United States Patent

Desty

[15] 3,635,651

[45] Jan. 18, 1972

[54] **BURNER**

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[73] Assignee: **The British Petroleum Company Limited**, Moor Lane, London, England

[22] Filed: **Mar. 31, 1970**

[21] Appl. No.: **24,221**

[30] **Foreign Application Priority Data**

Apr. 28, 1969 Great Britain 21,541/69

[52] **U.S. Cl.** **431/328**
[51] **Int. Cl.** **F23d 13/12**
[58] **Field of Search** 431/326, 328, 300, 298

[56] **References Cited**

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Primary Examiner—Carroll B. Dority, Jr.
Attorney—Morgan, Finnegan, Durham & Pine

[57] **ABSTRACT**

A burner, preferably of rigid material such as metal foam which is pierced by airholes for the passage of combustion air and arranged to carry fuel across the combustion zone. Conveniently the burner has an evaporator in which the airholes are situated and a feeder for lifting fuel to the level of the evaporator. In the preferred configuration gravity assists fuel transfer. For example, the evaporator comprises two sloping portions joined together at their lowest portions and each joined to a feeder at its highest portion.

13 Claims, 8 Drawing Figures

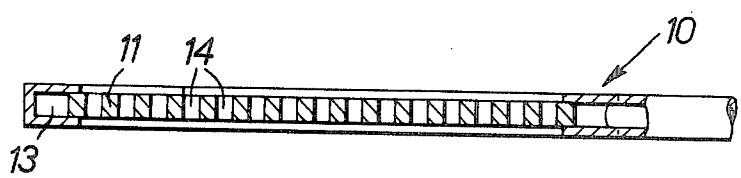


FIG.1.

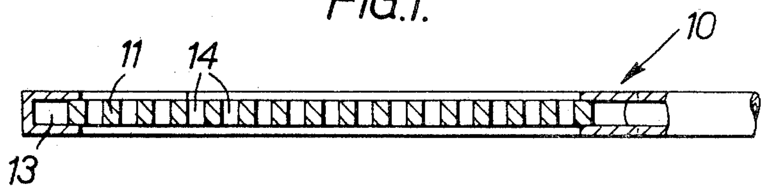


FIG.2.

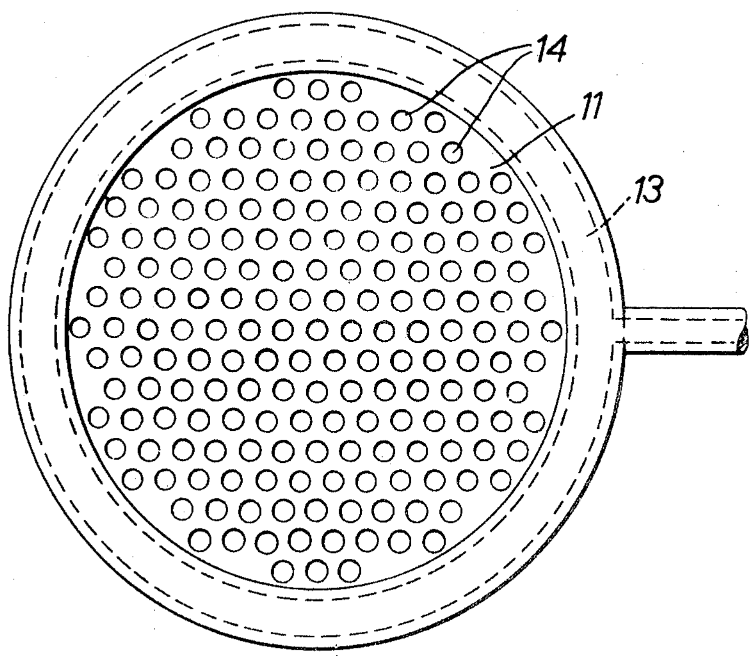


FIG. 3.

