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(54) Heat exchange apparatus.

(57) A heat exchange apparatus for removing residual heat from a domestic or small commercial boiler has three heat exchange vessels 12,14,16 which contain water to be heated by the the flue gas. Provision is made for draining out condensation which may form in the apparatus: condensation forming on these cooled vessels 12,14,16 falls or is guided onto a base 80 shaped so that condensate drains out through an outlet 84 provided. A reversal 90 in the direction of flue gas proximate the base of vessels 14 and 16 promotes deposition of fly ash. Deposited fly ash can be removed through a door 92. The apparatus is made from steel plate. To protect it against corrosion caused by sulphur acids contained in the flue gas, and which dissolve in the condensation, its inner casing is dip-coated with a thermosetting synthetic resin paint curable by stoving.

EP 0 033 229 A2

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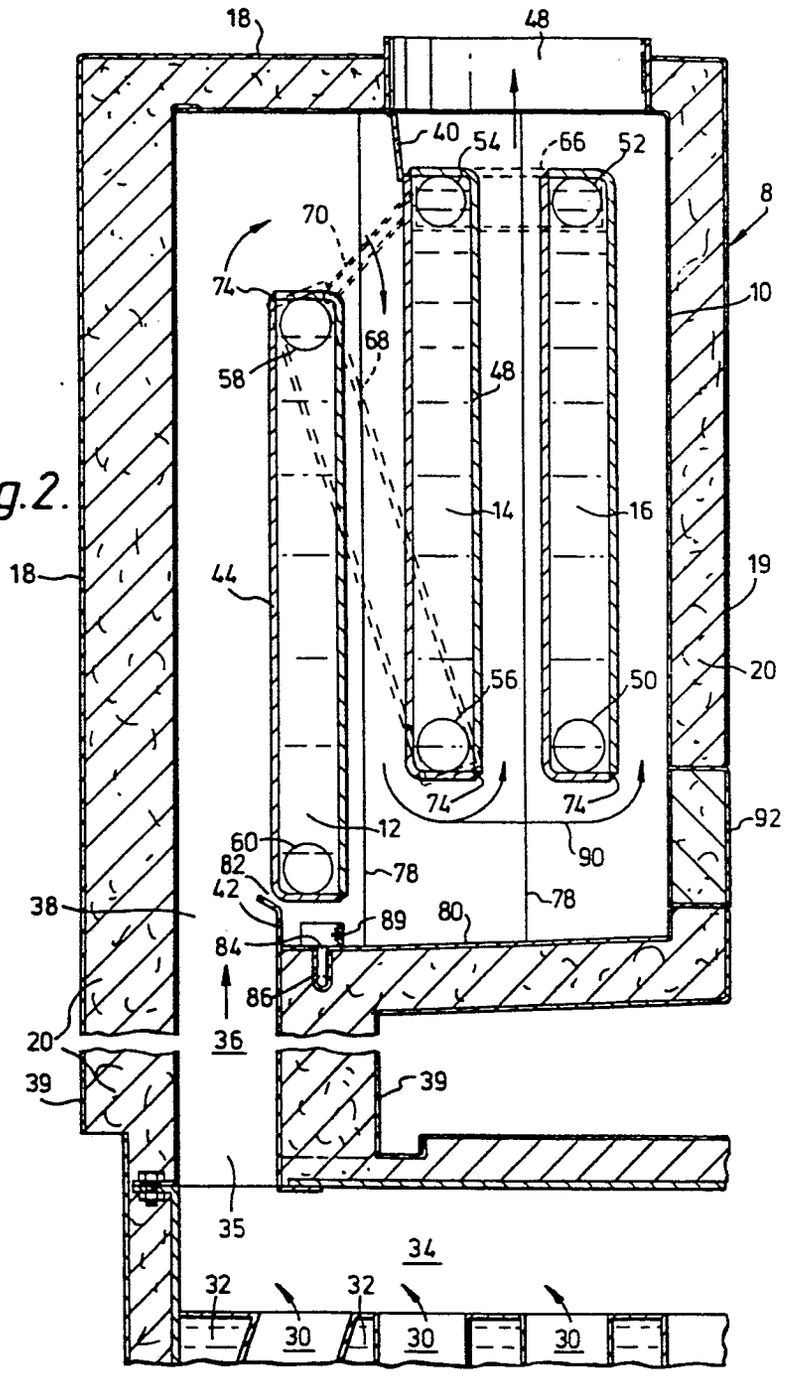
Fig.2.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HEAT EXCHANGE APPARATUS

