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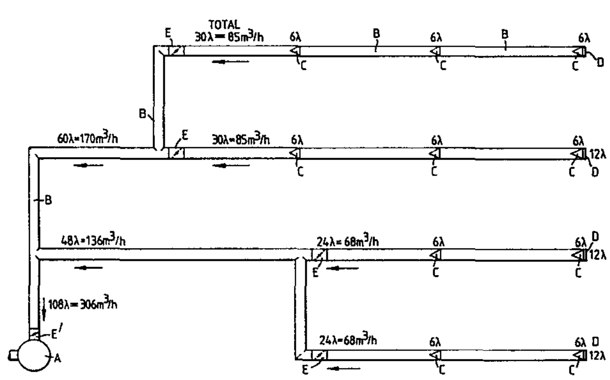
(71) Applicant: **PHOENIX BURNERS LIMITED, 8 Prince George Road, London SW 19 2PX (GB)**

(72) Inventor: **Taylor, Frank Martin Hussey, Dr., 16 Phillimore Place, Kensington London W8 7BU (GB)**

(74) Representative: **Meddle, Alan Leonard et al, FORRESTER & BOEHMERT Widenmayerstrasse 4/I, D-8000 München 22 (DE)**

## (54) A heating system.

(57) An infra-red gas heating system is described. The system comprises a heating pipe (18) and a plurality of combustion devices distributed along the length of the heating pipe for supplying hot gases to the interior of the pipe to cause the pipe to emit infra-red radiation from its surface. Each combustion device comprises a burner unit (G) disposed in the heating pipe (18) and control means (F) having an air orifice (11) for supplying the correct amount of air for complete combustion of fuel to the burner unit, means being provided to cause a predetermined excess of air to flow through the pipe in use of air to flow through the pipe in use of the system so that each of the serially arranged burner units can operate within the pipe with complete combustion of fuel in an atmosphere which contains the combustion gases of any upstream burner units. Radiant heat from the pipe may be deflected by means of a reflector means and the temperature of the pipe may be controlled locally by insulating means provided inside the pipe.




EP 0 070 360 A2

"A Heating System"

THIS INVENTION relates to a heating system wherein heat is provided by the emission of infra-red radiation.

Infra-red radiation heats objects directly with a minimal loss of heat energy to the air between the heating apparatus and an object. The object, having absorbed the infra-red radiation, may conduct some of the heat from the surface into the interior of the body of the object and re-radiate the remainder, becoming a secondary source of infra-red radiation. The re-radiated heat energy will then be absorbed by other cooler surfaces or by the surrounding air.

The amount of heat lost to the surrounding air, roof space and in the creation of draughts is therefore negligible for infra-red heating systems.

It is known to use infra-red radiation generated by the passage of hot gases through a heating pipe, for example by burning an air/gas mixture in the pipe, to heat living quarters and places of work, for example, shops, offices and factories.

However, until a decade ago infra-red radiation could only be used efficiently to provide high temperature, for example as required in bake ovens. Such systems used as a source of heat only the upper range of the infra-red spectrum. Direct heating systems for living and working areas were, at that time, very inefficient, utilizing little, if any, of the infra-red radiation produced to heat objects directly.

More recently, by providing control means for supplying the correct proportions of air and gas to produce an efficiently combustible mixture, connecting the control means to a plurality of combustion devices contained in connecting pipes situated in the space to be heated, and by operating the heating system at a pressure slightly less than one atmosphere, it has been possible to use more of the infra-red radiation emitted from the walls of the connecting pipes to heat objects directly. However, due to the presence in the connecting pipes of the combustion products produced by preceding combustion devices, insufficient oxygen may be present to effect complete combustion, thus preventing efficient operation of the combustion devices.

According to the present invention there is provided an infra-red heating system, comprising a heating pipe and a plurality of combustion devices distributed along the length of the heating pipe for supplying hot gases to the interior of the pipe to cause the pipe to emit infra-red radiation from its surface, in which system each combustion device comprises a burner unit disposed in the heating pipe and control means having an air orifice for supplying to the burner unit the correct amount of air for complete combustion of fuel fed to the burner unit, means being provided to cause a predetermined excess of air to flow through the pipe in use of the system so that each of the serially arranged burner units can operate within the pipe with complete combustion of fuel in an atmosphere which contains the combustion gases of any upstream burner units.

