is provided which is driven by an electric motor 25. This fan is centrally disposed at the outlet end of the casing 10 and will draw air into the inlet 11 and force it forwardly through the combustion chamber 13 and the annular space 15 surrounding it, as shown in FIG. 2. Around the nozzle 22 and opening 21 on the rear surface of the wall 20, air-directing vanes 26 are provided which extend tangentially relative to a central collar 27 surrounding the opening 21 and nozzle 22 and being concentric therewith. These vanes extend outwardly beyond the annular combustion chamber wall 13 but terminate short of the casing 10. They form pockets which receive the air from the fan and rotate it around the nozzle and direct it through the slots 28, provided in the collar 27 for the respective pockets, as indicated by the arrows in FIG. 2, it being understood that the fan will be driven in a counter-clockwise direction as viewed from the rear end of the heater.

The nozzle 22 is one of the common pressure-atomizing types in which the oil under pressure is received and atomized or oil not under pressure is received and atomized by air under pressure. In either standard type, the oil is atomized into a spray or mist or fine droplets which are directed forwardly and outwardly through the opening 21 toward the annular wall of the combustion chamber 13. In the oil pressure-type, the oil is under a pressure of from 80 to 300 p.s.i. whereas in the air pressure type, the air is under a pressure of from 2 to 10 p.s.i. Both types of burners will create droplets in sizes ranging from 0.0002-inch to 0.10-inch.

The rear portion of the annular wall 13 behind the static ring 14 is of special form and is indicated by the numeral 30. It is of such a nature that it has high porosity to permit the passage of air directly therethrough. The air will be supplied by the fan 24 and may be termed secondary air for combustion. The air will be forced into the rear end of the chamber 15 and most of it will pass inwardly through the wall section 30, as indicated by the arrows in FIG. 1, due to the baffling effect of the static ring 14 but some of it will pass on forwardly through the annular passage 18. The porous wall section 30 is also of such a nature that it has high capillarity and absorbency so that it not only will permit passage of air directly inwardly through it but will absorb and retain the oil and spread it over its inner surface for evaporation and combustion when the oil droplets from the nozzle 22 directly impinge thereon. In FIG. 1, the combustion chamber wall is shown as being of metal and the section 30 thereof is made porous by having a series of small openings in the metal throughout its area. The inner surface of the metal wall is lined with a layer of fire-resistant highly absorbent material 30a.

The annular liner wall section 30a may be made in various ways to be porous and to have the desired capillarity. It may be of ceramic or metal woven cloth or screen or of paper or felt having the necessary heat resistance. I prefer to use ceramic cloth of woven yarn composed of long, thin ceramic fibers, since the spaces between the woven strands permit air passage through the layer at a right angle and the individual fibers of the strands provide elongated small passages to increase capillarity and absorbency of the layer. An example of

a suitable cloth which I have used is one known as "Fiberfrax" cloth produced from "Fiberfrax" long staple fibers by the Carborundum Company which has the following chemical composition:

Al_2O_3 —51.3 percent; SiO_2 —45.3 percent; ZrO_2 —3.4 percent

Approximate fiber diameter:

2 microns to 40 microns with a mean in the range of 4 to 10 microns.

Approximate fiber length:

$\frac{1}{2}$ inch to 10 inches, averaging 2 inches to 3 inches.

Density of the cloth:

24 pounds per cubic foot.

Thickness of the cloth:

0.020 inch to 0.250 inch.

Thread count:

8 per inch to 30 per inch, with an average of 15.

Other examples of suitable materials are cloths which could be made of Micro-quartz fibers which are produced by LOF Glass Fibers Co. and which fibers are of 98 percent pure quartz, or of other fibers which have the necessary resistance to high temperature and will provide a cloth having the necessary high capillarity.

A high degree of capillarity and absorbency is present in the ceramic cloth ring or layer to provide lateral flow over the face of the ring in sufficient quantity to keep the ring well saturated with fuel. The high rate of evaporation from this wet ring provides a strong cooling action due to the latent heat of evaporation of the fuel. This cooling action tends strongly to prevent cracking of the fuel in the liquid state by lowering the temperature of the cloth.