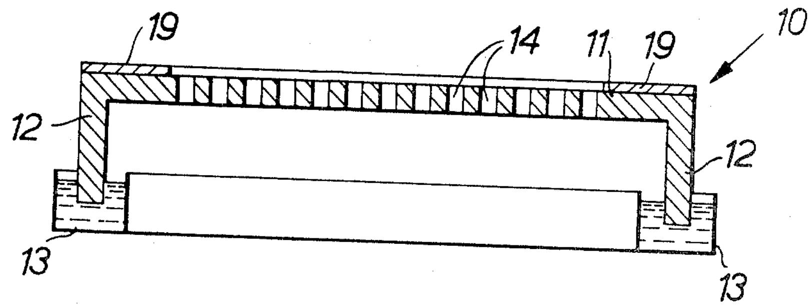


FIG. 4.

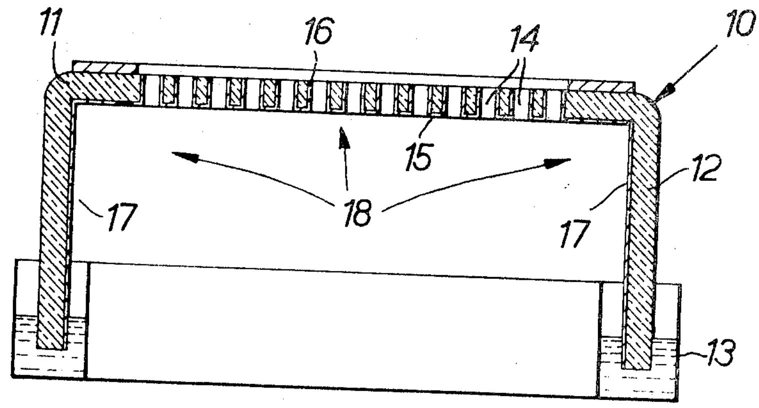


FIG. 5.

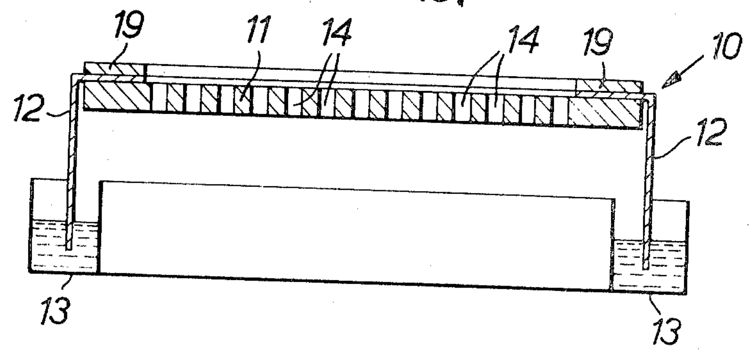


FIG. 6.

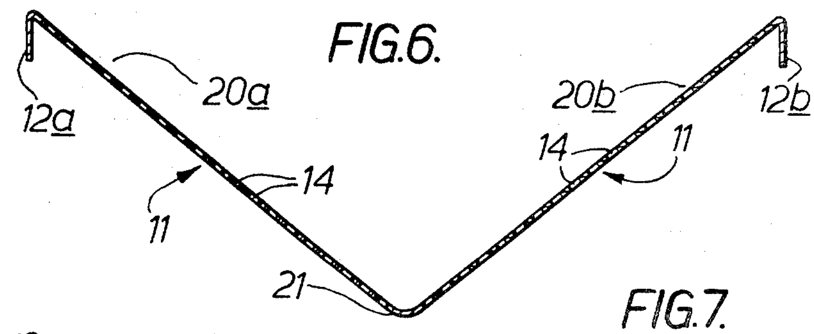


FIG. 7.

