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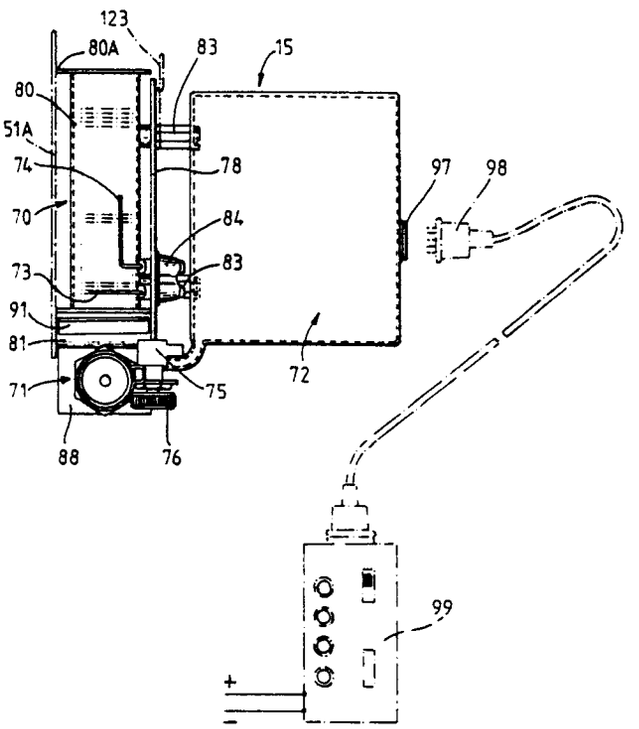
(54) Improvements in or relating to heating apparatus.

(57) Heating apparatus comprising a heater unit (10) close coupled to an air inlet and exhaust outlet device (11) which is detachable to provide access to a removable burner assembly (70) and automatic electronic control means (72) which are assembled as a replaceable unit. In the apparatus an exhaust flow space (18), an air entrance chamber (33), an air chamber (66) and a combustion chamber (41) are close together and substantially parallel so that the apparatus is compact and can be mounted in an opening in a wall (1) with minimal external projection.

FIG.2.



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IMPROVEMENTS IN OR RELATING TO HEATING APPARATUS

This invention concerns improvements in or relating to heating apparatus such as gas fuelled heaters for habitable static or mobile structures, and especially for touring caravans.

Many different types of heating apparatus and many forms of such types are known, but all appear to have disadvantages characteristic of their types.

For example, in a first type of heating apparatus, for example, our Carver Caravelle warm air heating apparatus, a heater unit is mounted on a floor of the caravan or other habitable structure so as to draw air from and discharge exhaust into an underfloor space via a downwardly projecting inlet and flue assembly. This first type of apparatus has the advantage that the inlet and flue assembly is shielded by the structure from any wind in the vicinity of the structure, so that the inlet and flue assembly is not subjected to wind generated disturbances of the air and exhaust flows; but this first type of apparatus has the major disadvantage that any blockage or restriction of the openings to the underfloor space, caused by drifting snow or long grass, can cause an unacceptable or even dangerous build up or accumulation of exhaust gas in the underfloor space, and any escape of fuel gas can likewise accumulate. The apparatus has the further disadvantage, in that the service or repair the heater unit a person has to remove the apparatus from the floor or work from below the floor.

In a second type of heating apparatus, for example, our Carver Trumatic SD 2000 and SW 1800 warm air heating apparatus, a heater unit is disposed within the habitable structure, which unit draws air in through an inlet duct leading to an inlet and discharges its exhaust through a flue leading to an outlet above the level of the inlet. This type of apparatus, if properly installed in a structure, substantially avoids the risks of blockage by snow causing gas accumulation and wind disturbances of the inlet air and exhaust flows; but has numerous disadvantages including the need to design the ductwork flue inlet and outlet to suit the structure - (or vice versa), installation costs, maintainance costs, the volume occupied by the apparatus within the structure and weight, all of which are serious disadvantages for compact lightweight structures such as caravans. The apparatus has the further disadvantage in that it may be situated in a relatively confined and inaccessible part of the structure, and requires to be partially dismantled within the structure for service or repair of the heater unit.

In a third type of heating apparatus, a heater unit is connected by ductwork to any one of various forms of balanced flue assembly mounted on an external wall of the structure, and whilst the balanced flue assembly can be located to minimise the risks of blocking by snow it projects a considerable distance, e.g. some twenty or more centimetres, from the external wall so that the air inlet and exhaust openings of the balanced flue assembly are well away from the external surface of the wall, so that the third type of apparatus has the major disadvantage that it is not suitable for mobile structures such as touring caravans, and is only suitable for static structure such as houses and chalets. This type also has many disadvantages similar to those of the second type, particularly the cost, bulk and weight of the ductwork in addition to the bulk and cost of the balanced flue assembly. As is well known the balanced flue assembly has to project a considerable distance from the external surface of the wall, because the air inlet and exhaust outlet have to be subject to similar wind generated effects, so as to minimise the disturbance of the air and exhaust flows through the apparatus. Furthermore, the length of the ductwork required is considerable in order to attenuate disturbance of said flows. The apparatus has the furthe disadvantage in that it may be situated in a relatively confined and inaccessible part of the structure, and requires to be partially dismantled within the structure for service or repair of the heater unit.

A fourth type of heating apparatus, for example, our Trumatic "E" series warm air heating apparatus, avoids all the problems and disadvantages associated with the first three types of apparatus, by using an electrically powered fan or pump to provide a controlled air flow to and exhaust flow from a heater unit. The flow through the heater unit, being controlled, can easily be made substantially immune to wind generated disturbance, so that combustion within the heater unit can be arranged easily for optimum efficiency and to control the production of toxic or otherwise harmful exhaust emissions. This fourth type of apparatus is particularly suitable for mobile structures such as motor caravans and boats, because like the first type it is compact and enables the air inlet and exhaust outlet to be situated where they are not exposed to impact damage, but has the disadvantage of requiring a continuous substantial electrical power supply for the fan or pump. This type of apparatus is often installed so as to be relatively inacessible for service and repair.

In some of the many types of heating apparatus there are simple controls, such as a manually openable fuel supply valve, to control the supply of fuel to a burner which is arranged to be lit manually, e.g. by a match or by a spark producing device, but such simple controls have well known disadvantages and have been generally superceded by automatic controls offering safety features such as as automatic ignition, and fuel supply shut off in the event of overheating and/or flame failure. However, such automatic controls require a considerable supply of electrical power, are complex to instal in the heating apparatus, and require skilled maintainence.

An improved form of control system, which greatly reduces the problem of electrical power consumption, is disclosed in our British Patent Application No. 2123525A, and has been incorporated in some of our "Carver" heaters to provide a heater unit of a kind generally comprising a thermally conductive body, a burner assembly for heating said body, valve means for controlling a supply of combustible fuel to the burner assembly, ignition means for initiating combustion, sensor means for sensing the presence of combustion and/or the temperature of said body, electronic automatic control means responsive to manually actuable means and said sensor means to control said valve means and said ignition means.

However, certain problems and disadvantages remain, particularly the disadvantages of cost and complexity of installation, complexity of repair, and the need for skilled maintainence; and an object of the present invention is to enable such disadvantages to be reduced or avoided.

In accordance with a first form of the invention, there is provided a heater unit comprising a thermally conductive main body, a burner assembly for burning fuel in a combustion chamber for heating said body, a valve assembly for controlling a supply of combustible fuel to the burner assembly, ignition means for initiating combustion, sensor means for sensing at least the presence of combustion and/or the temperature of said body, electronic automatic control means responsive to manually actuable means and said sensor means to control and actuate said valve assembly and said ignition means; characterised in that said burner assembly, valve assembly, ignition means, sensor means and electronic automatic control means are assembled together as a single repleaceable unit removably installed in said heater unit, and in that the replaceable unit is provided with a separable electrical connector device or devices for releasably electrically connecting said unit to said manually actuable means, and is releasably connected to a fuel supply duct.

