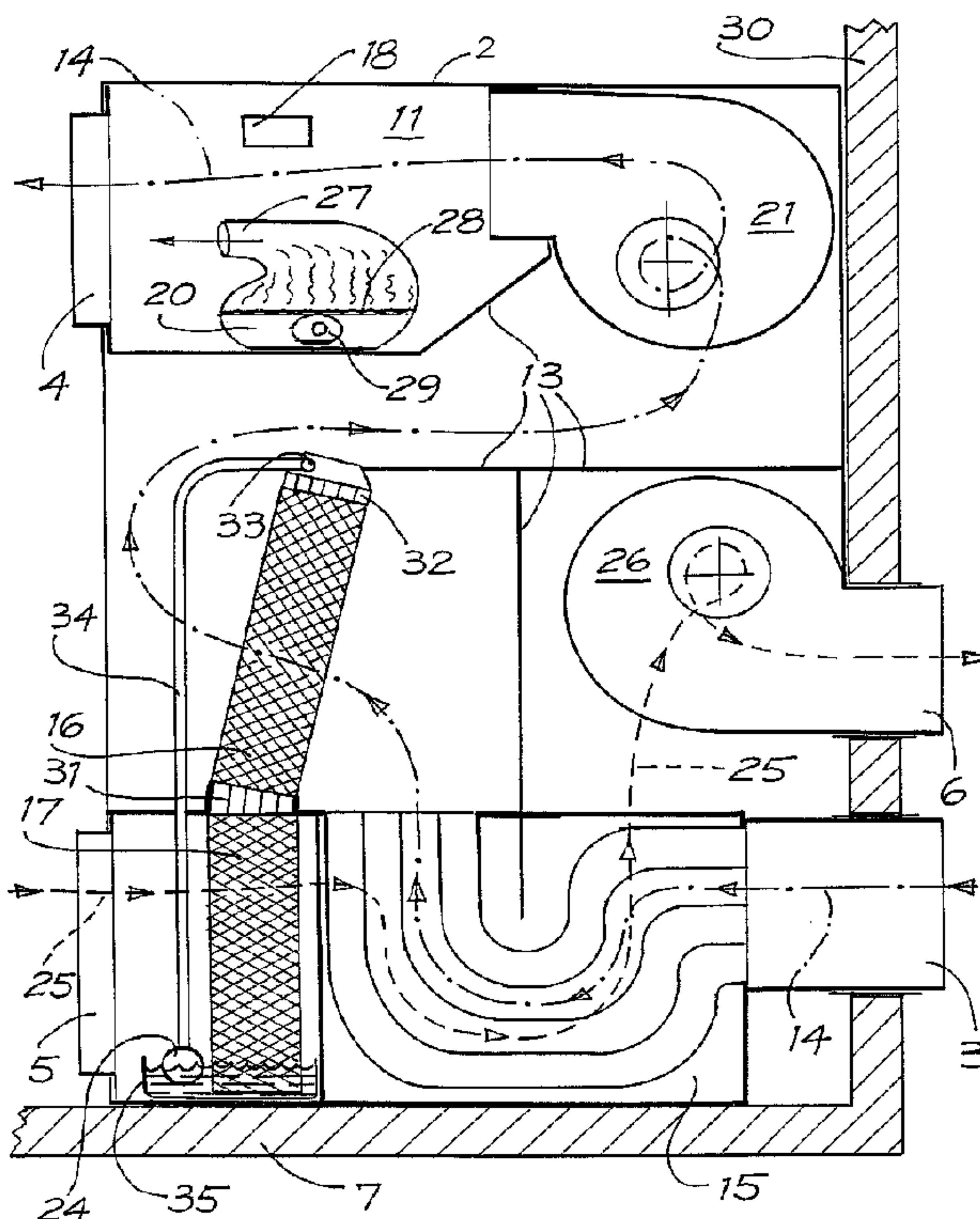




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(57) **Abrégé/Abstract:**

A fresh air heating unit has a casing (2) containing a stale air flow path (25) and a fresh air flow path (14). Combusted gas products from a gas burner (29) are mixed with the fresh air to heat it to a desired temperature before it is discharged into an enclosure. The two paths extend through a heat exchanger (15) and the rate of flow of stale air driven by a fan (26) through the casing is substantially equal to the rate of flow of fresh air driven through the casing by a second fan (21). As the rate of flow of fresh air from the casing into an enclosure is substantially matched by the rate of flow of stale air from the enclosure, and heat is transferred between the two air flows by the heat exchanger (15), a total replacement of air in the enclosure at a relatively high rate can be sustained in an economically viable manner. The level of noxious combustion products in the enclosure and produced by the gas burner (29) can thus be kept beneath that regarded as harmful by health authorities.