Thus, an infra red heating system embodying the invention provides the advantage that a combustion device operating in a series of combustion devices in an atmosphere containing combustion products from the other burners may still release the total heat of combustion without flame vitiation.

Preferably each combustion device in the series provides the same heat output and may be pre-adjusted at a factory to give that output.

The gas/air ratio may be preset and maintained during variations in the overall draught and temperature conditions.

Preferably, a control means associated with each combustion device regulates the amount of gas supplied thereto.

Conveniently, a single adjusting means is provided to allow the heat capacity of the system to be adjusted or to compensate for changes in the characteristics of the fuel.

Thus, when using a gaseous fuel, a change in, for example, the wobbe number can be compensated for by a simple adjustment allowing the required total heat output and the preset gas/air ratio to be maintained. Preferably, the adjusting means comprises a damper.

Conveniently, reflecting means are associated with one or more parts of a heating pipe to direct the radiant heat energy produced thereby to the space required to be heated. Usually, the reflecting means comprise an elongate reflector arranged axially above a part of the heating pipe to direct radiant heat energy downwardly from the pipe part to the space to be heated and an elongate reflecting shield supported axially beneath the pipe part to deflect a portion of the radiant heat energy radiated from the pipe part upwardly into the reflector. Such reflecting means provide the advantage that the heat energy may be directed only to the space required to be heated thus preventing or reducing wastage.

Also, one or more parts of a heating pipe may be provided with insulating means to regulate the emission of radiant heat energy therefrom which insulating means usually comprise an insulating tube inserted into a part of a heating pipe so as to contact the inner surface thereof. The provision of such insulating means allows the conversion of radiant heat energy to be regulated as required and thus reduces the possibility of overheating of a particular space to be heated.

According to another aspect, the invention provides an infra-red heating system, wherein a heating pipe is heated by the passage of hot gases therethrough so that infra-red radiation is emitted from the pipe, and wherein reflecting means are associated with at least part of the pipe to direct the radiant heat energy therefrom to the space to be heated, the reflecting means comprising an elongate reflector arranged above the pipe to direct radiant heat energy from the pipe downwardly to the space to be heated and an elongate reflecting shield supported beneath the pipe to deflect a portion of the radiant heat energy from the pipe upwardly to the reflector.

In a further aspect, the invention provides an infra-red heating system, wherein a heating pipe is heated by the passage of hot gases therethrough so that infra-red radiation is emitted from the pipe, and wherein one or more parts of the pipe are provided with insulating means to regulate the emission of radiant heat energy therefrom, the insulating means comprising an insulating tube inserted into the pipe so as to contact the inner surface thereof.

In order that the invention may be readily understood, a preferred embodiment thereof will now be described, by way of example, with reference to the accompanying drawings, in which:

FIGURE 1 is a schematic representation of an infra-red heating system showing a particular arrangement of pipe legs containing varying numbers of burners;

FIGURE 2 is a vertical cross-section through part of an inter-connecting pipe containing a combustion device;

FIGURE 3 is a perspective view of part of a pipe leg of the system of Figure 1 having reflection means associated therewith to reflect the radiant heat energy produced by the pipe leg part;

FIGURE 4 is a view from one end of the pipe leg of Figure 3 showing the reflection means associated therewith; and

FIGURE 5 is a diagrammatic longitudinal cross-section through part of a pipe leg of the system of Figure 1 provided with insulating means to regulate radiation of heat energy from that part of the pipe leg.

Figure 1 illustrates schematically one arrangement for a heating system comprising several pipe legs, consisting of connecting pipes B and combustion devices C, and connected via manifold pipes B to a vacuum pump A. Non-adjustable end vents D are provided at the free ends of the pipe legs to allow a controlled amount of excess air to enter the pipe system.

The vacuum pump A draws the air/gas mixture through the pipes and allows a controlled reduction of pressure to just less than atmosphere.