The single replaceable unit can be assembled, tested, adjusted or repaired as a complete working unit in the factory prior to being inserted into the heater unit either during manufacture or to replace an existing faulty or damaged unit.

The replaceable unit is preferably mounted on the body so as to extend through an apertured part of the body so that the burner assembly is at one side of the apertured part and the electronic control means is at the other side of said apertured part, so that the electronic control means is shielded from burner heat.

The body preferably serves as a mounting for an enclosure which constrains a fluid to be heated to contact said body. The enclosure may be part of hot air flow duct or a water container.

The sensor means preferably comprises a flame sensor for the burner and a thermostat responsive to the temperature of the body.

There are further problems which concern some kinds of the aforementioned known types of heating apparatus when constructed for heating water. In particular steam explosion risks caused by overheating arising from various causes, in spite of the provision of electrically powered safety controls. Heating apparatus in mobile and occasionally or seasonally used structures may be especially vulnerable to such risks.

The heater unit may be constructed as a water heater unit comprising a reservoir, the thermally conductive main body being arranged to heat water in said reservoir; and is characterised in that the electronic automatic control means is responsive to flame failure at the burner assembly to shut off the valve means, and in that relief means is provided to cause a proportion of the contents of the reservoir to be ejected at the burner assembly and/or the ignition means in the event of the temperature and/or pressure in the reservoir exceeding a predetermined value.

The relief means is preferably a replaceable fusible (melting) device screwed into the body.

The electronic automatic control means preferably latches or locks out in a valve-off condition automatically upon failure of a predetermined ignition sequence, so that any automatically actuated ignition sequence after flame failure which is abortive, e.g. due to dousing of the burner assembly by operation of the relief means, gives rise to automatic shut-down of the heater unit.

The heater unit preferably forms part of heating apparatus of the invention, the apparatus further including a combined air inlet and exhaust outlet device, and which is characterised in that:-

(a) the combined device defines an air inlet duct to an air chamber in said heater unit;

(b) a partition is provided between said air and combustion chambers; and

(c) at least part of the combined device and partition are connected to the main body so as to be releasable from one side of the main body to provide access to the single replaceable unit.

The partition or removable part thereof may be mounted on the main body, or the removable part of the partition may be mounted on the replaceable unit for removal therewith. This apparatus is extremely compact, can be constructed to give good control of the air and exhaust flows, and provides simple access to the replaceable unit, e.g. for cleaning or replacement of the replaceable unit without requiring special tools or skills.

An object of preferred forms of the invention is to enable at least some of the aforementioned disadvantages, characteristic of the previously mentioned types of heating apparatus, to be reduced or avoided.

The combined device comprises a divider plate, an outer plate, and an exhaust duct extending through the inlet duct and the divider plate to terminate at an exhaust outlet in a flow space between the divider and outer plates. An outer end of the inlet duct is preferably peripherally surrounded by a surround, the divider plate is preferably disposed so as to partially close the outer end of the inlet duct to leave an inlet opening or openings between the divider plate and the surround.

The combined device preferably includes an air permeable screen, e.g. of wire mesh, at the inner end of the air inlet duct so that the space within the duct between the screen and a divider plate forms an entrance chamber. It has been found that the screen and this chamber substantially dampen or attenuate any directionally forceful or surge air flows through the inlet opening.

The exhaust opening is preferably situated in the flow space so that the spacing between the exhaust opening and the outer plate is less than, preferably less than about one third, of the minimum distance between the exhaust opening and the periphery of the flow space. The periphery of the flow space is preferably provided with a barrier to obstruct ingress of objects into the flow space.

The outer plate is preferably parallel to said first plane and is spaced no more than three centimetres from said divider plate, the preferred spacing being about two centimetres. Also, the entrance chamber is preferably narrow so that the screen is parallel to and within five centimetres of the divider plate, and is preferably about one centimetre from the divider plate, so that the overall distance from the screen to the outer plate is less than eight centimetres, and can be about three centimetres.

The combined device provides the major advantage that even when the surround is mounted directly on an external wall of a structure so that the first plane is level with or no more than a few millimetres out from the outer surface of the wall, so that the outer plate is very close to the wall, the combined device successfully overcomes the problems of permitting and promoting orderly air inlet flow to and exhaust flow from the heater unit substantially irrespective of the force, variability and direction of the wind to which the combined device is exposed. The heating apparatus is thus substantially universally acceptable and suitable for use in both mobile and static habitable structures.

Furthermore, the combined device is particularly suitable for close coupling to the heater unit so that the whole apparatus can be made very compact and suitable for mounting directly on the wall of the structure. The costs and problems of lengthy ductwork can thus be eliminated because the flow smoothing and surge damping characteristics of such ductwork, which minimise or attenuate wind induced disturbances of the air and exhaust flows, are not needed.

The surround is preferably adapted for direct mounting on a wall of a structure, or on a part of a heater unit which part is adapted to abut the wall so that the surround is close to the wall.

The partition is preferably disposed between the combustion chamber and the air chamber so as to provide a secondary air inlet between a lower portion of the combustion chamber and a lower portion of the air chamber; and the an air permeable screen preferably confronts said partition across a main portion of the air chamber, which main portion of the air chamber is disposed above the lower portion of the air chamber.

Thus air flowing through the screen enters the main portion in a direction towards the partition, is constrained to change direction to move downwards to the lower portion, and thereafter has to change direction again in order to pass through the secondary air inlet to provide a flow of secondary combustion air, which flow is further constrained to change direction in the lower portion of the combustion chamber prior to flowing upwards around the burner to a flame zone above the burner so that the secondary combustion air has to follow a tortuous path from the air inlet to the flame zone.

The direct distance between the screen and the flame zone is preferably small in comparison with the overall height and/or width of the air and combustion chambers, and in particular the distance between the screen and the partition is preferably less than 10cm, e.g. about 2 to 4cm.

The flame zone is preferably slightly above the level of the bottom of the screen.

The burner is preferably supplied with a primary combustion air and fuel mixture in which the primary combustion air is drawn from the lower portion of the air chamber via a further tortuous path in which the flow from this lower portion is

constrained to change direction to flow along a restricted path to enter a mixing chamber, to change direction again to flow upwards in the mixing chamber to the level of a fuel jet and to further change direction to enter the burner.

The exhaust duct preferably extends across the main portion of the air chamber, through the screen and through the inlet duct.

This heating apparatus has the advantage that the effects upon the combustion efficiency of the apparatus of any wind generated disturbance of the flows in the inlet and exhaust ducts are very small; and the advantage that the apparatus is compact and easy to construct and instal. The heating apparatus is particularly suitable for and preferably includes the combined air inlet and exhaust outlet device so that the air inlet and exhaust outlet ducts of the combined device serve as or-are continuations of the air inlet and exhaust outlet ducts of the apparatus. The screen of the apparatus preferably serves as a or is the air permeable screen of the combined device. The apparatus can thus be made extremely compact, e.g. the overall direct distance between the flame zone and the outer plate can be, and preferably is, less than 15cm e.g. about 7 to 8 cm.

In accordance with the invention, there is also provided heating apparatus constructed and arranged to be installed in a structure having an external wall, the heating apparatus comprising a heater unit and an air inlet and exhaust outlet device which device provides an air inlet duct having an inner end open towards an air chamber in the heater unit, and characterised in that:-

(a) a partition is provided in the heater unit between said air chamber and a combustion chamber alongside said air chamber;

(b) the air inlet duct is arranged to provide an entrance chamber in said device and alongside the air chamber;

(c) the apparatus is constructed and arranged to be installed so as to leave one side of said device exposed; and

(d) at least a part of said device is relesably mounted so as to be displaceable, from said one side, to expose the interior of the heater unit to provide access to at least part of said partition and a burner assembly of the heater unit.

The divider plate and surround, or part of the surround, may be integral and apertured to provide one or more apertures serving as the air inlet opening or openings.