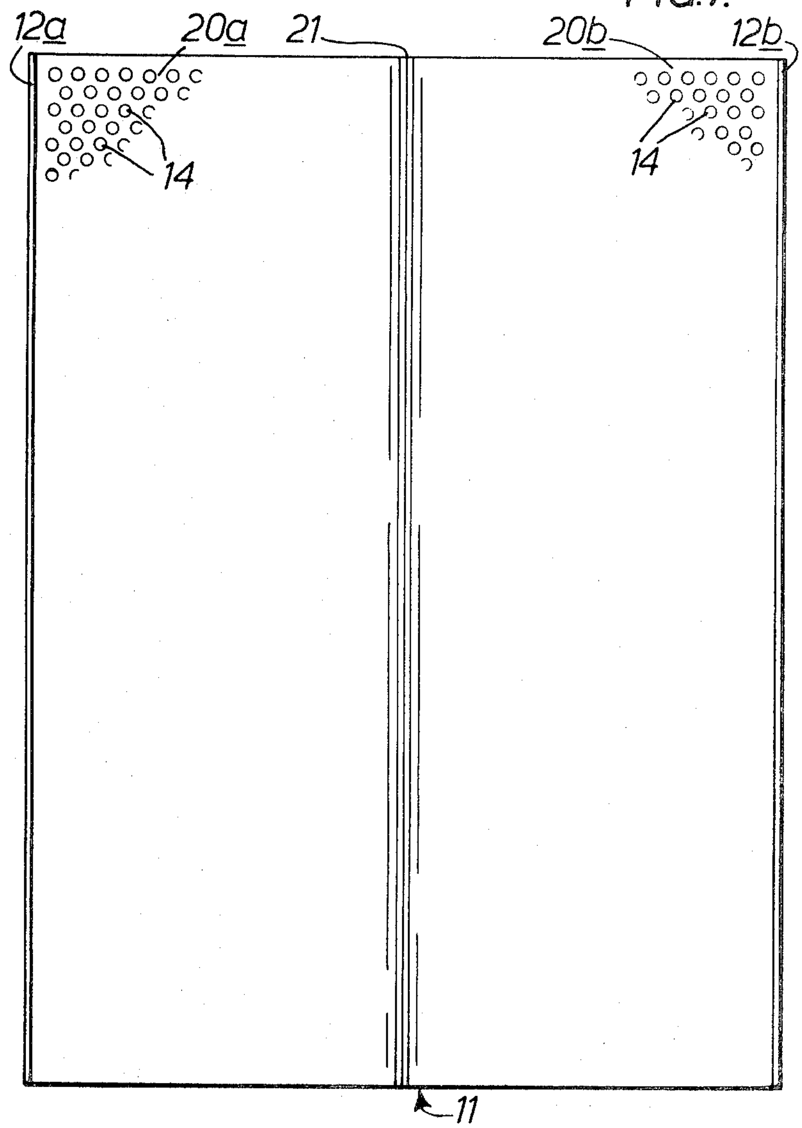
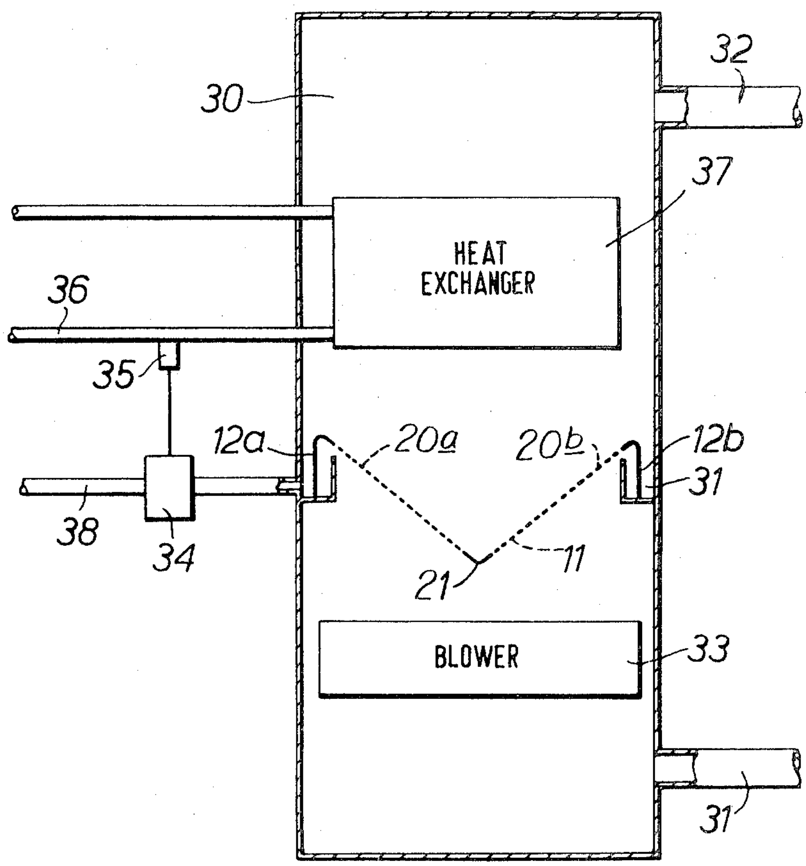


FIG.8.