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A damper E is provided in each pipe leg upstream of its interconnection F with another leg to regulate the suction effect of the vacuum pump A and make each leg independent of the suction effect in the remainder of the system.

Another damper E', situated upstream of the vacuum pump A, allows the suction effect of the vacuum pump to be regulated simultaneously in the whole system.

To accommodate variations in and combinations of combustion device firing rates the "equivalent burner" concept for calculating the correct gas/air ratio has been replaced by a flow unit method, where one flow unit $\lambda$ is the quantity of air required to support the combustion of 235 $cm^3$/s (10 cu.ft./h) of natural gas which is equivalent to 10550.65 kJ/h = 2.93 KW.

To provide for complete combustion of natural gas (which mainly is comprised of methane) a gas/air ratio of 1:2 is required giving : $\lambda$ = 787 $cm^3$/s (100 cu.ft./h).

As shown in Figure 1 each combustion device C requires 6$\lambda$ or 1.7 $m^3$/h of air, whilst each end vent D is constructed to allow 12$\lambda$or 3.4 $m^3$/h to enter the apparatus.

Figure 2 shows a vertical cross-section through an individual combustion device C.

The combustion device C comprises a control box F and burner unit G.

The burner unit G includes a pipe having internally screwthreaded ends 17 which engage externally screwthreaded ends 21, 21' of connecting pipes 18, 18' to mount the burner in a pipe leg. However, other methods of connecting the burner unit pipe in a pipe leg may of course be employed.

Gas enters the control box F by means of a gas pipe 1 and a regulator 3 ensures that the correct amount of gas is supplied to the system. The regulator 3 is connected to a chamber 22 containing; a zero governor 4 which maintains the gas at atmospheric pressure; a pilot valve 5 to control the amount of gas supplied to a spark chamber 23, by means of a pilot gas tube 12 connected to the pilot valve 5; and a main valve 6 to control the amount of gas entering the burner unit via a channel 11 connected to the output 10A of chamber 22.

An air filter 2 removes dust particles etc, from the air to avoid choking the apparatus with extraneous matter. Air passing through the filter 2 either enters the pilot gas tube 12 by means of an air orifice 8 in the gas tube 12, or passes through an orifice 10 designed to let the correct amount of air through a channel 11 to a burner grid 16. A wall 14 of the channel 11 protects a pilot light in the spark chamber 23 from draughts caused by air passing through the channel 11.

Similarly, a curved back wall 15 of the channel 11 shields the burner grid 16 from the flow of combustion gases passing through the connecting pipe 18.

A pre-ignition purge timer, (not shown) is started when the temperature of the space to be heated drops below a predetermined desired temperature and the timer actuates the vacuum pump to clear the system of any remaining combustion gases or other unwanted matter.

The vacuum pump A is designated to reduce the pressure inside the heating system to a pressure of 3 inches of water (5.6 mmHg) below atmospheric pressure. The suction effect produced by the pump A is regulated by the dampers E provided in each pipe leg and by the damper E' provided upstream of pump A.

The end vents D allows 12 $\lambda$ or 3.4 $m^3/h$ of air to be drawn into the system under the action of the pump A.

The operation of a combustion device C will now be described.

Gas is drawn into the system through a gas pipe 1 and air is sucked through an air filter 2 into the control box F by the pump A. The regulator 3 ensures that the correct amount of gas passes into the chamber 22 and the pressure of the gas is maintained at one atmosphere by means of the zero governor 4.

Initially gas is drawn through the pilot valve 5 into the pilot gas tube 12 and mixed with air entering the tube 12 by means of the air orifice 8.

The air/gas mixture passes by means of an opening 20 into the spark chamber 23. A heat control means (not shown) actuates electrical means (not shown) to induce the contacts 13 of a spark-plug 9 to spark. The air/gas mixture in chamber 23 then ignites.

A sensor (not shown) detects the pilot flame and allows the main valve 6 to open. Gas is then passed through an opening 10A in the chamber 22 into the channel 11 and air is drawn into the channel 11 (by the suction effect produced by the gas flow) through the orifice 10 which is of the correct dimensions to produce the optimum air/gas mixture.