The replaceable unit and the heater unit are preferably arranged so that removal of the air inlet duct or air inlet duct and partition provides access for removal of the replaceable unit. The body preferably incorporates a mounting extension which can be mounted on a wall of habitable structure so as to extend through said wall, and the air inlet duct is preferably connected releasably to said mounting extension.

There is a further risk which can cause costly structural damage or steam explosion in water heaters, especially in mobile or occasionally used structures and in cases of neglect, which risk arises if water in the reservoir is allowed to freeze.

Accordingly the heater unit is preferably constructed as a water heater unit comprising a reservoir provided by an assembly comprising a container clamped to a mounting by a clamping device, and is characterised in that the clamping device extends through one end part of the container and within the interior of the container to engage the mounting so that the other end part of the container is thrust onto the mounting and a seal on the mounting to make sealing engagement therewith; and in that the assembly is adapted to yield resiliently, upon a predetermined internal pressure or thrust being reached, so that said other end part can be moved by the internal pressure or thrust to an extent sufficient to interrupt said sealing engagement.

The reservoir is preferably adapted and arranged to provide an internal expansion space above normal water level, which space allows sufficient room for the water to freeze without said predetermined pressure being reached if the ice occupies said space.

Said one end part is preferably dished so as to project into the reservoir.

The preferred features of the invention are preferably used in combination in order to provide an extremely safe, compact, easy to construct, instal and repair water heating form of the apparatus.

An example of heating apparatus, in the form of water heating apparatus incorporating the forms of the invention mentioned hereinbefore and combinations of features thereof, is hereinafter described with reference to the accompanying diagrammatic drawings, wherein:-

FIGURE 1 shows a vertical longitudinal cross-section through the apparatus as installed in a habitable structure, such as a caravan, at the junction of a wall and a floor of the structure;

FIGURE 2 shows a plan view of a replaceable burner and control unit of the apparatus, and indicates a remote control and indicator unit;

FIGURE 3 shows a combined air inlet and exhaust outlet device of the apparatus in rear elevation;

FIGURE 4 shows the apparatus in front elevation with the combined device removed to reveal a heater unit of the invention;

FIGURE 5 shows a heater unit in front elevation with the burner and control unit removed to reveal a main body of the heater unit.

The heating apparatus broadly comprises a heater unit 10 close coupled to a combined air inlet and exhaust outlet device 11.

The heater unit 10 broadly comprises a gas fueled heater assembly 12, and an enclosure 13 to constrain fluid to be heated to contact the heater assembly 12.

The heater assembly 12 includes a main body 14, in the form of a single aluminium alloy casting, which main body 14 is directly secured to said structure, serves as a mounting for a replaceable burner and control unit 15 (FIGURE 2) of the heater assembly, serves as a mounting for the enclosure 13, serves as a mounting for the combined device 11, and serves as a direct heat transfer body to transfer heat generated in the heater assembly to the fluid to be heated, as hereinafter described.

The combined device 11 includes a main assembly comprising an outer plate 16 about 18 cm wide by 18 cm high; a divider plate 17 spaced about 2 cm from the outer plate 16 so as to define a flow space 18 therebetween; a shaped surround 19 which supports several pillars 20 which locate the plates 16 and 17; a barrier 21 of round wire mounted on the pillars 20 so as to be located around the periphery of the flow space 18; and a wire mesh screen 22 located on the surround 19.

The surround 19 has a peripheral portion 23 and a convergent inner portion 24; disposed around a short air inlet duct 25 so that an outer end 26 of the inlet duct 25 lies in a first plane 27 and is bounded by a flow affecting portion 28 of an outer surface of the peripheral portion 23, which portion 28 lies in said first plane, and so that an inner end of the inlet duct 25 is bounded by an apertured inner end 29 of the inner portion 24. In this embodiment the inner end of the inlet duct 25 is occupied by the screen 22. The divider plate 17 is located substantially in said first plane so as to occupy most of the outer end 26 of the inlet duct 25 whereby to leave a narrow inlet opening 26A in said plane between the periphery of the divider plate 17 and the portion 28 of the outer surface. In this embodiment the inlet duct is about 1 cm long between the plate 17; and the screen 22, and the inlet opening is about 1 cm wide at the top and sides of the plate 17 and about 3 cm wide at the bottom. Thus the assembly is only about $3\frac{1}{2}$ cm in depth between the outer plate and the screen and projects about $2\frac{1}{2}$ cm outwardly from said first plane.

The divider plate 17 and screen 22 are apertured to receive an outer portion 30 of an exhaust member 31 which defines an exhaust duct and is common to the heater unit 10 and the combined device 11. The outer portion 30 is about 7 cm in height and width and projects about $1\frac{1}{4}$ cm from the divider plate 17 into the flow space 18 to terminate at an exhaust outlet 32. The portion 30 is located so that the outlet 32 is about 3 cm from the top of the periphery of the flow space 18, and is about 5 cm from the sides and 8 cm from the bottom of said periphery. The outer portion 30 extends through the inlet duct so as to occupy part of the space between the divider plate and the screen, which space serves as a damping chamber 33.

The main body 14 comprises a main wall 34 at an inner end of a mounting extension comprising an outwardly projecting peripheral wall 35 having an outer flanged end 36. The wall 35 extends, in use, through a wall 1 of the structure so that the flanged end abuts an outside surface 2 of the wall, and so that the body 12 rests on a floor 3 of the structure. The flanged end 36 is apertured to receive fasteners to serve as means 36A for securing the body 12, and thus the apparatus, to the structure, and to receive further fasteners securing the peripheral portion 23 of the surround 19 (and thus the main assembly) to the flanged end 36, so that the surround 19 overlies and conceals the flanged end 36 and so that said first plane is close to, e.g. to about 5mm, from the plane of outside surface 2. To reduce the overall projection of the main assembly from the surface 2, the structure may be recessed to allow the flanged end to be let into the wall 1 so that the first plane is closer to, is coplanar with or is even behind the plane of the surface 2.

The main wall 34 is provided on one side, as shown in Figure 5, with:-

(a) outwardly projecting webs which form side walls 40 and a top wall 40A of a combustion chamber 41, 42;

(b) vertical fins 43 which project substantially across an upper portion 41 of the combustion chamber;

(c) transverse support webs 44;

(d) a thermostat locator socket 45; and

(e) a water drain duct 46, which extends through an opening in the surround 19 and is closed and concealed by a manually operable water drain plug 47.

The main wall 34 has therein:-

(a) a large lower aperture 48, through which the burner and control unit 15 extends;

(b) sockets 49 for fasteners to secure a tapered portion 37 of the exhaust member 31 and partition 51, in the form of a sheet metal member, to the webs 40 and 44;

(c) sockets 52, with a gas fuel connector duct 53 therebetween, for fasteners 79 to secure the unit 15 in position so as to make a gas tight connection with the wall 34 around the duct 53;

(d) an upper internal transverse water outlet duct 54 extending from an opening 55 (FIGURE 1) to a water pipe socket (not shown);

(e) a lower internal transverse water inlet duct 56 leading from an opening 57 (FIGURE 1) to the drain duct 46; and

(f) a socket 50 for a fusible safety device 58.

The main wall is provided on its other side - (FIGURE 1) with a circular flange 60 having a chamfered annular projection 61 to support an elastomeric ring seal 62; water inflow baffle 63, and a clamp securing socket 64 co-axial with the axis of the circular flange 60.

The exhaust member 31 has a horizontal top wall and the tapered portion 37 decreases in height and increases in width from the outer portion 30 to an inner end flange 38 clamped to the webs 40. The portion 37 engages the partition 51 so that the latter serves as a partition between the combustion chamber 41, 42 and an air chamber 65, 66, 67 bounded by the peripheral wall 35, the screen 22 and the partition 51. The air chamber 65, 66 and 67 comprises an upper portion 65 above the level of the combustion chamber, a main portion 66 between the screen 22 and the partition, and a lower portion 67 between the partition and the part of the surround 19 below the level of the screen 22.