32
30
37
HEAT
EXCHANGER
36
35
12a
20a
20b
12b
31
38
34
21
11
BLOWER
33
31

BURNER

This invention relates to burners and in particular to burners which operate on vaporizable liquid fuels such as kerosene.

It is known to burn liquid fuels for heating purposes in wick burners in which the wick conveys fuel from a reservoir situated below the combustion zone to the bottom of the combustion zone. Such burners give satisfactory combustion with silent blue flames but they have only been used for small portable heaters. This invention relates to a burner which is suitable for use in applications which require a higher output than a small portable heater and for which automatic control is desirable, e.g., domestic central heating.

The invention consists in a burner at least a portion of which is an evaporator adapted:

a. to hold liquid fuel by surface tension,

b. to evaporate liquid fuel held within the evaporator into a combustion zone adjacent to one surface of the evaporator by transfer of heat from the combustion zone, and

c. to permit flow of fuel held within the evaporator so as to replenish fuel lost by vaporization,

the evaporator being pierced by airholes arranged so that, during the use of the evaporator as a component of a burner burning a vaporizable fuel, combustion takes place between air passing through the airholes and fuel evaporated from the evaporator.

According to a preferred embodiment of the invention the evaporator also has one or more downwardly depending, preferably vertical, feeders adapted to dip into a fuel bath whereby, during use in a burner, the feeders raise liquid fuel to the level of the evaporator.

(Note in this specification the words "horizontal," "vertical" and "downward" are related to a burner which is in its optimum orientation. In fact the orientation is not critical, at least within the limits acceptable in domestic practice.)

The evaporator may be horizontal or it may comprise sloped portions, e.g., it may be dome shaped or dish shaped. Burners in which the evaporator comprises a portion downwardly sloped in the direction of fuel flow are advantageous because gravity assists the fuel transfer. Particularly suitable angles of slope are 20°–70° to the horizontal, preferably 40°–50° to the horizontal.

In a preferred configuration the evaporator comprises two sloping portions, preferably rectangular, joined together at their lowest regions.

In the case of burners which comprise feeders and evaporators with sloping portions the feeders should be joined to the evaporators at the highest portions.

It will usually be desirable to use the thinnest evaporator consistent with achieving the necessary fuel transfer since the greater the thickness the greater the heat capacity of the evaporator and the fuel contained therein. A low-heat capacity facilitates ignition since the smaller the heat capacity the more easily the fuel is raised to evaporation temperature. (Ease of ignition is particularly important in the case of a burner which is turned on and off by an automatic control system.) A thin evaporator confers an additional advantage when the burner is turned out. Combustion continues until the supply of fuel contained in the evaporator is exhausted and this exhaustion is more satisfactorily achieved when the supply is small, i.e., when the evaporator is thin. Thus it is desirable that the evaporator is less than 10 mm. thick and for certain applications, e.g., domestic central heating, it is desirable that the evaporator be less than 5 mm., and preferably less than 3 mm., thick.

In order to achieve uniform air distribution it is desirable that the airholes be uniformly distributed over the evaporator. The airholes are preferably circular in shape and preferably of an area of 0.1 –1 cm.^{2}. The number of airholes is such that they account for 20 –50 percent, preferably 25 –35 percent of the total area of the evaporator.

The invention includes both rigid and nonrigid burners. Nonrigid burners are made of flexible material, e.g., ceramic fibers, and therefore, since the burner would collapse under its own weight, it must be used in conjunction with a support member adapted to hold the burner in the required configuration. On the other hand rigid burners, e.g., wicks made of a porous metal such as a metal foam, are capable of supporting their own weight and therefore no support member is necessary.