This invention relates to heat exchange apparatus, also known as an "economiser", serving to withdraw heat from flue gases. It is primarily concerned with apparatus which would receive the flue gas from domestic or small commercial heating apparatus used to heat a fluid medium, especially water. Such heating apparatus would typically have a heat output in the range 60,000 to 300,000.Th.U/h (approximately 16 to 84 kilowatts) and heat a fluid medium such as water for central heating or air for a ducted warm air central heating system. It may be oil or gas fired apparatus in accordance with my co-pending United States Application Serial No. 177919, Canadian Patent Serial No. 358404 and European Patent Application No. 80.302818.2, intended to be published under No. 0024376.

It is often the case with domestic or small commercial heating apparatus that the flue gas leaving the apparatus still contains a certain amount of recoverable heat and the apparatus of this invention can be employed for recovering further heat from the flue gas and thereby increasing the overall heating efficiency. The apparatus of the present invention serves to transfer heat from the flue gas to a fluid medium and this fluid

medium will generally be the same as that which is heated in the main heating apparatus; if so the heated fluid medium which flows out from the heat exchange apparatus of this invention passes on to the main heating apparatus where it is heated further.

One problem which can arise with heat exchange apparatus of the type indicated is that if an overall efficiency of much over 80% is achieved the flue gases are cooled almost to the dew point. The combustion products of oil and natural gas include a lot of steam and such cooling entails a risk of condensation forming. This can form in the heat exchange apparatus or in the chimney especially during starting up from cold. The amount of this condensation can be substantial. It can have a damaging effect on the structure of the chimney as well as other problems, and can lead to corrosion of the boiler, thus shortening its life. Hitherto it has frequently been considered necessary to keep the temperature above the dew paint throughout the system, which entails substantial waste of heat.

The problem is exacerbated in the case of fuel with a substantial sulphur content. Oil frequently does have a substantial sulphur content. The condensation tends to absorb sulphur-containing combustion products emanating from any sulphur content of the fuel and corrosive

sulphur acids can be formed. It will be readily appreciated that the presence of such corrosive acids on cast iron or welded steel parts can greatly reduce the working life of the equipment. Even stainless steel is not resistant to these acids. Attention does not appear to have been paid, heretofore, to the problem of acid condensation from flue gas.

One object of this invention is to provide heat exchange apparatus for withdrawing heat from flue gases which will enable an improvement in overall efficiency, for example to 90-95%, to be obtained without undue difficulty being caused by condensation. Broadly the invention achieves this by providing for drainage of condensation out of the heat exchange apparatus in an acceptable manner. Preferably condensation forming on any cooled part of the apparatus, or dripping back from the chimney, is intercepted and drained out, so that none of the condensation returns to the boiler.

Another problem which can arise with heating apparatus in which fuel is burnt is that fly ash particles, i.e. particles of solid material entrained in the flue gas, can accumulate and tend to block the chimney, particularly at its base or at a point in the chimney at which there is a change in the direction of flow. Such fly ash can cake into hard material in the

presence of the condensation referred to above. In one of its forms the present invention seeks to overcome this problem by inducing the deposition of entrained solid particles within the heat exchange apparatus and moreover at a place where this deposition can be tolerated and from which the deposited particles can reasonably easily be removed. Deposition is induced by constraining the flue gas to reverse its direction from downwardly to upwardly, preferably accompanied by an increase in the cross sectional area available for flow.

A further object of this invention is to provide heat exchange apparatus of the type specified which will be resistant to the corrosive effects of sulphur acids contained in any condensation.

To this end the invention provides heat exchange apparatus having surfaces which are to be exposed to flue gases coated with a thermosetting synthetic resin resistant to the heat of the flue gas. Preferably the resin is applied by a dip coating process and more preferably it is an epoxy resin paint applied by dip coating and cured by heating.

The economiser can be mounted, for example on a wall, above an existing boiler or other fuel burning heating apparatus. Alternatively, where the economiser and fuel burning apparatus are being designed to go

together, they can be made to form a single unit with the economiser mounted above and supported by the fuel-burning apparatus.