The burner and control unit 15 (FIGURE 2) comprises a burner assembly 70, a solenoid actuated gas valve assembly 71, automatic electronic control means in a housing 72, ignition means in the form of an ignition electrode 73, sensor means comprising a flame sensor electrode 74 and a thermostat 75 manually presettable by means of a rotatable knob 76 which projects through an opening 77 in the thermostat socket 45, and a mounting 78 dimensioned to abut the main wall 34 so as to close the lower aperture 48. The valve assembly 71 is secured to the main wall 34 by the fastenes 79 to receive gas from the duct 53.

The burner assembly 70 comprises an elongate hollow rectangular burner 80 mechanically connected to the valve assembly 71 by a mixing chamber 81 in which a jet 82 (FIGURE 4) of the assembly 71 confronts a partially open end of the burner 80. The burner 80 is mounted adjacent one side of the mounting 78 by spacer supports 83, and the housing 72 is mounted adjacent the other side of the mounting 78 by the same spacer supports 83. One of these supports 83 secures a carrier 84, on which the electrodes 73 and 74 are mounted, to the mounting 78, and these electrodes are connected electrically to the automatic electronic control means. The latter is also electrically connected 6 to the solenoid actuated gas valve assembly 71 and to the thermostat 75 which is mounted on a carrier 85 secured to said assembly 71.

The mixing chamber 81 has open opposite sides 86 which are blanked-off by the mounting 78, the main wall 34 and the partition member 51; has a small opening 87 in one end below the bottom level of a valve body 88 of the valve assembly 71; a further opening 89 in the end opposite and co-axial with the jet 82, which end restricts the open end of the burner 80; and an upper flange 91 which engages one side wall 40 of the combustion chamber 41, 42 so that the valve assembly 71 is protected from heat in the combustion chamber 41, 42 by said mixing chamber 81. Fasteners 88A secure the valve body 88 to the mixing chamber 81.

The burner 80 is located in a lower portion 42 of the combustion chamber so as to provide spaces therein at each side of and below the burner, and so that a flame zone 92 in the combustion chamber above the burner is located above the level of the bottom of the screen. The bottom portion of the partition 51 is shaped to provide a primary air inlet 93 between the lower portion 67 of the air chamber and a space 94 below the valve body 88; and to provide a larger secondary air inlet 95 between the lower portion 67 and the space below the burner in the lower portion 42. The partition member 51 abuts the other end 80A of the burner to hold the end 80A against the main wall 34.

Above the level of the burner 80, a thermal insulation member 96 extends upwards within the combustion chamber alongside the partition member 51, and is held by the latter against the fins 43.

The automatic electronic control means may be of any suitable form, but in this embodiment is substantially as described in our aforesaid co-pending application. The housing 72 incorporates a socket 97 for a multiple pin connector plug 98 which has leads to a remote control unit 99 providing a manually actuable switch, indicators, a fuse and electricity supply connectors. However, a supply voltage discriminator is included in the electronic control means to shut-down the heating apparatus when the supply voltage is below a predetermined voltage, and to re-start the apparatus when the necessary working voltage is restored. The unit 99 includes an indicator diode labled "low voltage" which is illuminated whilst the voltage is low, in addition to diodes to indicate normal heater operation, and a fault or malfunction induced "lock-out" condition.

The safety device 58 comprises a screwed-in hollow replaceable insert having discharge openings 100 in the combustion chamber and, at the other side of the main wall 34, is closed by a plug 101 of a material which melts at a specific temperature.

The enclosure 13 comprises an elongate cylindrical water container 103 having a re-entrant end portion 104 through which one end part 102 of tie bar 105 of a clamping device extends to receive a nut 108. The other end part 107 of the tie bar is secured in the threaded socket 64. The nut 108, recessed to accept a seal 109, engages the portion 104 to thrust the container 103 towards the main wall 34, whereby to engage the other end portion 110 against the flange 60 and the seal 62 to make sealing engagement therewith. A moulded two part insulating cover 112 surrounds the container 103 and provides a moulded-in recess to receive the housing 72.

In normal operation, in still air (no wind) conditions and with the structure disposed so that the tie bar is horizontal, the container 103 and main body 14 together serve as a reservoir 13A for water which is supplied via a pipe (or hose) not shown and the internal duct 56 to enter the reservoir via the opening 57 to bring the water to a normal level 113 just covering the top of the opening 55 to leave a normal air space 114 above the water.

When the remote manually actuable switch is closed, electricity is supplied via the remote control unit 99 and the plug 98 to the automatic electronic control unit. The latter actuates the solenoid gas valve assembly 71, to allow gas from a supply pipe 115 to flow to the jet 82 via the duct 53 and the assembly 71, and energises the ignition electrode 73. The gas flow from the jet 82 causes a gas and primary combustion air mixture to flow from an upper part of the mixing chamber 81 into the burner 80 via the opening 89, and causes primary combustion air to be drawn into the upper part of the mixing chamber along a tortuous flow path through the inlet opening 26A, the inlet duct 25, the screen 22, the main and lower portions 66 and 67 of the air chamber, the primary air inlet 93, the space below the valve body 88, the opening 87 and the lower part of the mixing chamber 81 so that the air undergoes at least five or six changes in direction along said flow path prior to changing direction in the upper part to enter the opening 89.

When the flame sensor electrode 74 senses that ignition is established, the automatic electronic control unit halts the ignition electrode energisation and assumes a running condition requiring only a few milliwatts of electrical power as described in our said co-pending Application. Heat is absorbed by the fins 43 and the main wall 34 and is conducted through the latter to the water in the reservoir. Combustion heat causes an exhaust flow to rise in the combustion chamber and thus to flow through the exhaust duct and the flow space 18 to atmosphere; and causes a flow of secondary combustion air to be drawn to the flame zone above the burner 80 along a tortuous path through the inlet opening 26A, the inlet duct 25, the screen 22, the main and lower portions 66 and 67 of the air chamber, the secondary air inlet 95 and the spaces at each side of and below the burner 80, so that the air undergoes at least four or five changes in direction along said flow path.

Heating continues until the thermostat responds to the main wall (and thus the water) reaching a desired temperature, whereupon the gas flow to the burner is shut off, and the automatic electronic control unit assumes a stand-by (monitoring) condition requiring minimal electrical power, until such time as the thermostat responds to a fall in temperature whereupon the ignition sequence is commenced to re-start heating.

In the event of flame failure during the running condition, a further ignition sequence will be initiated; and in the event of any ignition sequence being non-effective after a predetermined time the automatic electronic control unit will shut-off the gas flow and assume a lock-out or shut-down condition which can be cancelled only by the control system being manually switched off and on again.

The heating apparatus has many advantages in that, for example:-

1. The apparatus is particularly easy to instal in a structure which provides a suitable aperture in an external wall.

2. The apparatus is extremely simple to service, repair or clean, because the main assembly of the combined air inlet and exhaust outlet device 11, the exhaust member 31 and the partition 51 can be removed from outside the structure without disturbing the remainder of the apparatus to expose the unit 15.

3. The unit 15 can be removed, after exposure, as a single replaceable unit, by releasing the fasteners 79 and detaching the plug 98, for service, repair, testing or replacement by a new and pretested unit.

4. Overheating in the event of a valve, thermostat or electrical failure is restricted by melting of the plug 101 causing water or steam to issue forcibly from the openings 100 to extinguish combustion and to soak the burner and/or electrodes to frustrate any subsequent ignition sequence and cause the control unit to assume the lock-out condition.

5. The hazard presented by any continuous discharge of gas, caused by control unit or valve failure, is minimised, because the total internal volume of the apparatus, which can be occupied by

the gas, is extremely small so that the energy available within the volume for unwanted combustion is restricted, and because the pressure which such unwanted combustion can generate is limited by the relatively short length of, and large flow cross-sectional areas of, the inlet and exhaust ducts, thus minimising the risk of any harmful explosion arising.