Anisotropic burners are particularly suitable for most applications. Anisotropic burners offer a lower resistance to liquid fuel flow in directions across the combustion zone than in the direction of airflow, e.g., the pore size is smaller measured in the direction of airflow than at right angles thereto. For embodiments which comprise a horizontal evaporator there is a lower resistance to liquid flow in a horizontal direction than in the vertical direction, e.g., the pore size is larger measured in horizontal directions than in the vertical direction.

Anisotropic burners have the property of facilitating fuel flow in desired directions (i.e., across the combustion zone to achieve uniform fuel distribution) but hindering fuel flow in undesired directions i.e., fuel dripping out of the burner.)

The invention includes burners which incorporate burners according to the invention as defined above.

The invention will now be described by way of example with reference to the accompanying diagrammatic drawings in which:

FIG. 1 is a vertical cross section of a burner having a foam metal evaporator,

FIG. 2 is a top view of the burner shown in FIG. 1,

FIG. 3 is a modification of the burner shown in FIG. 1 having a flat horizontal evaporator and feeders,

FIG. 4 is a supported evaporator version of the burner shown in FIG. 3,

FIG. 5 is a modification of the burner shown in FIG. 3 having a separate feeder,

FIG. 6 is a vertical cross section through a burner having the preferred configuration,

FIG. 7 is a plan view of the burner shown in FIG. 6, and

FIG. 8 is a diagrammatic cross section of a domestic central heating boiling which includes a burner as shown in FIGS. 6 and 7.

The arrangement shown in FIGS. 1 and 2 comprises a burner 10 which has an evaporator 11 having the form of a horizontal circular disc of crushed metal foam. The evaporator 11 is pierced by airholes 14 arranged in a hexagonal pattern, i.e., each internal hole has six nearest neighbors whose centers form a regular hexagon.

The burner 10 was made from a cylindrical block of metal foam by crushing it parallel to its axis in the ratio 3:1 and the airholes 14 were cut at the same time. Originally the metal foam took the form of a three dimensional network of tubular nickel stands which defined dodekahedral pores of average diameter 0.3 mm. The compression flattened original pores so that they became thin in the vertical direction.

(Irregular dodekahedra can pack to fill space and the foam can be regarded as an example of such a packing. From this point of view the metal strands form the edges of the dodekahedra.)

The circumference of the evaporator 11 engages with a fuel bath 13. During use the evaporator 11 contains a reservoir of liquid fuel which is held in the pores by surface tension and conveyed horizontally by passage from pore to pore. The pores offer a high resistance to vertical flow so that no fuel drips from the under side of the burner.

While the burner is alight the heat of combustion draws air through the airholes 14 and the heat vaporizes fuel into the combustion zone, which is adjacent to the upper surface of the evaporator, so that the burner remains alight.

The heat output can be controlled by reducing the flow of fuel into the fuel bath 13 thereby reducing the rate of fuel supply to the combustion zone. As the fuel supply is reduced to zero the burner first goes out at the center because of fuel starvation. This creates a "dead" area at the center which spreads (as the fuel supply reduces) until the whole burner is extinguished. Thus the burner is capable of good heat control.

To reignite the burner the fuel supply is restarted and a light is applied. This starts combustion and the burner operates as described above.

The burner shown in FIG. 3 comprises a foam metal evaporator **11** having a feeder **12**. (The evaporator **11** is formed of crushed metal foam as described above and the feeder consists of an annular cylinder of uncrushed metal foam.)

The feeder **12** stands in a fuel bath **13** and it lifts fuel to the level of the evaporator **11** by means of wicking action. Transfer of the fuel across the burner and combustion then take place as described above. The fuel supply to the burner is conveniently controlled by varying the level of liquid in the fuel bath **13**. Evaporation of fuel outside the combustion zone is hindered by the guard ring **19**.

The burner shown in FIG. 4 is similar to that shown in FIG. 3 except that the evaporator is constructed from a fibrous ceramic material instead of a metal foam. Since the fibrous material is not self-supporting it is carried by a support member (generally indicated by the numeral **18**) which comprises a horizontal base plate **15** upon which the evaporator **11** rests. The base plate **15** has upwardly extending tubes **16** whose bores form the airholes **14**. The support member **18** also comprises a circular support ring **17** which stands in the fuel bath **13** and holds the evaporator in the working position.