An example of heat exchange apparatus (to be referred to as an "economiser") embodying this invention will now be described with reference to the accompanying drawings in which:

Fig. 1 is a perspective view of the economiser showing its mounting as a common unit with fuel-burning heating apparatus, and

Fig. 2 is a section through the economiser taken on the line II-II of Fig. 1.

Referring to the drawings, the economiser 8 (i.e. heat exchange apparatus) broadly comprises a casing 10 through which flue gas passes and within which there are heat exchange vessels 12,14,16 which in use are filled with water to be heated and which are exposed to the flue gas. If desired these vessels 12,14,16 could be provided with metal fins or could be corrugated to enhance their heat exchange efficiency.

The casing 10 is contained within an outer casing 18, whose front face is designated 19. The space between the two casings is packed with thermal insulation such as glass wool 20.

As shown by Fig. 1, the economiser 8 is mounted

above an oil-fired water-heating boiler 22 which is generally as described in my co-pending applications referred to previously. The two pieces of apparatus are constructed as a single unit with the weight of the economiser taken by the boiler 22 beneath. It will be seen that the sides of the outer casing 18 of the economiser lie flush with the sides 26 of the outer casing of the boiler.

Within the boiler 22 oil is burnt as fuel (although gas could be used as fuel) and the hot flue gases produced rise up through an array of tubes 30 extending through a tank 32 containing water to be heated. The flue gases then collect in an upper manifold 34 and leave by an exit 35 which extends across substantially the full width of the boiler 22 between the layer of heat insulation which the boiler has at each side. From the exit 35 a duct 36, which also extends across substantially the full width of the boiler, carries the flue gas up to the inlet 38 to the casing 10. The duct 36 is formed by an extension of the casing 10 and it is contained within an outer casing 39 integral with the casing 18. Heat insulation 20 is provided between the duct 36 and this outer casing at the front and rear (as shown by Fig. 2) and also at each side. The inlet 38 to the casing 10 extends across the full width of that

casing.

Within the tubes 30 are spiral metal retarders (not shown). The spacing of the economiser 8 above the boiler 22, together with a forward tilt to the rearmost tubes 30 allows these retarders to be pulled out for cleaning.

As shown by Fig. 2, within the casing 10 the flue gases are constrained by baffles 40, 42 to flow first upwardly over the rear surface 44 of the heat exchange vessel 12 then downwardly over the facing surfaces of the vessels 12 and 14 and thereafter round and up over the front surface 46 of the vessel 14 and both surfaces of the vessel 16. The flue gases finally flow out of the casing 10 through an upper outlet 48.

Both the main boiler 22 and the economiser 8 are employed to heat water, for a central heating system for instance. This water flows first through the vessels in the economiser 8 generally in countercurrent to the flue gas and then into the tank 34 of the boiler 22. In more detail, the cold return of water from the central heating system is connected so as to flow into the heat exchange vessel 16 through its inlet 50 (Fig. 1). Water leaves this vessel through an upper outlet hole 52 and is carried by duct 66 to an inlet hole 54 of the vessel 14. The water flows out of vessel 14 through a hole 56 into duct 68 leading to an upper inlet hole 58 of the vessel

12 which has a lower, outlet hole 60 connected by a pipe 62 to an inlet 64 of the tank 34. An outlet, not shown, from the tank 34 provides the hot flow to the central heating system.

The ducts 66, 68 are cuboidal boxes welded to the side wall of the casing 10. Each of these boxes is open on its side welded against the wall of the casing, which thus closes the boxes to form ducts between the holes 54 and 56 and between the holes 58 and 60.

In order to allow venting of air when the apparatus is initially filled, a small tube 70 is provided connecting the ducts 66 and 68 and on the outer side of the duct 66 a small bleed valve, of the type used for central heating radiators, is provided through which air trapped in the apparatus can be vented.

Each of the vessels, 12,14,16 is constructed from two pieces of sheet steel which are bent into an L shape (see Fig. 2) and the two pieces then joined by welds 74 to form a hollow box section. This box section is then welded at each end to a plate 76 forming a part of a sidewall of the casing 10. When the economiser is assembled the three plates 76 at each side butt edge to edge and are welded together at the butt joins 78. Sufficient gas-tightness is achieved without welding down the full length of each butt join 78 but welding must be

provided where the ducts 66,68 cross butt joins, in order to achieve water-tightness.