The ceramic cloth ring is composed of fibers that will withstand approximately 2000° F. for long periods of time without noticeable deterioration. These fibers must also withstand the effects of hot fuel and the products formed by chemical reaction of the fuel, either by oxidation or thermal cracking for long periods without noticeable deterioration.

For effective and carbon-free operation, the ceramic cloth ring is thin—not less than 0.020 inch and not more than 0.250 inch in thickness, and a thickness which I have found very satisfactory is 0.090 inch.

The annular wall or ring also may be made of a mat of metal filaments which are combined into feltlike material. The material is preferably made of overlying filaments which are pressed together and welded or fused together by heating to a suitable temperature without heating to such a high temperature that the physical structure of the filaments will be destroyed. The filaments will not be pressed together too tightly so as not to destroy the capillary pockets or interstices in the material. A porosity of more than 80 percent is desirable. The material will have natural passages completely therethrough, or actual openings provided, so as to permit passage of air through the material of the wall. Since the material is formed of metal, it will be heat resistant and will adequately withstand temperatures up to 1500° F.

Thus, a high degree of capillarity and absorbency will be present in the metal felt ring to provide lateral flow over the face of the ring in sufficient quantity to keep the ring well saturated with fuel. The high rate of evaporation from this wet ring provides a strong cooling action due to the latent heat of evaporation of the fuel. This cooling action tends strongly to prevent cracking of the fuel in the liquid state by lowering the temperature of the metal felt. For effective and carbon-free operation, the metal felt ring is thin, not less than 0.026 inch and not more than 0.250 inch in thickness, and a thickness which I have found very satisfactory is 0.065 inch.

Another suitable arrangement of the cloth or other material is indicated in FIG. 3 where the perforated outer wall 30f is shown with the absorbent cloth 30b disposed directly therewithin. It is desirable, especially for large areas, that the cloth 30b be supported by an interior metal screen or mesh 30c.

In FIG. 4, I have shown still a different arrangement for a high-porosity, high-capillarity, heat-resistant ring or annular wall 30d. In this case, the wall is a suitable thickness of spongelike open cell refractory material which is self-supporting and will be engaged directly by the droplets of oil that will be absorbed therein and will spread throughout the area thereof so that the oil will evaporate and burn at the inner surface thereof. Air for combustion will readily pass directly inwardly through this wall.

The heater arrangement shown in FIG. 1 will be suitable for a small portable heater and will not need a stack since the nature of the burner is such that there is substantially complete combustion with a clean flame.

The rate of burning in a conventional pressure-atomizing oil burner is determined by rate of vaporization of the oil droplets released by the nozzle. This also determines the size of the combustion chamber since no liquid droplets may be permitted to strike the inside walls of the chamber. If they do so, coke will form at the point of impingement.

In my new and novel oil burner, as described above, the liquid droplets, mainly the larger ones, are purposely made to impinge on the annular sidewall of the combustion chamber. These are droplets created by a pressure-atomizing nozzle, and will range in size from 0.0002-inch to 0.010-inch in diameter. The smaller droplets in the spray burn in suspension and the larger droplets reach and strike the annular absorbent wall where the oil is spread out, evaporated and mixed with the secondary air coming through the wall. This causes very rapid evaporation of the fuel and hence produces a very hot compact fire. To cool the nozzle and provide air to initiate burning while the atomized droplets are suspended, before striking the porous annular wall, primary air is introduced into the combustion chamber around the nozzle. Some of the droplets, the smaller ones, are ignited just after leaving the nozzle and burn in suspension and others, the larger ones, strike the absorbent annular sidewall where they spread out on the high capillary surface thereof. Burning is further speeded up by the fact that secondary air, passing through the porous wall, mixes quickly and intimately with the oil vapor coming off the inside of the wall. The vapor and secondary air combine at the surface of the wall and burn intensely in this area.

The shape of the flame may be tailored by varying the amount of swirl in the primary air and changing the ratio of primary to secondary air. If the maximum amount of swirl is used, as I have done with a portable space heater of the type shown in FIG. 1, and a maximum amount of primary air used, relative to the amount of secondary air, a short, bushy flame will result, as indicated in this Figure. A number of burners using the principle of my invention have been built. Some have produced long, thin flames and some short, bushy flames. In no case has carbon formed on the annular porous wall.