6. The direct distance between the main wall 34 and the outer plate 16 is less than twelve cm so that the heater assembly 12 (excluding the container 103) is extremely compact.

7. The exhaust duct is surrounded by combustion air containing spaces within the main body so that any exhaust leakage merely acts as a combustion air polutant and is recycled therewith eventually to be ejected via the flow space 18, thereby obviating any risk of exhaust escaping into the interior of the structure.

8. Whilst the drain plug is provided to allow the reservoir to be drained to prevent freezing of water therein when the apparatus is not in use, the air space above the normal water level is calculated to be sufficient to allow for expansion during freezing. However, if for any reason, e.g. boiling or an abnormal water level 116 arising from the apparatus or structure being inclined, the pressure in the reservoir increases beyond a predetermined pressure, the end portion 104 of the container is adapted to deform resiliently to cause the end portion 110 to move away from the main wall 34 until the sealing engagement is broken to allow air, steam, water and/or ice to escape at least until the excess pressure is relieved, so as to avoid the risk of structural damage to the apparatus. If required, the seal 62 may be replaced after the cover 112, nut 108 and container 103 have been removed.

9. The combustion characteristics, particularly with respect to flame stability and control of exhaust emissions (e.g. CO, CO_2 and unburnt hydrocarbon content), are excellent and are substantially immune from the effects of any wind to which the combined device 11 is likely to be exposed in normal use, irrespective of the strength, direction and variability of such wind.

The positioning of the inlet opening or openings with respect to the divider plate and the external surface of the surround; and the sandwiching of parallel and relatively narrow but large volume i.e. tall and wide, spaces and chambers 33, 66 and 41 are especially valuable features which contribute to several of the aforementioned characteristics and advantages of the apparatus.

The invention is not confined to the details of the foregoing embodiment and many variations, modifications and functional equivalents of the various characteristics, features, and details are possible within the scope of the invention; as defined by the appended claims. For example, the heater assembly may include a main body which has further fins on the side opposite to the combustion chamber for heating air constrained to flow past these further fins by an enclosure having openings to receive air from and to return heated air to space within a structure, whereby to provide a warm air space heater unit.

The exhaust member 31 may be replaced by other suitable means for providing a suitable exhaust duct, e.g. an outer duct portion defined by a hollow exhaust part, carried by or integrally formed with the divider plate, and an inner duct portion defined by an exhaust member which is mounted on the heater assembly so as to engage said outer duct portion. The exhaust member may be integral with or secured to the partition or an upper part of the partition 51.

The surround and divider plate may be integral, e.g. formed as a moulding or casting, and apertured to provide an array of inlet openings 26B in said plane 27, as indicated in broken lines in FIGURE 3.

The partition 51 may be modified so that only a lower part 51A of the partition has to be removed for removal of the unit 15, and said lower part 51A may be attached to the unit 15 as indicated in broken lines in FIGURE 2.

Additional insulation may be provided e.g. as indicated in broken lines and by reference numerals 120 and 121 in FIGURE 1, and additional locating devices, such as the insulation locating clip 122 and a mounting locating lug 123 (indicated in FIGURE 3) may also be provided.

The electrodes 73 and 74 may be mounted directly on the mounting 78.

The heater preferably includes a normal pressure relief valve 124 removably inserted into a pressure relief duct, in a part 125, which duct leads to the outlet duct 54 and opening 55, for discharging steam or water, e.g. onto the burner assembly, if a predetermined pressure, e.g. below that at which the end portion 104 yields, is exceeded.

The replaceable burner and control unit, e.g. generally as shown in FIGURE 2, may be used in other types of heating apparatus; and said unit may be modified for insertion into a heater unit upwardly from below or from either side of a part of the heater unit which defines part of the combustion chamber.

The outer and divider plates and the screen, may be partially instead of wholly, removable; and may be pivotally or hingedly connected to the surround or main body, so that the air inlet duct, or

the lower part thereof, can be swung open for access to the partition and burner assembly, upon releasable retaining means, e.g. a catch or fastener, being released.

It will be readily appreciated that various of the features and combinations thereof disclosed herein constitute valuable inventions, such as:-

(a) the combination of automatic control means adapted to initiate an ignition sequence in the event of flame failure, in combination with a fusible or other safety device arranged to douse the burner or igniter to cause the ignition sequence to be negated;

(b) the use of a main body which serves as the major load bearing member on which the other parts of the apparatus are directly or indirectly mounted, as a heat transfer member for heating a fluid, and as a member for mounting the apparatus on a structure;

(c) heating apparatus primarily comprising three preassembled units namely the combined device, the main body with enclosure and safety devices, and the replaceable unit; together with manually actuable control means and optionally, in the case of space heating forms of the apparatus, a decorative or protective interior cover, which could be mounted on the enclosure or on an interior surface of the wall of the habitable structure.

Claims

1. A heater unit comprising a thermally conductive main body (14), a burner assembly (70) for burning fuel in a combustion chamber (41, 42) for heating said body, a valve assembly (71) for controlling a supply of combustible fuel to the burner assembly, ignition means (73) for initiating combustion, sensor means (74, 75) for sensing at least the presence of combustion and/or the temperature of said body, electronic automatic control means (72) responsive to manually actuable means and said sensor means (74) to control and actuate said valve assembly (71) and said ignition means (73); characterised in that said burner assembly (70), valve assembly (71), ignition means (73), sensor means (74, 75) and electronic automatic control means (72) are assembled together as a single replaceable unit (15) removably installed in said heater unit, and in that the replaceable unit (15) is provided with a separable electrical connector device or devices (97) for releasably electrically connecting said unit to said manually actuable means, and is releasably connected to a fuel supply duct - (53).

2. A heater unit as claimed in Claim 1, further characterised in that the replaceable unit (15) is mounted on the main body (14) so as to extend through an aperture (48) in part of the body (14) so that the burner assembly (70) is at one side of the apertured part and the electronic control means - (72) is at the other side of said apertured part, so that the electronic control means is shielded from burner heat.

3. A heater unit as claimed in Claims 1 or 2 further characterised in that the burner assembly - (70) is mounted on the valve assembly (71), and the valve assembly is releasably secured to said main body (14) by fasteners (79).

4. A heater unit as claimed in Claim 3 further characterised in that the main body (14) provides side walls (40) for the combustion chamber (41, 42) into which the burner assembly (70) projects; and wherein the burner assembly (70) comprises a mixing chamber (81), which is secured to the valve assembly (71) and is adapted to engage one of said walls (40).

5. A heater unit as claimed in any preceding claim further characterised in that the main body - (14) serves as a mounting for an enclosure (13) which constrains a fluid to be heated to contact said main body.

6. A heater unit as claimed in any one of claims 1 to 4 and comprising a reservoir (13A) for water the main body (12) being arranged to heat water in said reservoir; and further characterised in that the electronic automatic control means is responsive to flame failure at the burner assembly (70) to shut off the valve means (71), and in that relief means (58) is provided to cause a proportion of the contents of the reservoir (13A) to be ejected at the burner assembly (70) and/or of the ignition means (73) in the event of the temperature and/or pressure in the reservoir exceeding a predetermined value.

7. A water heater unit as claimed in Claim 6, wherein the reservoir (13A) is provided by an assembly comprising a container (103) clamped to a mounting (60, 64) on the main body (14) by a clamping device (105), and further characterised in that the clamping device (105) extends through one end part (104) of the container and within the interior of the container to engage the mounting - (64) so that the other end part of the container is thrust onto the mounting (60) and a seal (62) on the mounting (60) to make sealing engagement therewith; and in that the assembly is adapted to yield resiliently, upon a predetermined internal pressure or thrust being reached, so that said other end part (104) can be moved by the internal pressure or thrust to an extent sufficient to interrupt said sealing engagement.

8. Heating apparatus comprising a heater unit as claimed in any preceding claim and a combined air inlet and exhaust outlet device (11), characterised in that:-

(a) the combined device (11) defines an air inlet duct (25) to an air chamber in said heater unit;

(b) a partition (51) is provided between said air and combustion chambers; and

(c) at least parts of the combined device - (11) and partition (51) are releasable to provide access to the single replaceable unit (15).