The air/gas mixture passes through channel 11, being prevented from extinguishing the pilot flame by means of the wall 14 of channel 11, to the burner grid 16, where combustion occurs upon contact with the pilot flame.

The combustion gases are drawn through the pipe 18', by the action of the vacuum pump A, the pipe being thereby heated and radiating energy in the form of infra-red radiation.

Combustion gases from any preceding burner units passing the burner grid 16 are deflected by a curved back wall 15 of the channel 11. The wall 15 thus shields the burner flames from the combustion gases preventing contamination of the air/gas mixture which could decrease the combustion efficiency and also preventing the flames being extinguished by the draught caused or by lack of oxygen.

The vacuum pump A removes the combustion gases from the system and these waste gases then pass out of the dwelling or work place and are discharged into the atmosphere.

Figures 3 and 4 illustrate means associated with a part B' of a pipe B for reflecting the radiant heat energy emitted by that pipe part to the area of the dwelling or work place required to be heated.

As shown, the reflecting means comprises an elongate reflector 24 of substantially inverted W-shape in cross-section disposed above the pipe part B' such that the longitudinal axis of the reflector is parallel to the axis of the pipe B. The reflector 24 is designed to reflect radiant heat energy radiated upwardly from the pipe part B' down to the area being heated.

The reflecting means also comprises an elongate radiant heat shield 25 of inverted V-shape in cross-section suspended by support brackets 26 beneath the pipe part B' such that the longitudinal axis thereof is parallel to the pipe axis. The radiant heat shield 25 serves to reflect a portion of the radiant heat energy reflected downwardly from the pipe part B' onto the reflector 24 to ensure that the radiant heat energy is distributed more evenly over the area being heated.

The radiant shield 25 can be used locally to reduce the radiant intensity immediately below the radiant pipe. In the absence of the reflecting means the radiant heat intensity is highest at a point immediately below the radiant pipe B' as a result of the Inverse Square Law. By virtue of its shape and position the radiant shield 25 interrupts the direct radiant heat path and reflects heat back to the top reflector 24 which redistributes the radiant heat away from the centre line of the radiant pipe

Both the reflector 24 and the radiant heat shield may be made, for example, of 22 or 24 SWG NATL (TYP) aluminium and are approximately from 4 to 8 feet (1.2 to 2.4 metres) in length depending upon requirements. One or more reflecting means may be provided within the system of Figure 1 depending upon the particular heating requirements for the areas to be heated.

Figure 5 illustrates diagrammatically a part B'' of a pipe B provided with insulating means to regulate the amount of radiant heat energy emitted from that part of the pipe B.

As shown in Figure 5, the insulating means comprises an insulating tube 27 of, for example, 0.5 metres in length and made for example of ceramic fibre or a similar material having high heat insulation properties. In the arrangement shown, the insulating tube 27 is made of alumina having a wall thickness of 5 to 10 mm.

The insulating tube 27 is inserted into the pipe part B'' so as to contact the inner surface thereof. The insulating tube 27 allows the amount of radiant heat energy emitted from the portion of the pipe containing the tube to be reduced by reducing the temperature of the pipe B at that point.

Insulating tubes may be provided at various points within the system of Figure 1 to reduce radiant pipe temperatures in localized positions thus controlling radiant heat emission along pipes B of the system and preventing overheating of areas where little heating is required.

As can be seen from Figure 5, apertures 28 may be provided in the insulating tube or tubes 27 provided in the system to provide extremely localized areas of higher radiant heat energy where required.

CLAIMS

1. An infra-red heating system, comprising a heating pipe and a plurality of combustion devices distributed along the length of the heating pipe for supplying hot gases to the interior of the pipe to cause the pipe to emit infra-red radiation from its surface, in which system each combustion device comprises a burner unit disposed in the heating pipe and control means having an air orifice for supplying to the burner unit the correct amount of air for complete combustion of fuel fed to the burner unit, means being provided to cause a predetermined excess of air to flow through the pipe in use of the system so that each of the serially arranged burner units can operate within the pipe with complete combustion of fuel in an atmosphere which contains the combustion gases of any upstream burner units.

2. A system according to claim 1, wherein each combustion device is preadjusted to provide the same heat output.

3. A system according to claim 1 or 2, wherein a single adjusting means is provided to allow the heat capacity of the system to be adjusted or to compensate for changes in the characteristics of the fuel.

4. A system according to any preceding claim, wherein the fuel comprises a combustible gas and the gas/air ratio supplied to each combustion device is preset and maintained during operation of the combustion device.

5. A system according to claim 4, wherein a control means associated with each combustion device regulates the amount of gas supplied thereto.

6. A system according to any preceding claim, wherein pumping means are provided to maintain the pressure within the system just below atmospheric pressure during operation thereof.

7. A system according to claim 6, wherein timing means are provided to actuate the pump means to purge the system of any remaining combustion gases or other unwanted matter prior to operation thereof a predetermined

time after the temperature of the space to be heated drops below the desired temperature.

8. A system according to claim 6 or 7, wherein the system comprises a plurality of heating pipes connected in parallel to the pumping means, each heating pipe having a plurality of combustion devices distributed therealong..

9. A system according to claim 10, wherein each heating pipe is provided with damping means upstream of the combustion devices to regulate the suction effect produced therein by the pumping means.

10. An infra-red heating system according to any preceding claim, wherein reflecting means are associated with one or more parts of the or a heating pipe to direct the radiant heat energy produced thereby to the space required to be heated.

11. A system according to any preceding claim, wherein one or more parts of the or a heating pipe are provided with insulating means to regulate the emission of radiant heat energy therefrom.

12. An infra-red heating system, wherein a heating pipe is heated by the passage of hot gases therethrough so that infra-red radiation is emitted from the pipe, and wherein reflecting means are associated with at least part of the pipe to direct the radiant heat energy therefrom to the space to be heated, the reflecting means comprising an elongate reflector arranged above the pipe to direct radiant heat energy from the pipe downwardly to the space to be heated and an elongate reflecting shield supported beneath the pipe to deflect a portion of the radiant heat energy from the pipe upwardly to the reflector.

13. An infra-red heating system, wherein a heating pipe is heated by the passage of hot gases therethrough so that infra-red radiation is emitted from the pipe, and wherein one or more parts of the pipe are provided with insulating means to regulate the emission of radiant heat energy therefrom, the insulating means comprising an insulating tube inserted into the pipe so as to contact the inner surface thereof.

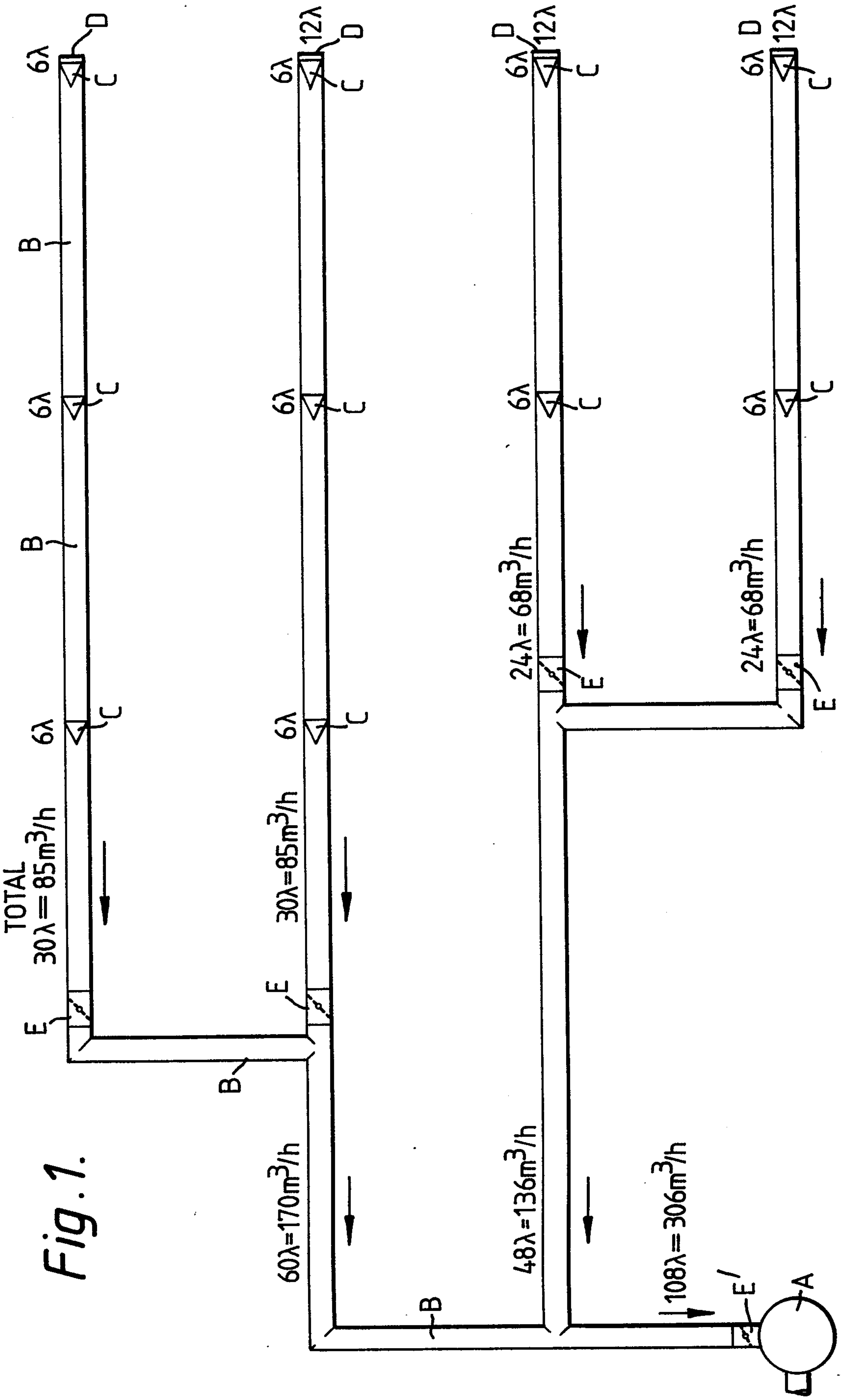
D
12λ
6λ
C
B
E
TOTAL
30λ = 85m³/h
30λ=85m³/h
24λ=68m³/h
24λ=68m³/h
60λ=170m³/h
48λ=136m³/h
108λ=306m³/h
E'
A

Fig.1.