The hot flue gases coming into the economiser 8 from the boiler 22 yield up a large proportion of their heat to the incoming return water flowing through the vessels 12,14,16 and which is consequently warmed by 7-10°F (4-6°C) before returning to the boiler 22 itself. The unit formed by the boiler 22 and the economiser 8 can achieve an overall water heating efficiency of around 90-95%. This cools the flue gases sufficiently that condensation can occur within the economiser (where it initially forms on the vessels 12,14,16) and also within the chimney into which the flue gas from the outlet 48 passes. Any condensation which forms on the front surface of the rearmost heat exchange vessel 12, or on the vessels 14 or 16, or any which drips back into the casing 10 from the chimney will fall onto the bottom surface 80 of the casing 10. Also the baffle 42 is shaped so that any condensation running down the rear surface of the heat exchange vessel 12 will be diverted through the small gap 82 between the vessel 12 and the baffle, rather than dripping back into the boiler. The reduction in efficiency caused by gas leakage through this aperture 82 is sufficiently small as to be acceptable.

The bottom surface 80 of the casing 10 is inclined

so that condensation falling onto it drains rearwardly, and flows out through an outlet aperture 84 from which a duct 86 leads first downwardly and then sideways (backwards from the plane of the paper as seen in Fig. 2) leading out through the side of the economiser. A flexible plastic tube 88 is connected onto the duct 86 and this is used to carry any condensation away to some convenient drain. The position of the economiser 8 above the boiler 22 gives some hydrostatic head, and enables the tube 88 to be run along a wall for some distance if this is required in order to reach a drain. A guard 89, to be further mentioned below, partially surrounds the outlet 84.

The economiser 8 also has provision for causing the deposition of fly ash at a point from which it can be removed reasonably easily. The vessels 12 and 14 together with the baffles 40,42 constrain the flue gas to reverse its direction, as indicated by arrow 90, from downwardly to upwardly beneath the vessels 14,16. The reversal of direction induces deposition of any fly ash from the flue gas stream. Moreover, the large void space at this point means that the cross section available for flow of the flue gas increases rapidly as the gas debouches from the passage between the vessels 12 and 14, so causing the speed of flow to reduce. This slowing further induces

deposition of any entrained fly ash.

In the front face 19 of the economiser an access door 92 is provided enabling removal of any fly ash which has accumulated in the void space beneath the vessels 14,16 (where the space available is such that some build up of ash is tolerable. Provision for promoting deposition of fly ash at a place from which it can be removed obviates the formation of blockages elsewhere. When the ash is removed the surfaces of the vessels 12,14,16 can be lightly brushed to maintain their heat exchange efficiency.

In order largely to prevent fly ash from entering the condensation drainage outlet 84, a guard 89 is placed around this. It consists of a small metal strip bent into a U-shape and positioned around the outlet 84 so that the opening between the arms of the U is at the rear. One arm only of the U-shape can be seen in Fig. 2. Alternatively the guard could completely encircle the outlet 84, but have a serrated bottom edge standing on the bottom surface of the casing 10. Condensate would pass between the serrations but these would act as a coarse filter, holding back the fly ash.

The parts of the economiser are made of mild steel plate. In order to protect the parts which are exposed to the sulphur acids contained in any condensation which

forms, a thermosetting synthetic resin coating is applied to all of the interior surfaces which in use are exposed to flue gas The coating is provided by applying a fairly thick film of a phenolic epoxy resin paint curable by heating, and then baking to effect the curing and provide a hard impermeable coating. The paint is applied by dip coating to the whole of the inner casing 10, with the vessels 12,14,16 and the ducts 66,68 in place and with the inlet 50 and outlet 60 temporarily blocked to close off the system of spaces which in use are filled with water.

To apply the paint the assembled casing 10 is submerged in a suitably shaped tank filled with the paint, so that (inter alia) all interior surfaces of the casing and the exterior surfaces of the heat exchanger vessels (which are the surfaces exposed to flue gas, in use) are coated by the paint. The casing is then lifted out and surplus paint allowed to drain back into the tank. After it has drained the casing is stoved to cure the coating.