9. Heating apparatus as claimed in Claim 8, wherein the combined device (11) comprises a divider plate (17), an outer plate (16), and an exhaust duct (30A) extending through the inlet duct - (25) and the divider plate to terminate at an exhaust outlet (32) in a flow space (18) between the divider and outer plates; wherein an outer end (26) of the inlet duct is peripherally surrounded by a surround (19); and wherein the divider plate (17) is disposed so as to partially close the outer end (26) of the inlet duct (25) to leave an inlet opening or openings (26A) between the divider plate and the surround (19).

10. Heating apparatus as claimed in Claim 9 wherein the outer plate (16), divider plate (17) and surround (19) are secured together to form a main assembly which is separable from the or part of the exhaust duct (30A).

11. Heating apparatus as claimed in Claim 8, 9 or 10 further characterised in that an air permeable screen (22) is provided between the air inlet duct - (25) and the air chamber (65, 66 and 67).

12. Heating apparatus as claimed in Claim 11 wherein the air permeable screen (22) is disposed at the inner end of the air inlet duct (25) so that the space within the duct (25) between the screen (22) and the divider plate (17) forms an entrance chamber (33).

13. Heating apparatus as claimed in claim 12 wherein the combined device (11) is close coupled to the heater unit so that said air chamber (65, 66 and 67) is disposed between and parallel with the entrance and combustion chambers (33, 41 and 42).

14. Heating apparatus as claimed in Claim 11, 12 or 13 wherein the exhaust outlet (32) is situated in the flow space (18) so that the spacing between the exhaust outlet and the outer plate (16) is less than the minimum distance between the exhaust outlet and the periphery of the flow space (18).

15. Heating apparatus as claimed in Claim 12 wherein the outer plate (16) is parallel to said divider plate (17) and is spaced no more than three centimetres from said divider plate; wherein the entrance chamber (33) is narrow so that the screen (22) is parallel to and within five centimetres of the divider plate, and wherein the overall distance from the screen (22) to the outer plate (16) is less than eight centimetres.

16. Heater apparatus as claimed in any one of Claims 11 to 15 wherein the direct distance between the screen (22) and the partition (51) is small in comparison with the overall height and/or width of the air and combustion chambers, and is preferably less than 10cm.

17. Heating apparatus as claimed in any one of Claims 11 to 16 wherein the partition (51) is disposed between the combustion chamber (41,43) and the air chamber (65,66,67) so as to provide a secondary air inlet (95) between lower portion (42) of the combustion chamber and a lower portion - (67) of the air chamber; and wherein the air permeable screen (22) confronts said partition (51) across a main portion (66) of the air chamber, which main portion of the air chamber is disposed above the lower portion 67) of the air chamber.

18. Heater apparatus as claimed in Claim 17 wherein the burner (80) is supplied with a primary combustion air and fuel mixture in which the primary combustion air is drawn from the lower portion (67) of the air chamber via a tortuous path in which the flow from this lower portion (67) is constrained to change direction at a primary inlet (93) to flow along a restricted path to enter a mixing chamber (81), to change direction again to flow upwards in the mixing chamber (81) to the level of a fuel jet (82) and to further change direction to enter the burner (80).

19. Heating apparatus as claimed in Claim 17 or 18, wherein an or the exhaust duct (30A) extends, from an upper part (41) of the combustion chamber, across the main portion (66) of the air chamber, through the screen (22) and through the inlet duct (25).

20. Heating apparatus as claimed in any one of Claims 8 to 19, as appended to claim 2 wherein the main body (14) is securable to a structure, serves as a mounting for said combined device - (11) and the partition (51) to permit removal thereof from said one side, and serves as a heat transfer member.

FIG. 1.

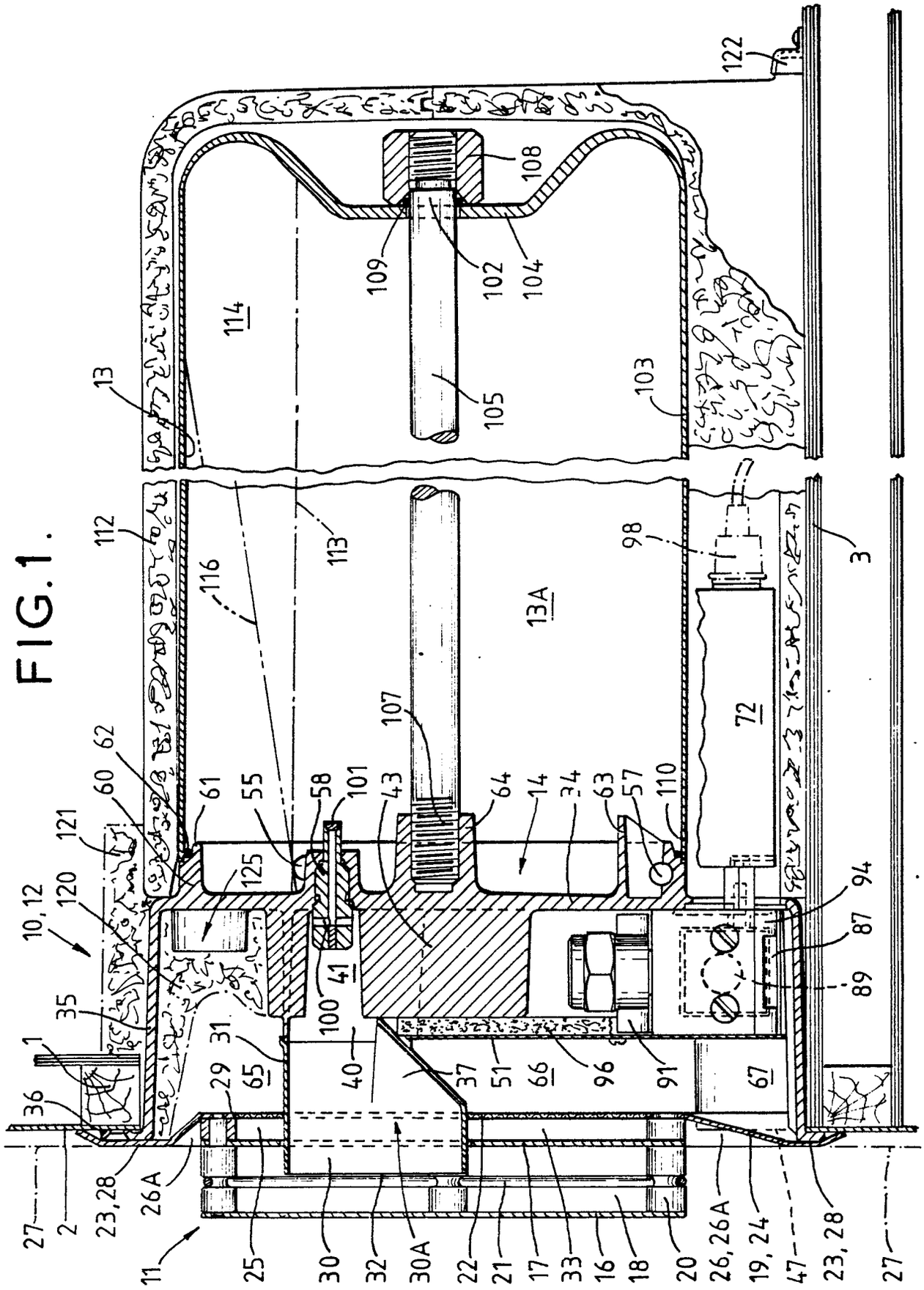
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FIG. 2.

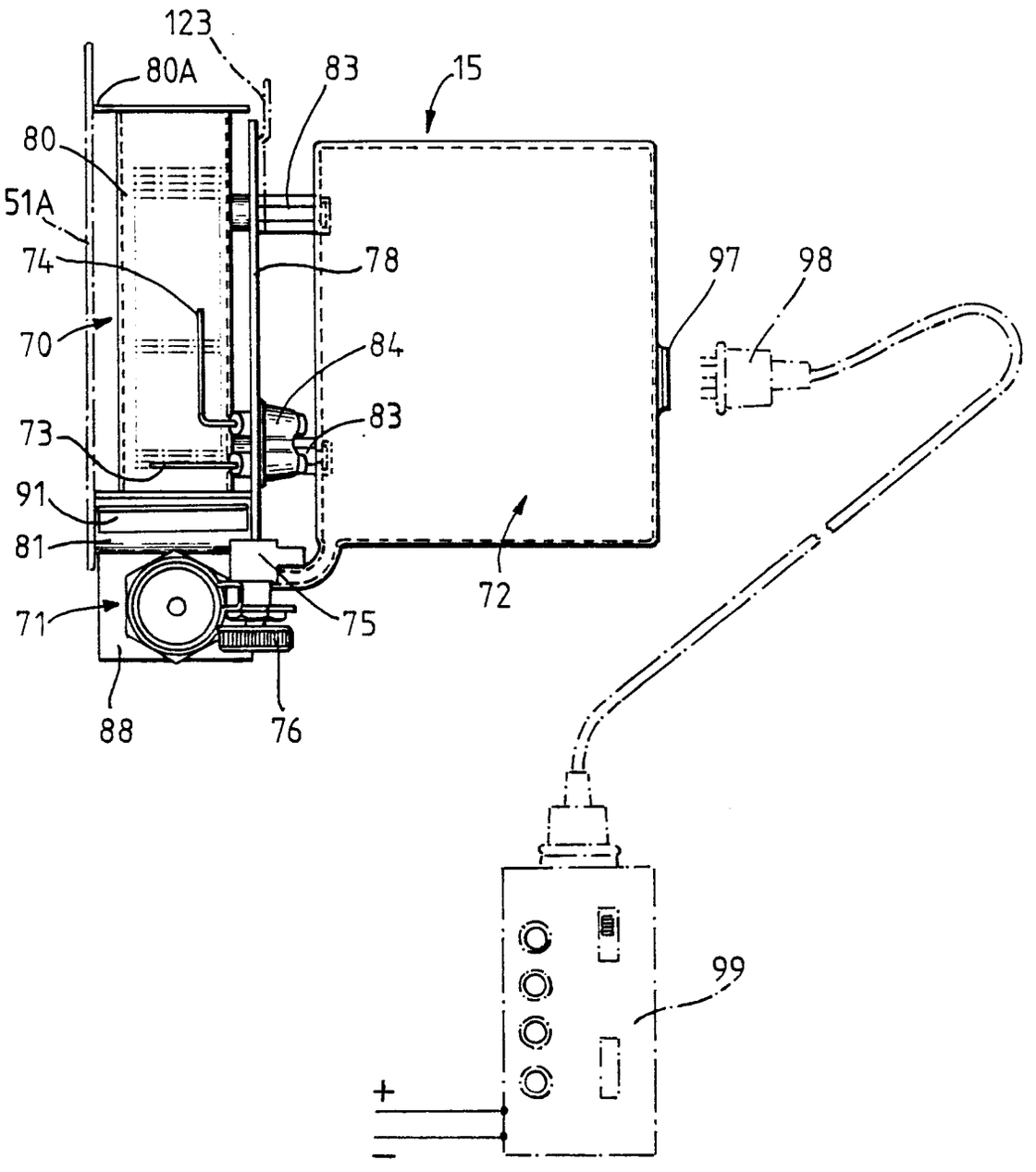

FIG. 3.

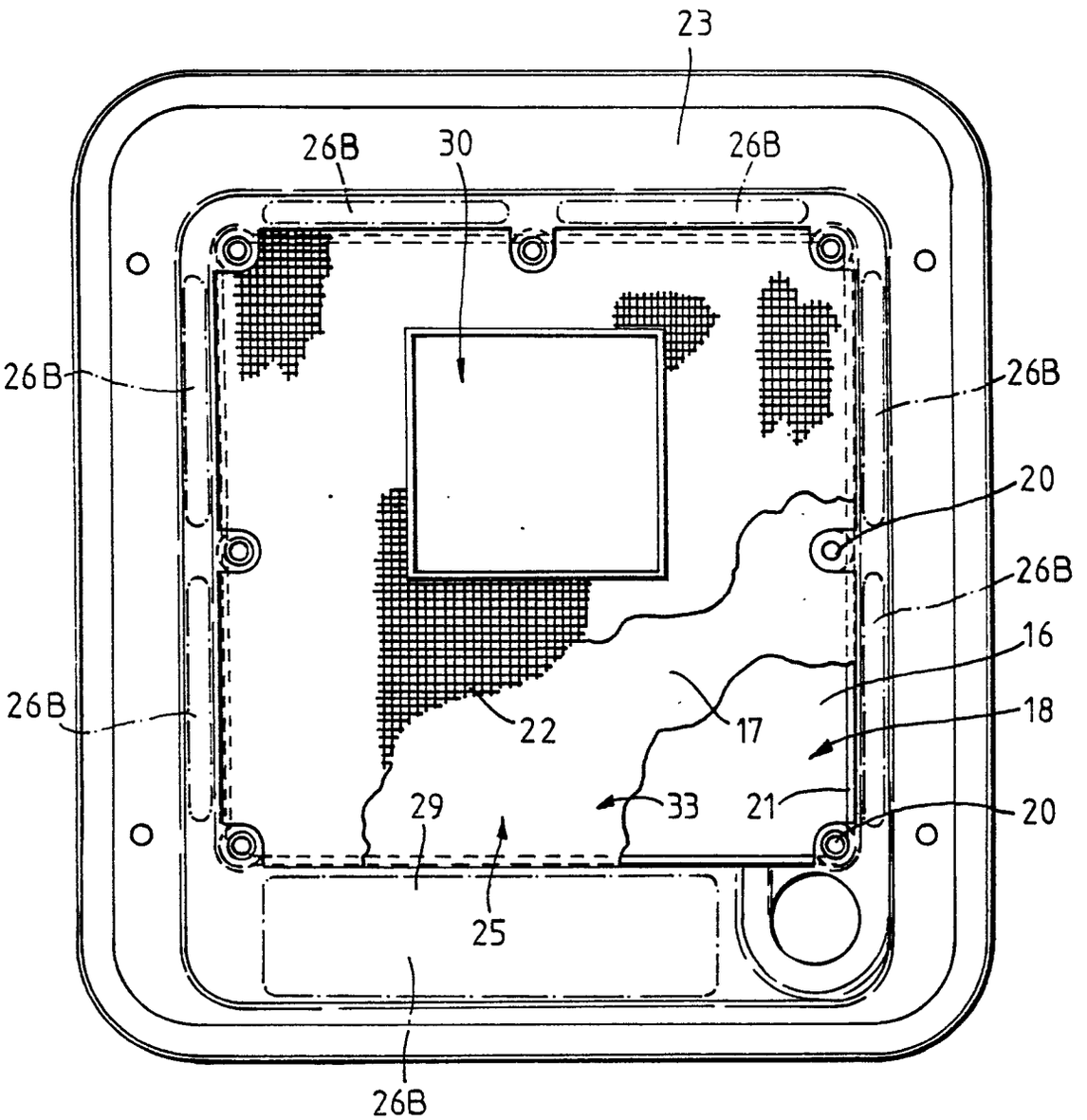

FIG. 4.

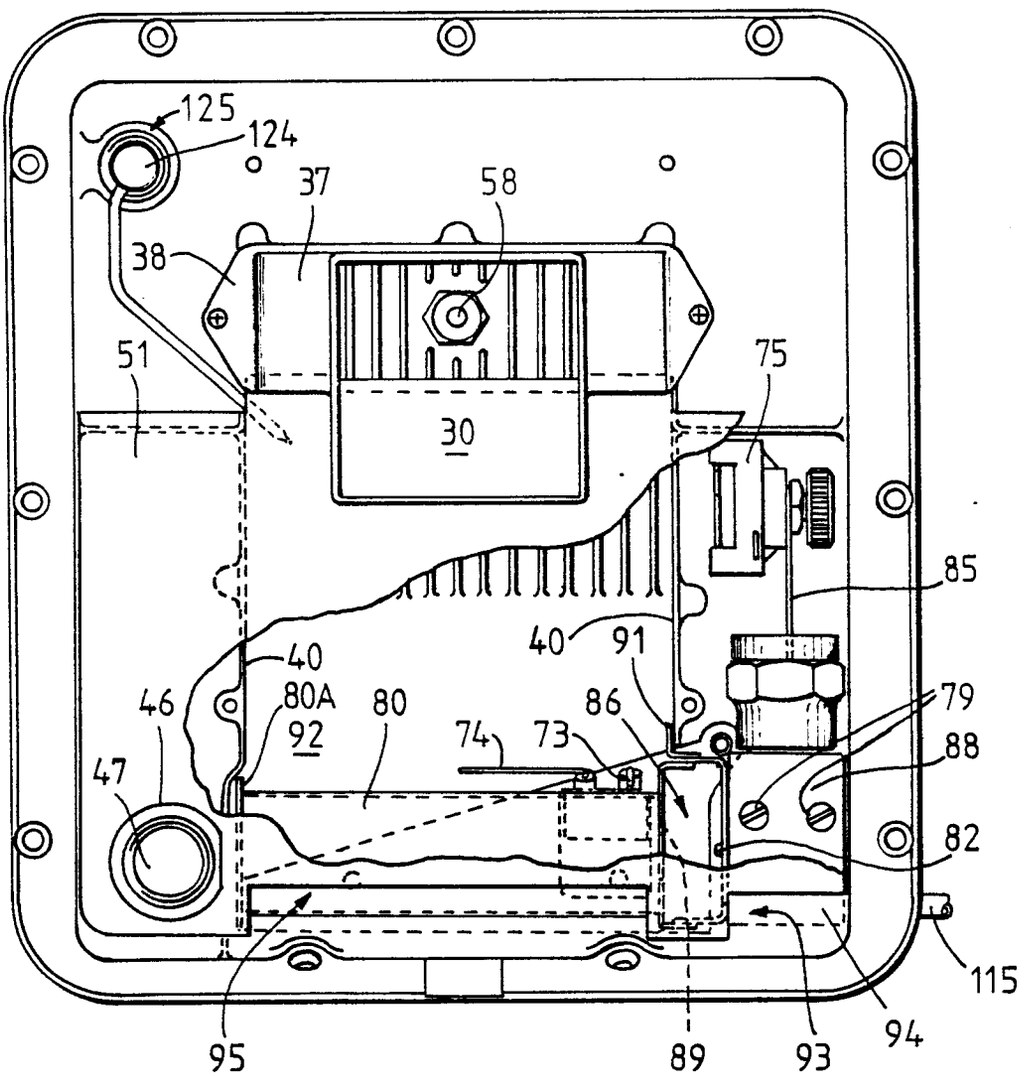
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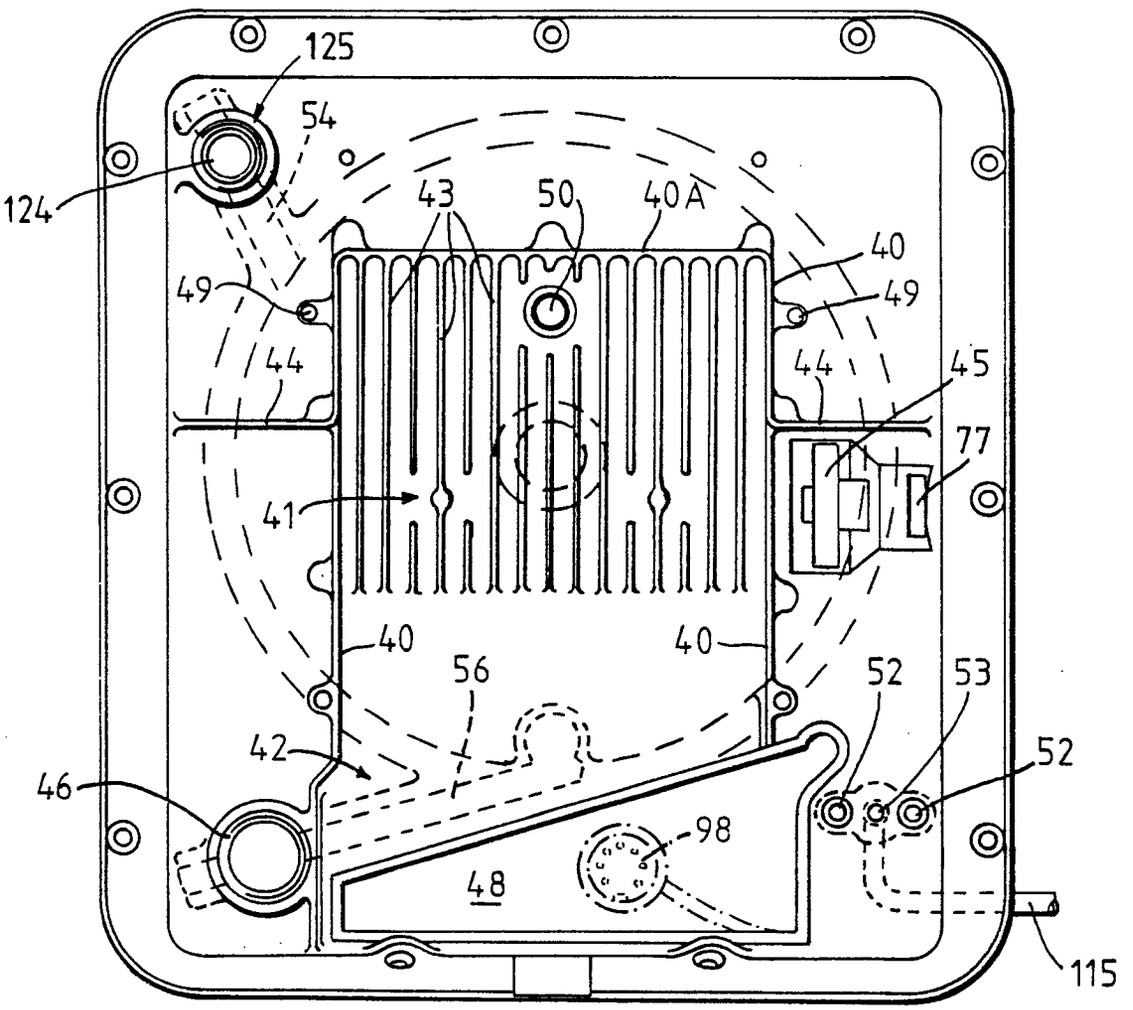
FIG. 5.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European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 86 11 4671.

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	GB-A-2 090 387 (ROBERT) * Whole document *	1	F 24 H 1/18 F 24 H 9/18 F 23 L 17/04 F 24 C 15/00
A	GB-A-1 334 003 (IMI LTD) * Claims 1,2,3 *	1	
A	PROSPECT DISTRIBUTED BY CARVER, November 1981, pages 1-13: "Heaters and accessories" * Pages 1,2 *	1,5	
A	EP-A-0 036 997 (PHILIPP KREIS GmbH)		
A	GB-A-2 076 508 (MORCO PRODUCTS LTD) * Abstract; figures *	1,8	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	US-A-3 789 827 (KOLKKA) * Figure 2 *	1,8,14	F 24 H B 60 H F 24 C F 23 C
A	US-A-3 168 091 (JACKSON) * Figure 7 *	1,17	
A	GB-A-1 076 677 (EMPIRE STOVE COMP.) * Whole document *	1,17	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18-02-1987	VAN GESTEL H.M.

CATEGORY OF CITED DOCUMENTS

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