In the embodiment shown in FIG. 5 the evaporator **11** is formed of crushed metal foam (as in FIG. 3) but the feeder **12** is formed of ceramic fibers which contact the evaporator **11** and hence transfer the liquid fuel. The feeder **12** is held in contact with the evaporator **11** by the guard ring **19**.

Laboratory tests were carried out on a burner as illustrated in FIG. 3 using kerosene as the fuel and during these tests it was noticed that the combustion zone had a circular cross section with combustion complete about 0.5 cm. above the top of the evaporator. The important dimensions of the burner are given in table 1 and table 2 gives experimental results.

Table 1

Overall Diameter	6.4 cm.
Diameter of Combustion Zone	4.2 cm.
Cross-Sectional Area of the Combustion Zone	13.9 cm.^{2}
Diameter of each Airhole	4 mm.
Number of Airholes	37
Total Area of Airholes	4.7 cm.^{2}
Length of Each Airhole	2 mm.

Table 2

Length of Chimney	cm.	20	20	20
Smaller Wicking Height	mm.	7	9	10
Larger Wicking Height	mm.	9	11	12
Kerosene Flow	ml./min.	1.88	0.8	nil
Total Output	watts	1,160	490	—
Output (unit area)	watts/cm.^{2}	84	35	—
CO_2 in Flue Gas	% vol	10.6	—	—
Excess Air	% vol	37	—	—

(The "smaller wicking height" means the vertical distance between the fuel level in the fuel bath **13** and the bottom of the evaporator **11** and the "larger wicking height" means the distance to the top of the evaporator.)

The burner shown in FIGS. 6 and 7 is made of the same metal foam described earlier. It comprises an evaporator **11** which is formed of two rectangular sheets **20*a*** and **20*b*** which are 3 mm. thick, slope at 45° to the horizontal and are joined at their lowest edges along the line **21**. The sheet **20*a*** is joined to a feeder **12*a*** at its upper edge. Similarly the sheet **20*b*** is joined to a feeder **12*b***. The sheets **20*a*** and **20*b*** are pierced by circular airholes **14** arranged in a uniform hexagonal pattern (i.e., each has six nearest neighbors.) The diameter of the airholes **14** is 3 mm. and their total area represents 30 percent of the total area of the evaporator.

The burner was made by pressing and bending a flat sheet of the metal foam and the curvature between the feeders and the two sheets was chosen to avoid over straining the metal foam. During the pressing the foam in the evaporator was reduced in thickness in the ratio 3:1.

When the evaporator shown in FIGS. 6 and 7 is incorporated in a burner each of the feeders **12*a*** and **12*b*** stands in a fuel bath to which liquid fuel is supplied. FIG. 8 shows a domestic central heating appliance of the hot water circulating type which incorporates such a burner.

The appliance shown in FIG. 8 comprises a combustion chamber **30** of rectangular cross section which has an air inlet **31** and a flue gas outlet **32** which are connected to a balanced flue.

A fuel bath **13** is situated on the longer sides of the rectangle and the feeders **12*a*** and **12*b*** of an evaporator as shown in FIGS. 6 and 7 stand in the fuel bath **13**. A blower **33** is situated below the burner and a heat exchanger **37** (for heating the circulating water) above.

Fuel is supplied to the bath **13** by the fuel line **38** under the control of the flow controller **34**. The setting of the flow controller **34** is varied by a thermostat **35** situated in the outlet **36** of the heat exchanger **37**. When the temperature of the water in the outlet line **36** falls below the setting of the thermostat **35** the flow controller increases the fuel supply; when the temperature rises too high the fuel supply is reduced or cut off so that the burner goes out.

(As a safety factor a level controller, not shown, is usually fitted. This overrides the flow controller should the fuel level tend to rise so high that there is danger of overflow.)