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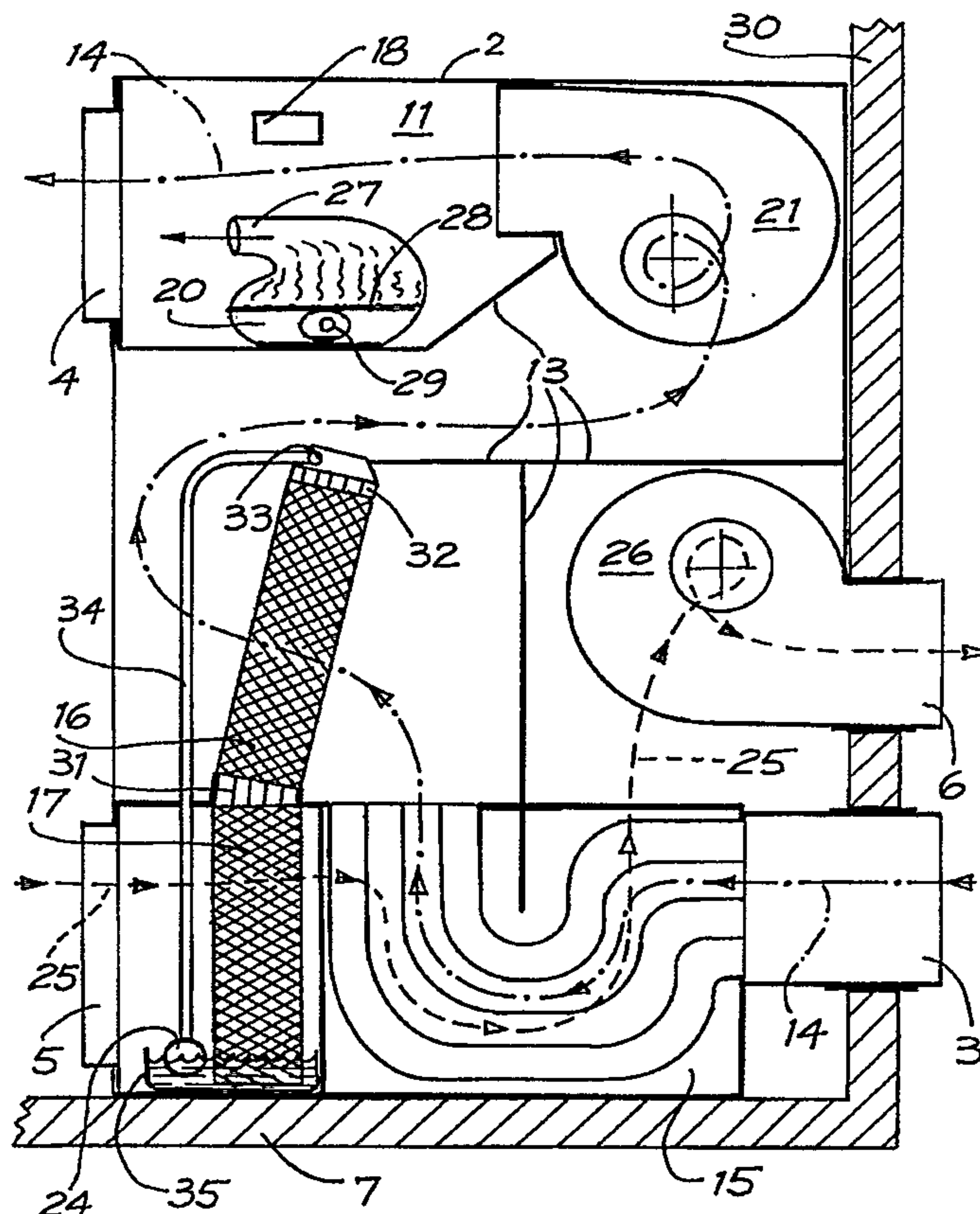
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HEATING UNIT

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FIELD OF INVENTION

THIS INVENTION relates to an air heating unit used to provide warm air at a relatively high rate of flow to an enclosure such as a home, workshop, restaurant, club or factory. More specifically the invention is concerned with such a unit having a casing containing a burner to heat the air, a fan to drive the air through the casing, isolating gas heat exchange means; a fresh air inlet opening in the casing, and a supply outlet through which fresh warm air leaves the casing and is passed into the enclosure. Such an air heating unit is referred to hereafter as being "of the type hereinbefore described".

10 STATE OF THE ART

One construction of currently available air heating unit of the type described, has two isolating gas heat exchangers in its casing, each heat exchanger having a primary and a secondary circuit. The first heat exchanger has its primary circuit supplied with hot combusted gases from a gas burner, and its secondary circuit supplied with fresh air which, after passage through the heat exchanger, is fed to the enclosure. The combusted gases leaving the primary circuit still have substantial heat content and they are passed through the primary circuit of the second isolating gas heat exchanger before being discharged to atmosphere through a flue outlet by a fan.

Fresh air is drawn through the inlet opening of the casing by a second fan and is passed, in turn, through the serially-connected secondary circuits of the second and the first heat exchangers, respectively, before being supplied to the enclosure by way of the supply outlet.

The two heat exchangers are made of metal as the first heat exchanger has to cope with the high temperature of the combustion products produced by the burner, and the second heat exchanger has to withstand the risk of the formation of corrosive acids in it as a result of the combusted products flowing through its primary circuit being cooled beneath dew-point by the relatively cold fresh air passing through its secondary circuit. Such cooling can cause moisture to condense on the wall of the primary circuit which then dissolves acid-forming gases from the combustion products. For this reason the primary circuit of the second heat exchanger is formed as a vertical, externally-finned tube enclosed within a box providing the secondary circuit. Liquid condensing in the primary circuit can then be immediately drained out and discharged

to a suitable sump. Such a heat exchanger has cross-flow characteristics and therefore has a thermal efficiency in the region of 50% or less.

A heating unit constructed as outlined immediately above, requires the heat output of the burner to be sufficient to raise the temperature of the incoming air to the temperature at which it is to be supplied to the enclosure. As this temperature difference through which the temperature is raised may exceed twenty degrees Centigrade and the rate of flow of air through the casing is relatively high - a domestic dwelling of about 200 square metres of area requiring air to be delivered to it at a rate of between 550 and 600 litres per second - a burner of substantial size is required. Flue gases naturally contain noxious combustion products which are produced at such a high rate that the health regulations require the flue gases to be discharged outside the buildings. This prevents risk of dangerous pollution of the fresh air being supplied to the enclosure by the noxious combustion products. The running costs of such a unit are high as a large part of the heat energy supplied to the enclosure is lost with the warm stale air leaving the enclosure.

THE INVENTION

In accordance with the present invention a heating unit of the type hereinbefore described, has a casing provided with an extraction inlet through which fan-driven, warm stale air is recovered from said enclosure and returned to atmosphere by way of a primary circuit of said isolating gas heat exchange means; an air flow path extending between said fresh air inlet and said supply outlet of the casing and formed in part by a secondary circuit of said isolating gas heat exchange means; and a gas burner which is arranged to discharge its combustion products directly into said air flow path; in which unit the heat transfer characteristics of said heat exchange means the rate of flow of air through the secondary circuit, and the control of the burner's operation are so matched with one another that the unit is able to provide the enclosure with a stream of fresh air over a range of desired temperatures without the proportion of combustion products in the air stream exceeding the requirements regarded as being deleterious to human health. The preferred form of gas burner is one specifically designed to produce relatively small amounts of noxious gases and carbon dioxide. Such burners are commonly referred to in the trade in Australia as "infrared ceramic surface combustion burners".

PREFERRED FEATURES OF THE INVENTION

The heat exchange means may be of any suitable design such as cross-flow or counterflow. It may comprise more than one heat exchanger connected in series or parallel. The unit of the invention can be designed to be small and simple, and may be made more cheaply than currently available conventional units of the same air-heating capacity. It is also cheaper to operate as a burner of small size can be used because of the improved heat recovery from the stale air leaving the enclosure.

A particular design of counterflow heat exchanger usable with the invention forms the subject of my Australian Patent Nos. 637,090 and 660,781.

Preferably the second circuit of the heat exchange means is so arranged that ambient fresh air passes through it before it encounters the burner. The heat transfer to the fresh air is then optimised. The burner is preferably, although not necessarily, arranged in the fresh air path between the fan which drives the fresh air through it, and a fresh air supply outlet. The invention is usable in an air heater and in a unit having an air-cooling facility so that it can be fitted into a house requiring warm air in winter and cool air in summer.