The paint can be a stoving modified epoxy paint containing pigment, paint extenders (finely ground powders such as barytes and talc) liquid synthetic resins such as epoxy alkyd and melamine-formaldehyde, hydrocarbon and other solvent liquids such as ethyl

cellosolve (2-ethoxyethan-1-ol)

An epoxy phenolic enamel paint has been successfully used. It was a paint supplied by Pinchin Johnson Paints Packaging and Coil Coating Division, London, England under their designation PJ 2088. This paint has hitherto been used for coating steel drums, an application where it is not, of course, subject to heat in use. As supplied it contained 40-44% solids by weight. For application it was diluted by adding thinner from the same manufacturer, supplied under their designation number 0000 5 1059. The thinner comprises ethyl cellosolve blended with low boiling naptha. About 4 to 5 litres of this were added to 100 litres of the paint. This dilution gave a creamy consistency slightly more viscous than domestic gloss paint. After dipping the casing, surplus paint was allowed to drain back into the tank at room temperature for approximately 30 minutes. After it had drained the casing was stoved at 403°F (206°C) for 7 minutes to cure the coating. The paint film which remained after the casing had been allowed to drain was rather thick and gave an eventual baked coat about 0.002 inch (50 microns) thick. Only a single coat would normally be applied but if appropriate to meet extremely difficult conditions a further coat could be applied. This would be put on after the first coat had

been baked and the casing allowed to cool back to room temperature. It would be applied by dip coating as above, with stoving at the same temperature but for 15 minutes.

CLAIMS

1. Heat exchange apparatus for transferring heat from flue gases to a fluid medium comprising a casing (10) having an inlet (38) thereto and an outlet (48) therefrom for flue gas and heat exchange means (12,14,16) within the casing defining one or more spaces for the passage of a fluid medium, the heat exchange means having surfaces exposed to the flue gas for the transfer of heat from the gas to the said fluid medium, the lower part (80) of the casing having at least one drainage outlet (84) for any moisture which may condense out within the casing, and being shaped so that such moisture will drain to the or a said outlet (84).

2. Apparatus according to Claim 1, wherein condensation draining off any surface of the said heat exchange means (12,14,16) will drain to the or a drainage outlet (84).

3. Apparatus according to Claim 1, or Claim 2, wherein the flue gas outlet (48) is positioned so that any condensation draining back through it into the casing will drain to the or a drainage outlet (84).

4. Heat exchange apparatus for transferring heat from flue gases to a fluid medium comprising a casing (10) having an inlet (38) thereto and an outlet (48) therefrom for flue gas and heat exchange means (12,14,16) within the casing defining one or more spaces for the passage of a fluid medium, the heat exchange means having surfaces exposed to the flue gas for the transfer of heat

from the gas to the said fluid medium,, the heat exchange means (12,14,16) and/or one or more baffles (40,42) being arranged within the casing (10) so as to constrain the flue gas to reverse its direction of flow from downwardly to upwardly, thereby to induce deposition of any solid particles entrained in the flue gas as it reverses its direction;

the casing including a closable aperture (92) enabling periodic removal of solid material deposited from flue gas in the region of the reversal of direction.

5. Apparatus according to Claim 4, wherein the cross section available for flow of flue gas increases at the region of the reversal of flow, inducing a retardation of the speed of flow and further inducing deposition of entrained particles.

6. Heat exchange apparatus for transferring heat from flue gases to a fluid medium comprising a casing (10) having an inlet (38) thereto and an outlet (48) therefrom for flue gas and heat exchange means (12,14,16) within the casing defining one or more spaces for the passage of a fluid medium, the heat exchange means having surfaces exposed to the flue gas for the transfer of heat from the gas to the said fluid medium, surfaces of the casing (10) and of the heat exchange means (12,14,16) which are exposed to the flue gas having a coating of a thermosetting synthetic resin.

7. Apparatus according to Claim 6, wherein the resin is an epoxy phenolic paint.

8. Apparatus according to Claim 6 or Claim 7 formed of mild steel, wherein the steel surfaces are phosphated prior to the application of the resin thereto.

9. Apparatus according to any one of the preceding claims, wherein the heat exchange means comprises a plurality of heat exchange units (12,14,16) each defining a space for the fluid medium and having surfaces exposed to the flue gas, the flue gas which passes through the casing being constrained to flow first upwardly over one surface of one heat exchange unit (12) thereafter downwardly between that unit (12) and a second (14), then to reverse its direction of flow from downwardly to upwardly and flow over a second surface of the second unit (14) and at least one surface of a third unit (16), the heat exchange units (12,14,16) being connected together, so that the flow of fluid medium through them is generally countercurrent to the flow of flue gas.