The burner comprised in the appliance shown in FIG. 8 operates substantially as described above. The feeders **12*a*** and **12*b*** lift fuel by capillary action to the upper edges of the sheets **20*a*** and **20*b*** and then gravity assists the transfer of the fuel (which is in the liquid phase) towards the line **21**. As it passes through the evaporator fuel vaporizes into the combustion zone adjacent to the upper surface of the evaporator where it burns with air flowing through the airholes.

Automatic ignition is conveniently achieved by an electrical system (not shown in any drawing.) The system comprises a coil heater for heating a small area of the burner and an electrode for generating sparks in cooperation with the metal foam. To achieve ignition the ignition system is switched on and the fuel is restarted. When the liquid fuel reaches the heated area some vaporizes and the vapor is ignited by the sparks. This produces a flame which spreads over the whole area of the burner.

It is emphasized that in all the burners described in the examples the whole of the base of the combustion zone is adjacent to the upper surface of the evaporator. Thus the evaporator and the liquid fuel contained therein are heated and hence fuel is evaporated into the combustion zone. The evaporator holds a supply of liquid fuel which is able to move within the evaporator and thereby replenish the supply as fuel vaporizes into the combustion zone. Because the evaporator provides a good supply of fuel adjacent to the whole of the base of combustion it gives an evenly distributed supply of fuel vapor with the combustion zone.

The thermal conductivity of the metal foam mentioned in respect of FIGS. 1 and 2 has been found to give good heat transfer to the liquid fuel held within the evaporator. The pore size is good for retaining and transferring liquid fuels.

I claim:

1. An anisotropic burner which comprises an evaporator less than 10-mm. thick and having a body of porous material for holding liquid fuel in its pores by surface tension to provide a reservoir of liquid fuel contained in the evaporator from which fuel may be evaporated into a combustion zone adjacent to one surface of the evaporator by transfer of heat from the combustion zone, said body of porous material being pierced by airholes for conducting air through the evaporator

to said combustion zone, said airholes being arranged so that, during use of the evaporator as a component of a burner burning a vaporizable fuel, combustion takes place in said combustion zone between air flowing through the airholes and fuel evaporated from said reservoir, and the pores of said porous material being smaller measured in the direction of the airflow than at right angles thereto so as to offer a lower resistance to liquid fuel flow in said reservoir in directions across the combustion zone than in the direction of airflow and facilitate flow of fuel in directions across the combustion zone to achieve uniform fuel distribution in replenishment of fuel lost by evaporation from said reservoir while hindering fuel flow against the direction of said airflow.

2. A burner according to claim 1, which also comprises a fuel bath and in which said evaporator comprises, at least one downwardly depending feeder adapted to dip in said fuel bath whereby, during use in a said burner, liquid fuel is raised to the level of the evaporator.

3. A burner according to claim 1, which also comprises a fuel bath and in which said evaporator comprises, at least one vertically downwardly depending feeder adapted to dip in said fuel bath whereby, during use in said burner, liquid fuel is raised to the level of the evaporator.

4. A burner according to claim 1, in which the evaporator comprises a portion downwardly sloped in the direction of fuel flow and at an angle of 20°–70° to the horizontal.

5. A burner according to claim 4, in which the evaporator comprises two portions, each downwardly sloped in the direction of fuel flow, each at an angle of 20°–70° to the vertical and joined together at their lowest regions.

6. A burner according to claim 5, in which each sloping portion is rectangular.

7. A burner according to claim 5, in which each downwardly sloped portion is at an angle of 40°–50° to the horizontal.

8. A burner according to claim 7, in which each sloping portion is rectangular.

9. A burner according to claim 8, in which the evaporator is less than 5 mm. thick.

10. A burner according to claim 9, in which the evaporator is less than 3 mm. thick.

11. A burner according to claim 1, in which the evaporator is rigid.

12. A burner according to claim 11 in which the evaporator is made of porous metal.

13. A burner according to claim 12 in which the evaporator is made of metal foam.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,635,651 Dated January 18, 1972

Inventor(s) Denis Henry Desty

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 5, Line 15,
for "comprises, at least one" read -- comprises at least one --

Col. 5, Line 20,
for "comprises, at least one" read -- comprises at least one --

Signed and sealed this 18th day of July 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents