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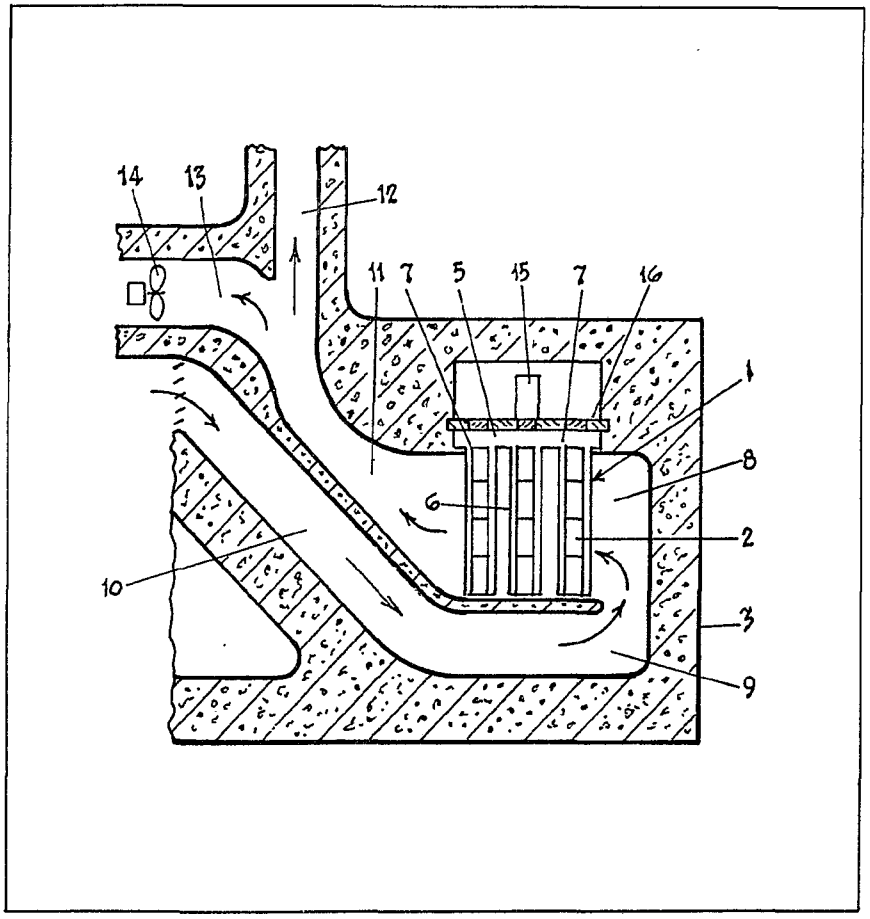
(54) **Utilising heat from nuclear waste for space heating**

(57) A heating unit utilising the decay heat from irradiated material comprises a storage envelope (1) for the material associated with a heat exchange system (6), means (9, 10) for producing a flow of air over the heat exchange system to extract heat from the material, an exhaust duct (12) capable of dischanging the heated air to the atmosphere, and means (14) for selectively diverting at least some of the heated air to effect the required heating. With the flow of air over the heat exchange system taking place by a natural thermosyphon process the arrangement is self regulating and inherently reliable.



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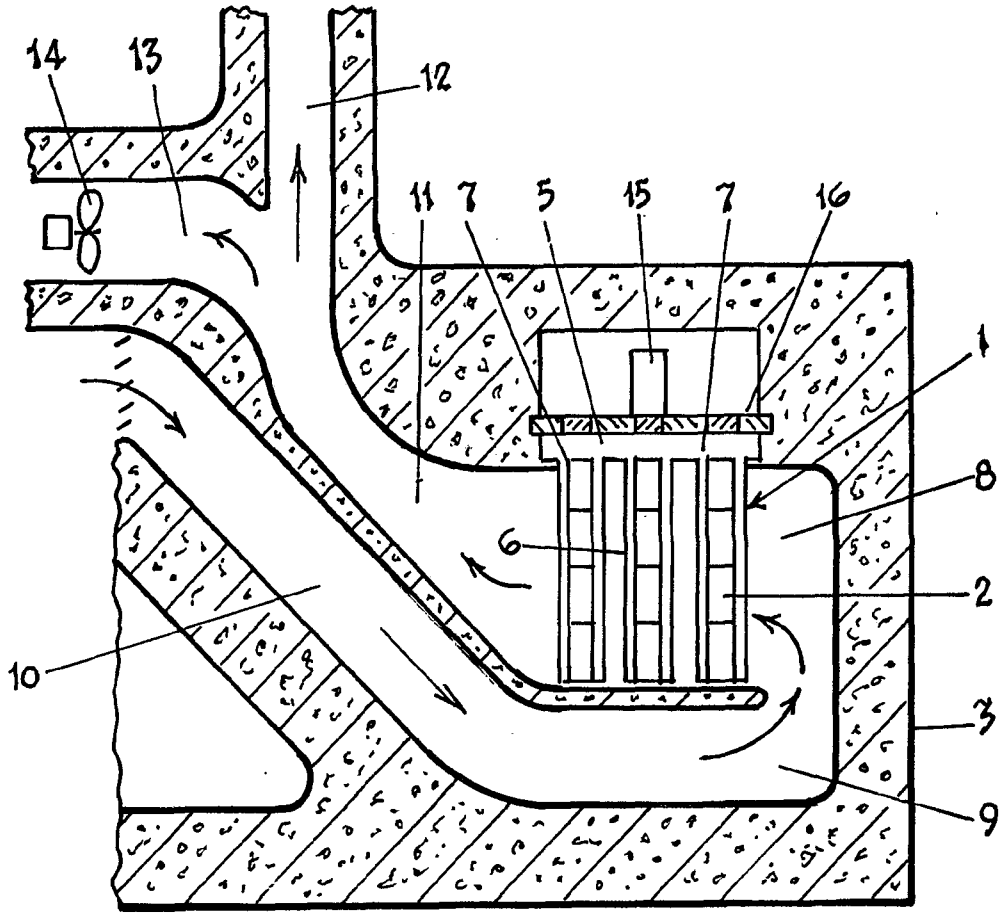
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SPECIFICATION