10. In combination, heat exchange apparatus according to any one of the preceding claims, and fuel burning apparatus (22), the two pieces of apparatus being of similar width and arranged as a single unit with the heat exchange apparatus (8) mounted above and supported by the fuel-burning apparatus (22), the flue gas passing through a connection (36) between them which extends across a major proportion of the width of the apparatus, and a heated fluid medium outlet (60) from the heat exchange apparatus being connected to a fluid medium inlet (64) of the fuel burning apparatus (22).

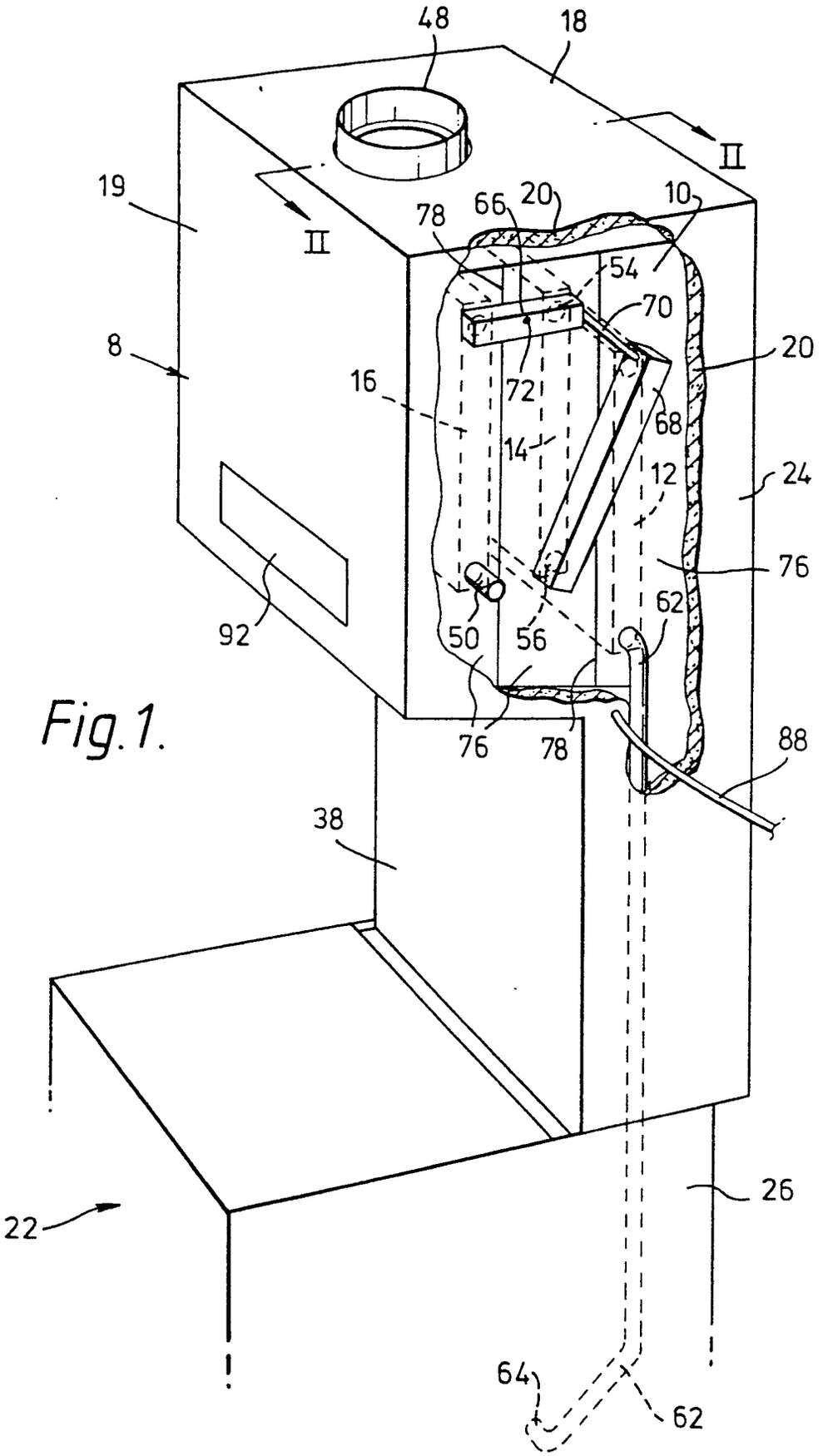
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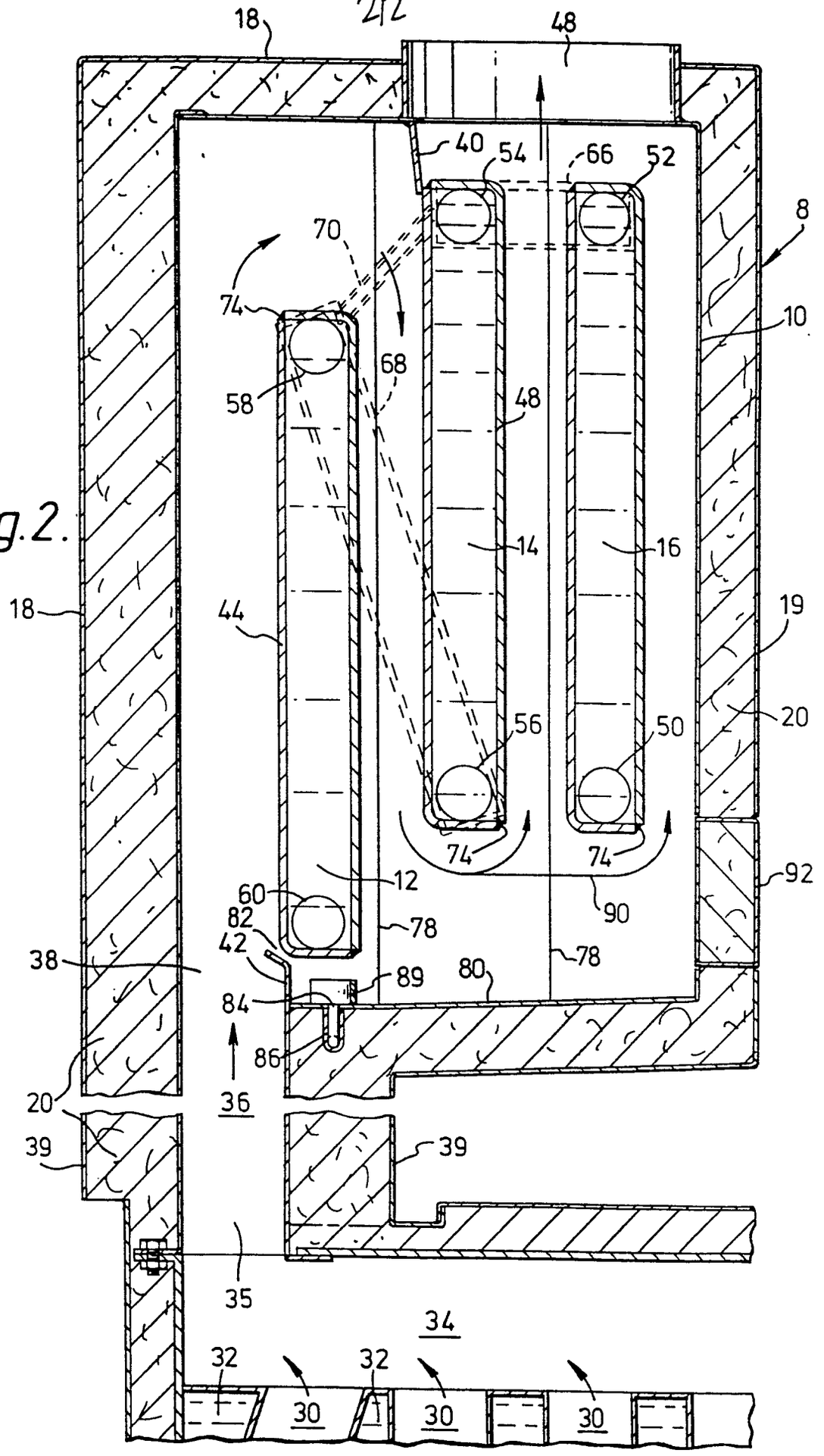
Fig.1.

Fig.2.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