The wall material must be porous to admit secondary air. As I have mentioned, it is imperative that it have good capillary action so as to absorb the fuel oils. As indicated above, I have found a very good material to be the "Fiberfrax" cloth. The natural holes produced in weaving this cloth seem about right for admission of secondary air and the passages between the fibers of the strands produce high capillarity. As shown, external and sometimes internal, support is used with this cloth since it is quite flexible. Internal support is not used on smaller burners, but on larger models a heavy screen or metal bars, or other means of support is used. It is sometimes desirable to leave some air space between the outer wall and the cloth so that air on the cold side of the cloth will be distributed evenly. In the portable heater application the static ring 14 is used to control the amount of air passing through cloth. The larger the ring, the higher the pressure behind the cloth and hence more air passes through the cloth.

I have actually taken flame temperatures in the combustion chamber of a conventional pressure atomizing burner and in the combustion chamber of my new burner. The flame temperatures in the combustion chamber with my burner averaged over 400° F. higher than those in the chamber with

the conventional burner. The effect of these higher flame temperatures is to produce absolutely clean combustion. All the fuel is burned so there are no unburned hydrocarbons. Smoke and monoxide or aldehydes are consumed and hence do not appear in the combustion products, even with careful measurement. Either a centrifugal blower or a propeller fan (FIG. 1) may be used to pressurize the combustion air. The latter is generally used where it is desired to swirl the combustion air. Also as described, vanes are sometimes used to increase this swirl and do so by passing the air tangentially through slots, as in FIG. 1, into the burner head. It appears that flame temperatures are higher in my burner because twice as much heat or more is released per cubic inch of combustion chamber volume.

The advantages of my burner may be summarized as follows:

Burns in 35 percent to 50 percent of combustion volume required by conventional pressure-atomizing burner.

Burns more fuel in smaller volume than spinner-type because finer droplets are produced which permit direct ignition of the smaller droplets before they reach the annular absorbent wall where the larger droplets subsequently strike and the oil thereof is burned.

Produces substantially higher flame temperatures.

These higher temperatures insure that combustion is absolutely complete with no carbon monoxide, smoke or unburned hydrocarbons in the final combustion products.

Burner is especially useful in application such as portable oil-fired heaters or heating air for drying agricultural products when clean, odor-free combustion products are a necessity.

Burner can also be used to advantage in residential and commercial furnaces and boilers since it does not deposit soot or produce smoke.

The shape of the flame may be tailored to suit the shape of the combustion chamber by proportioning primary and

secondary air. For example, I have produced a flame 6 inches in diameter and 10 inches long and one 3 inches in diameter and 17 inches long, both burning the same amount of oil. Because of rapid and thorough mixing of oil vapor and air, a clean flame is attained. In fact, I have in several instances, fired versions of the burner into relatively cool—600° to 700° F.—wall temperature combustion chambers and still have had excellent combustion.

Having thus described my invention, what I claim is:

1. A liquid fuel burner comprising an outer peripheral wall of a porous and absorbent nature providing a combustion chamber which extends axially and is open at its outer end, said combustion chamber being provided with an axially disposed inlet at its inner end, a pressure-type atomizing oil burner nozzle located for cooperation with the inlet to direct atomized oil droplets inwardly through the inlet and angularly outwardly into contact with said peripheral wall, and means for supplying air under pressure into said combustion chamber and including means for directing primary air for combustion around said nozzle and through said inlet and means for directing secondary air for combustion inwardly through said peripheral wall, said peripheral wall being of annular form and the inlet opening and associated nozzle being disposed at the axis thereof, said means for supplying secondary air for combustion being an annular air passageway surrounding said wall and including means for forcing air into the inner end thereof and wall means spaced outwardly of said inner end for directing flow of air inwardly through said porous wall toward the axis thereof, said means for directing primary air around said nozzle through said inlet comprising a collar surrounding said opening and said nozzle, said collar having a plurality of angularly spaced openings, means for producing flow of air axially toward said collar, and angularly spaced vanes around the collar for directing the air into said respective openings.

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