Heating unit

This invention relates to heating units, and an object of the invention is to provide a form of heating unit which utilises the decay heat from irradiated materials, more especially, though not exclusively, for the space heating of dwelling, industrial premises, offices and other buildings utilising the decay heat from vitrified nuclear waste.

According to the invention a heating unit comprises a storage envelope for irradiated material, associated with a heat exchange system, means for producing a flow of air over the heat exchange system to extract heat from the material, for maintaining its temperature below a predetermined value, an exhaust duct capable of discharging the heated air to the atmosphere, and means for selectively diverting at least some of the heated air to effect the required heating.

Preferably the flow of air over the heat exchange system and its discharge to the atmosphere is arranged to take place by a natural thermosyphon process; such an arrangement is inherently self regulating, as the amount of air flow is governed by the heat generated. One or more fans are conveniently employed to divert some at least of the air from the exhaust duct to one or more other ducts to convey it to a location or locations where heating is required. Alternatively or additionally one or more fans may be located in an intermediate position for diverting the heated air to a location or locations where heating is required directly from the heat exchange system, that is to say without that air entering the exhaust duct.

Such arrangements have the advantage that should the heat requirements be reduced or the fan or fans stop for any reason, the excess heated air is discharged safely to the atmosphere by means of the natural thermosyphon, so that an inherently reliable discharge of decay heat is achieved.

The diverted air may be used directly for heating although, if desired, it can be directed wholly or in part through an air/water heat exchanger system, to provide hot water for any purpose, or to other forms of heat exchangers.

Preferably the environment within the storage envelope is air maintained at sub-atmospheric pressure by means of an exhauster system discharging through suitable filters to the atmosphere. This ensures that any leakage that might occur will be into the enclosure.

The storage enclosure may, for example, comprise a plenum chamber at least one wall of which is pierced by a plurality of spaced apart openings each of which has sealed to its periphery the open end of a tube extending away from the plenum chamber and closed at its opposite end, the tubes being arranged to contain the irradiated material and being accommodated in a further chamber through which the flow of air takes place the tubes themselves then effectively providing a plurality of heat exchangers.

The size of the storage enclosure and amount of irradiated material that can be accommodated can be arranged to suit the heat output requirements of the heating unit for any particular application of the invention.

Conveniently the said openings are formed in the base of the plenum chamber, the tubes extending vertically downwards therefrom into said further chamber. Alternatively the tubes may extend horizontally from a side wall of the plenum chamber, or be disposed in any other convenient manner. The tubes may be provided externally with cooling fans for enhancing the transfer of heat to the air flowing over them.

One heating unit in accordance with the invention, for example for heating a building, will now be described by way of example, with reference to the accompanying schematic drawing, which represents a sectional elevation of the unit.

The heating unit basically comprises a storage envelope 1 for nuclear waste in the form of vitrified blocks 2. The envelope conveniently consists, as shown, of a plenum chamber 5 having a plurality of storage tubes 6 extending downwards from openings 7 in its base, the blocks 2 being arranged to be stacked within the tubes, which are closed at their lower ends.

The number of blocks 2 and the number and height of the tubes is arranged to suit the heat output requirements of the heating unit.

The environment within the storage envelope 1 is air, and an exhauster system (not shown) is provided for maintain the interior of the envelope at a slight depression, so that any leakage that may occur will be inwards, the exhausted air being discharged to the atmosphere through suitable filters (also not shown).

Any convenient means, shown diagrammatically at 15, transferring the blocks of nuclear waste from a suitable transport container into the storage envelope 1, through normally closed openings in the roof 16 of the plenum chamber 5.

Biological shielding, typically shown at 3, is arranged to provide adequate radiation shielding for the nuclear waste. The form of the shielding is arranged such that it provides the additional function of forming the necessary flow path for a natural thermosyphon of atmospheric air to cool the outside of the storage envelope. This flow of air is arranged such that it will discharge to the atmosphere when the heat is not required for heating purposes or for the eventuality when faults may occur in the building heating system. A typical arrangement is illustrated, the shielding 3 effectively providing a chamber 8 into which the storage tubes 6 extend, the chamber having an air inlet opening 9 at the bottom and one side in communication with the atmosphere through an inlet duct 10. At the opposite side of the chamber there is an outlet opening 11 which communicates with an upwardly extending exhaust duct 12 open to the atmosphere at its

upper end.

In use decay heat from the waste fuel 2 within the storage tubes 6 is transferred to the walls of the tubes by conduction, convection and radiation, and the heat is removed from the tubes by a natural thermosyphon process, the heated air from the chamber 8 passing upwards through the exhaust duct 12 and being replaced by cooler air drawn into the chamber through the inlet opening 9 as indicated by the arrows, the inlet and outlet openings 9, 11 being disposed so that air traversing the chamber 8 passes between the tubes.

A side passage 13 extends from the lower end of the exhaust duct, as shown, the passage having, within it, a fan 14 which is operative to draw hot air from the exhaust system and blow it into the building heating system. Should the fan stop for any reason then the hot air is discharged to atmosphere via the exhaust by means of the natural thermosyphon. By this means an inherently reliable discharge of decay heat is achieved.

A modification of this basic unit can be arranged such that the discharge from the fan can be directed wholly or in part through an air/water heat exchanger system to provide hot water for any purpose.

It will be understood that there may be more than one side passage and fan, and the heated air drawn into the passages may serve to heat different parts of the building or provide different heating requirements.

Moreover one or more fans may alternatively or additionally be provided for diverting heated air directly from the chamber 8 into passages taking the air into a heating system or to further heat exchangers, for example for heating water.

It will also be understood that alternative forms of storage envelopes and heat exchange systems could alternatively be employed, the essential feature being that the air flow system is entirely separated from the storage envelope, and incorporates an exhaust duct through which any heated air, not needed to provide the heating requirements, can be safely discharged to the atmosphere.

CLAIMS

1. A heating unit comprising a storage envelope for irradiated material, associated with a heat exchange system, means for producing a flow of air over the heat exchange system to extract heat from the material, for maintaining its temperature below a predetermined value, an exhaust duct capable of discharging the heated air to the atmosphere, and means for selectively diverting at least some of the heated air to effect the required heating.

2. A heating unit according to Claim 1 wherein the flow of air over the heat exchange system and its discharge to the atmosphere is arranged to take place by a natural thermosyphon process.

3. A heating unit according to Claim 1 or 2 including one or more fans arranged to divert some at least of the air from the exhaust duct to one or more other ducts to convey it to a location or locations where the heating is required.

4. A heating unit according to Claim 1, 2 or 3 including one or more fans arranged to divert air directly from the heat exchange system to a location or location where heating is required.

5. A heating unit according to any preceding claim including at least one air/water heat exchanger through which the diverted air is directed for heating water passed through the exchanger.

6. A heating unit according to any preceding claim in which the storage envelope contains air, and which incorporates an exhauster system for maintaining the interior of the envelope at sub-atmospheric pressure, and arranged to discharge the extracted air to the atmosphere through one or more filters.

7. A heating unit according to Claim 6 wherein the storage chamber comprises a plenum chamber at least one wall of which is pierced by a plurality of spaced apart openings each of which has sealed to its periphery the open end of a tube extending away from the plenum chamber and closed at its opposite end, the tubes being arranged to contain the irradiated material and being accommodated in a further chamber through which the flow of air takes place, the tubes themselves then effectively providing a plurality of heat exchangers.

8. A heating unit according to Claim 7 wherein the said openings are formed in the base of the plenum chamber, the tubes extending vertically downwards therefrom into said further chamber.

9. A heating unit according to Claim 7 or 8 wherein the tubes are provided externally with cooling fans for enhancing the transfer of heat to the air flowing over the tubes.

10. A heating unit substantially as shown in and as hereinbefore described with reference to the accompanying drawings.

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