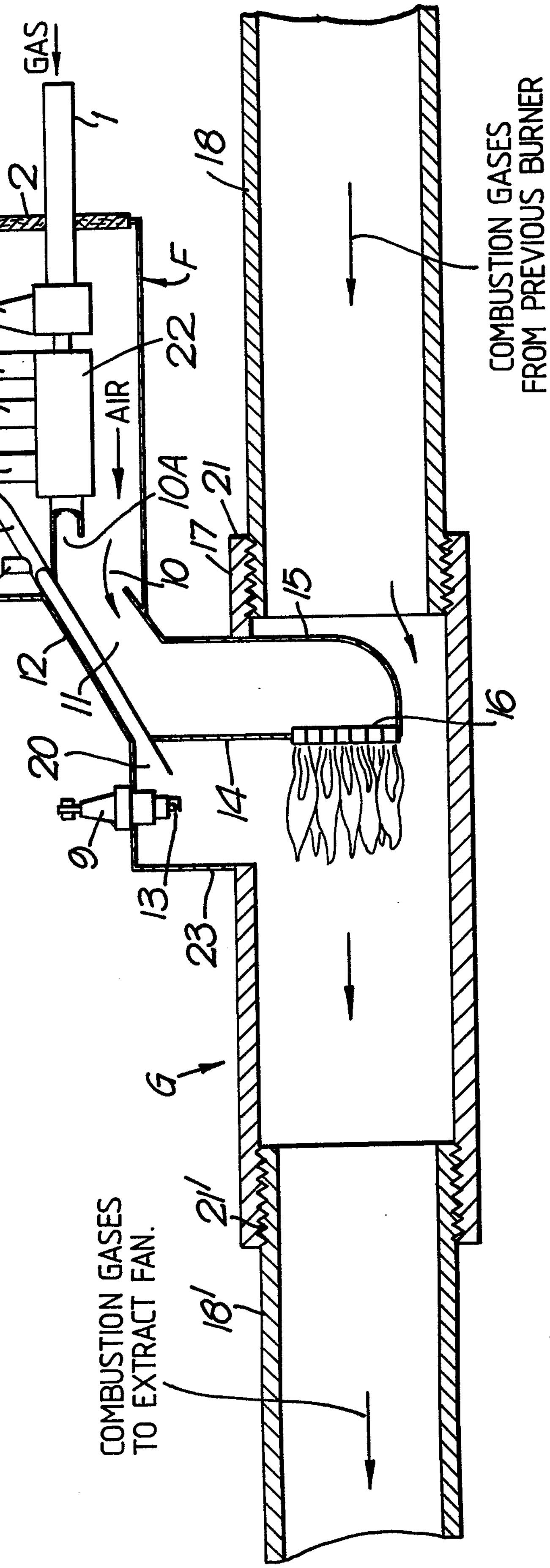
GAS
AIR
COMBUSTION GASES FROM PREVIOUS BURNER
COMBUSTION GASES TO EXTRACT FAN.
1
2
3
4
5
6
7
8
9
10
10A
11
12
13
14
15
16
17
18
18'
20
21
21'
22
23
F
G

Fig. 2.

Fig. 3.

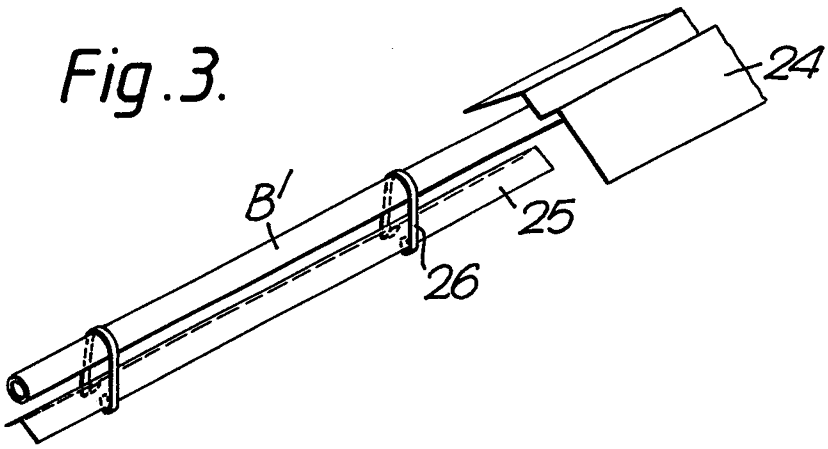


Fig. 4.

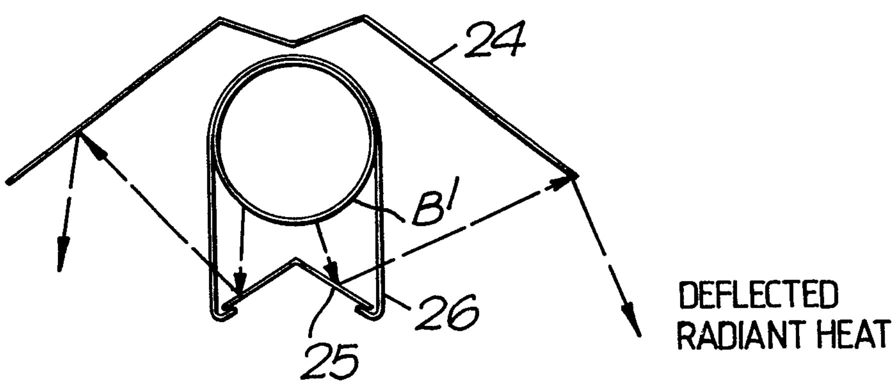


Fig. 5.