Thus, in accordance with a second aspect of the invention a heating unit of the type described has the casing provided with an extraction inlet through which fan-driven, warm, stale air is recovered from said enclosure and returned to atmosphere by way of a primary circuit of a counterflow isolating gas heat exchanger; an air flow path extending between said fresh inlet and said supply outlet of the casing and containing the secondary circuit of the heat exchanger; a gas burner which discharges its combustion products directly into the air flow path; a first evaporative air-cooling pad spanning the fresh air flow path; a second evaporative air-cooling pad arranged in the path of stale air flowing from the extraction inlet to the primary circuit of the heat exchanger; and, water circulating means for transferring water cooled by passage through the second pad, to the upper end of the first pad from the lower end of which the water is transferred back to the upper end of the second pad. The use of water cooled in one pad, to cool the other pad coupled with the use of water circulating means to provide the water circulation between the pads, forms the subject of my published

PCT International Patent Application No. WO95/33960.

The evaporative air-cooling pads are designed to offer a low resistance to air flow between their opposite sides while providing a large area which is exposed to the air flow and which is maintained wet by the water trickling down through the pad.

5 Examples of such pads are commercially available in Australia under the trade marks EDLdek and GLASdek and are marketed by the Swedish company "AB Carl Munters".

10 Preferably the first pad is located in the fresh air flow path upstream of the burner, and a supply fan is suitably located in the air flow path between the first pad and the burner. Conveniently an over-temperature cut-out safety device is provided to reduce any risk of damage to the unit by overheating of the first pad should the burner malfunction. It may conveniently be located above the burner.

15 When the unit of the second aspect of the invention is required to provide cool air, the burner is shut down and the water circulating means is operated. The stale air extracted from the enclosure passes through the second pad and evaporates some of the water from it. The latent heat of evaporation is extracted from the water trickling down through the pad so that this water is cooled significantly by the time it reaches the pad's lower end and is then pumped up to the upper end of the first pad.

20 The cool stale air from the second pad passes through the primary circuit of the isolating heat exchanger to cool the warmer and fresh ambient air entering the fresh air inlet. The cooled, fresh air is then passed through the first pad where it is further cooled by the cold water trickling down through the pad and supplied by the second pad.

25 In the preferred form of the invention the flow of stale air entering the casing from the enclosure is substantially equal to or slightly less than the flow of fresh air supplied to the enclosure by the unit. This minimises heat losses from the enclosure by way of stale air exhausting from it through openings such as doors and windows. The advantage of such a unit is that, when operating, it provides total air replacement in the enclosure without excessive and uneconomic heat losses. High rates of air flow to and from the enclosure can be economically maintained so that undesirable pollution

of the air in the enclosure from, for example, cigarette smoke or other harmful substances, can be kept beneath a level at which health risks start to arise.

INTRODUCTION TO THE DRAWING

5 The invention will now be described in more detail, by way of example, with reference to the accompanying diagrammatic single drawing which shows an air heating and cooling unit in vertical section and viewed from one side.

DESCRIPTION OF PREFERRED EMBODIMENT

10 The drawing shows a unit enclosed within a casing 2 having a fresh air inlet 3, an air supply outlet 4, an extraction inlet 5 for stale air, and a stale air outlet 6. The casing 2 is designed to stand against an outside wall 1 of an enclosure, such as a house, so that it rests on the floor 7 of the house. It may, however, alternatively be accommodated in an attic or cellar space of a house and connected by ducting to supply and remove air from openings in the floor or/and ceiling of the house.

15 The casing is divided internally into a fresh air flow path 14 and a stale air flow path 25, by partitioning 13. The fresh air flow path contains a secondary circuit of a counterflow, isolating, gas heat exchanger 15 of the design described and claimed in my Australian Patent Nos. 637,090 or 660,781. Such a heat exchanger has a theoretical thermal efficiency in the region of 80% and can handle large air flows of the order of 500-1000 litres per second upwards.

20 The secondary circuit of the heat exchanger 15 is connected at one end to the fresh air inlet 3 and supplies the fresh air to an upper first pad 16 of two evaporative cooling pads 16 and 17 respectively. After flowing through the cooling pad 16 and a fan 21, the air travels past a temperature sensitive cut-out switch 18 located in a fresh chamber 11 above the position of a gas burner in the form of a flask 20 containing a
25 steel-mesh or a ceramic perforated plate 28 located above a gas-air inlet 29. The combustion products produced by combustion of the gas on the upper surface of the mesh or plates 28, are discharged from the flask 20 through an outlet 27. Such a burner may have a capacity of between ten and fifty kilowatts. The fresh air from the

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fan 21 mixes with the combustion products of the burner in the chamber 11 and discharges through the air supply outlet 4 to the interior of the house.

Stale air from the interior of the house is withdrawn through the extraction inlet 5 by a second fan 26 which draws the stale air through the lower or second cooling pad 17 which is located at a level beneath the pad 16. The two pads 16, 17 are connected by a distributor 31 so that water trickling down from the lower end of the upper pad 16 is guided into the upper end of the lower pad 17. Water cooled by passage through the two pads 16, 17 collects in a reservoir tray 35 beneath the lower pad 17 and is recirculated by a float-controlled pump 24 through a pipe 34 to a cross-header 33 located above a second distributor 32 which guides the water into the upper end of the upper pad 16. A detailed description of how two such pads can be interconnected to share the same water, forms the subject of my above mentioned PCT International Patent Application WO95/33960.

The stale air leaving the lower pad 17 is sucked through a primary circuit 25 of the heat exchanger 15 as shown by the broken arrowed line, and is discharged through the outlet 6. Much of the heat extracted from the stale air is transferred to the fresh air in the heat exchanger 15.

OPERATION OF PREFERRED EMBODIMENT

When the heating unit is operating as an air heater, the pump 24 is not used. Stale air from the building at a temperature of about 22°C. is drawn through the inlet 5 by the fan 26 and passes through the dry pad 17 and the primary circuit of the heat exchanger 15. As the heat exchanger is of counterflow type, it has a high efficiency and can transfer a large proportion of the useful heat of the stale air to the fresh air flowing through the secondary circuit 14 of the heat exchanger. The stale air which passes through the heat exchanger has a high rate of flow which is normally of the order of 650 litres per second, and leaves the casing 2 by way of the fan 26 and the stale air outlet 6.

Ambient cool fresh air at a temperature around 0°C. enters the inlet 3 and is heated in the secondary circuit of the heat exchanger to a temperature of about 18°C. It then flows along the chain-dotted line to the upper cooling pad 16 through which it is sucked by the fan 21 which supplies the fresh air to the chamber 12. Here it mixes

with the hot products of combustion discharged from the burner outlet 27. This raises the temperature of the fresh air stream to between 40°C. and 50°C. and also increases its water content slightly so that, despite the rise in temperature from 18°C. to 40°C.-50°C. the air humidity actually increases to a level between 20% and 50%. This increase in humidity represents an advantage of existing air heating units of conventional design which invariably decrease the humidity when the air temperature is raised. To counteract this it is customary to provide conventional air heating units with a special air humidifier. This warm air containing the greatly-diluted products of combustion is discharged into the building at a rate of about 500-700 litres per second.

Should the fan 21 fail, the rise in temperature at the vicinity of the burner 20 is detected by the cut-out switch 18 which operates to switch off the burner. The heat output of the burner is controlled by circuitry (not shown but well known in the gas burner art) to maintain the temperature of the warm air supplied to the building at the desired value. Shutting down of the burner if fault conditions develop, can also be achieved by arranging for the burner control circuit to respond to the pressure drop in the fresh air path between the inlet and outlet sides of the heat exchanger.

During summer the unit is required to provide cool air to the building at a higher rate of typically between 900-1200 litres per second. The burner is not then operated. Instead the pump 24 is activated to circulate water between the two pads 16 and 17. Obviously some of this water is lost through evaporation and this is compensated for by a supply of make-up water (not shown) controlled by means of a float-controlled pump 24 which responds to the water level in the reservoir tray 35.

Cool stale air from the building is withdrawn through the extraction inlet 5 and supplied to the lower pad 17 so that it evaporates some of the water trickling down through it. This extracts the latent heat of evaporation from the pad 17 so that the water is progressively cooled as it trickles slowly down through it. The moist but still cool air then passes through the primary circuit of the heat exchanger 15 where it cools the incoming warm fresh air drawn into the casing from atmosphere by the fan 21. The stale air is then discharged by the fan 26 through the outlet 6.

The cooled fresh air from the inlet 3 passes through the heat exchanger 15, which cools it. The cooled fresh air then passes through the first pad 16 which is maintained

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cool by the cooled water pumped up from the reservoir tray 35 by way of the pump 24 and the pipe 34. The fresh air is thus cooled further and supplied to the house by the fan 21 at a rate of about 1200 litres per second.

5 The above described heating and cooling unit has few parts, is small in size and cheap to construct. It is also cheap to run.

The two fans 21 and 26 may be ganged to one another so that the rate of flow of fresh air to the enclosure is substantially equal to, or slightly greater than the rate of flow of stale air from the enclosure. It is desirable to maintain a slightly higher pressure of air in the enclosure than in the ambient atmosphere, so that cold air drafts are not
10 drawn into the enclosure from outside.

MODIFICATION OF PREFERRED EMBODIMENT

Although the above-described unit uses a counterflow heat exchanger because of its high thermal efficiency, it is not essential that the heat exchanger should be of this type. One could equally well use two cross-flow heat exchangers connected in series or
15 parallel, or another configuration, to provide an improved heat transfer. The purpose of the heat exchange means in the invention is to enable sufficient heat to be transferred from the stale air to the fresh air, to reduce the heat requirement of the burner to a level where its combustion products are so diluted by the fresh air stream that they no longer represent an unacceptable health risk and comply with the
20 prevailing health regulations. The actual design of the heat-exchange means to achieve this result is immaterial as also is the way it may be connected with other heat exchangers. Naturally, if a cross-flow heat exchanger is used in place of a counterflow heat exchanger, the cross-flow heat exchanger should have a significantly larger capacity so that the 'dwell' time of the air flow in it is much larger, and the rate
25 of flow is greatly reduced. This will greatly enhance the transfer of heat between the primary and secondary circuits of the heat exchanger.

An important advantage of the type of air heating unit described is that it can be operated to provide a continuous total replacement of the air in the enclosure, by having substantially the same rate of flow of stale air through the casing as the rate of
30 flow of fresh air to the enclosure. This total air replacement feature allows cigarette smoke and other impurities to be rapidly removed from the enclosure before they reach harmful levels.

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In many countries the maximum level of noxious combustion products permitted in air in an enclosed space is three parts per million. The unit of the invention is capable of achieving this low level of pollution during continuous operation and, by selecting the correct design of burner, the pollution level of noxious combustion products can be brought down to one-and-one-half parts per million.

CLAIMS

1. An air heating apparatus for providing a space with a stream of heated air, said apparatus including:

a fresh air inlet through which a stream of fan driven fresh air enters the apparatus, a supply outlet through which a stream of heated air leaves the apparatus and is passed into the space, a stale air inlet through which a stream of fan driven stale air is recovered from said space, and a stale air outlet through which said stale air is returned to atmosphere;

a heat exchanger provided with mutually isolated primary and secondary air flow circuits and adapted to provide heat transfer between said primary and secondary circuits;

a first air flow path extending between said fresh air inlet and said supply outlet and formed in part by the primary circuit of said heat exchanger;

a second air flow path extending between said stale air inlet and said stale air outlet and formed in part by the secondary circuit of said heat exchanger; and

a gas burner located in said first air flow path downstream of said primary circuit of said heat exchanger;

wherein said apparatus is adapted such that when heating said fresh air stream, heat is transferred from said stale air stream flowing through said secondary circuit of said heat exchanger to said fresh air stream flowing through said primary circuit of said heat exchanger, and said gas burner discharges its combustion products directly into said first air flow path to thereby further heat said fresh air stream.

2. An air heating apparatus as claimed in claim 1, wherein said gas burner is positioned upstream of the supply outlet and downstream of a fan which drives said stream of fresh air through the first air flow path.

3. An air heating apparatus as claimed in claim 1 or claim 2, wherein the heat exchanger is of a counterflow design having baffles which respectively guide said fresh air stream and said stale air stream respectively through said primary and secondary circuits comprising curved paths which are substantially parallel to one another over a major part of their lengths.

4. An air heating apparatus as claimed in any one of the preceding claims, said apparatus further including a first fan located in said first air flow path and a second fan located in the second air flow path, said first and second fans operating such that the rate of flow of fresh air to the space is substantially equal to, or slightly exceeds, the rate of flow of stale air recovered from said space.

5. An air heating apparatus as claimed in any one of the preceding claims, said apparatus further including a heat sensitive switch for shutting down said gas burner if the temperature sensed exceeds a predetermined value.

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