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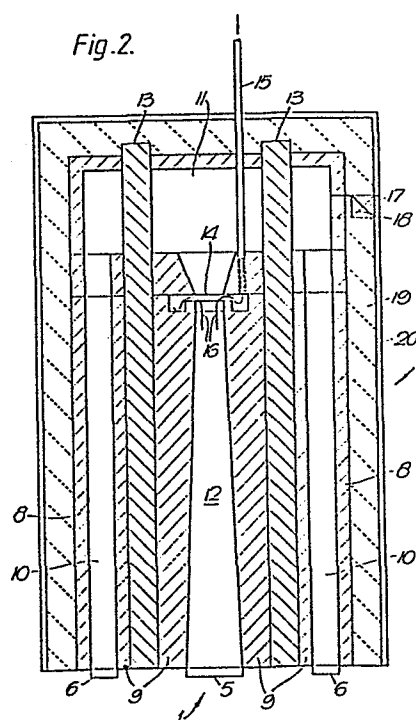
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54 Heater.

57 A heater in the form of a hot air gun 1 has a heat mass (8,9) capable of storing heat energy from heat sources (13) and capable of transferring that heat energy to a fluid e.g. air to be heated. The air enters the gun 1 through inlet 6 and passes via conduit 10, in which it is heated by contact with the heat mass (8, 9) to a plenum chamber (11). A venturi (14) pumps the air from the plenum chamber (11) to an outlet (5), via a conduit (12) where the air is again heated by contact with the heat mass (9). The heat mass (8, 9) transfers heat to the air rapidly so that during a pulse of air, much energy is transferred, but between air pulses the heat mass acts as a reservoir of heat.



1.

"HEATER"

The present invention relates to a heater for generating a flow of hot fluid.

5 It is well known to generate a flow of hot fluid, either liquid or gas by passing the fluid past one or more heating elements. For example, a standard hair drier has a fan which produces a flow of air which is expelled from the drier over an electrically heated coil
10 or wire. For industrial purposes, hot air blowers, operating on a similar principle to a hair drier, are used in a large number of situations e.g. for drying, softening of plastics materials or curing of adhesives. Similar arrangements are known for heating liquids.

15 The heating elements of such heaters have a relatively high thermal conductivity as this enables energy to be transferred quickly and efficiently to the gas (or liquid where appropriate). However, this means that energy loss is rapid and a high level of energy must
20 be supplied to the heating element in order to maintain it at a sufficiently high temperature to heat the gas. Any heating element will have a warm up time so that if the supply of energy at a high level is discontinued, the heating element will cool rapidly and there will then be
25 a delay between the resumption of the energy supply and

the heating element reaching the desired temperature.
For this reason such heaters are normally operated
continuously.

For industrial processes in which a continuous
5 supply of hot gas is required, such heaters are
satisfactory. However, there are many industrial
processes which require an intermittent hot gas supply.
An example of this is in shrink wrapping. In shrink
wrapping, an item or items to be wrapped are enclosed in
10 a loose sleeve or bag of thin film plastics material.
The film is heated to a temperature at which the film
shrinks to encase the item to be wrapped. Standard
shrink wrapping plastics material films must be heated to
a temperature between 80°C and 200°C in order to achieve
15 the necessary shrinkage.

It is known to use heaters known as hot air guns
in shrink wrapping which direct a jet or jets of hot air
onto the plastics film. These hot air guns operate on a
similar principle to that previously described and have
20 the same problem, namely that they must be operated
continuously in order to maintain the heating element or
elements at the desired temperature. It is usual to
transport the articles to be wrapped past the hot air gun
on a conveyor belt. It would be desirable for the hot
25 air gun to produce a pulse of hot air only when an

article to be wrapped is passing the gun, but this is not possible with the standard hot air guns because of the delays due to warm up time that would be imposed if the hot air gun was operated intermittently. Thus a large
5 proportion of the energy output of the gun is wasted and the energy input to the gun must be maintained continuously at a high level.

In addition to the hot air gun, it is known to shrink wrap articles using a "shrink tunnel". An article
10 loosely wrapped in a plastics film is passed by a conveyor through an oven heated to approximately 150°C and 300°C. The oven forms a heat mass which heats the air within it. To improve the heat efficiency, most shrink tunnels use fans within the oven to circulate the
15 air in it. However, the design of shrink tunnels inevitably results in very high energy losses, both due to radiation or convection from the oven itself and also due to the heating of the conveyor as well as the article. Furthermore, the air within the oven is
20 maintained at a continuously high temperature and so the effect of discontinuous energy output is not achieved. Also, such shrink tunnels are not portable.

Therefore the present invention seeks to overcome, or at least ameliorate, the problem of high
25 energy loss when a hot air gun is operated

intermittently, and provide a heater which produces pulses of heated fluid efficiently. This is achieved, according to the present invention, by the use of a heat element which is capable of storing heat energy and

5 capable of transferring that heat energy to the fluid to be heated during a pulse of heated fluid. A heating element capable of achieving these two results will be referred to hereinafter as a heat mass. The heat mass stores heat energy so that it acts as a reservoir of heat

10 energy whereby heat energy can be withdrawn from that reservoir during a fluid pulse and the reservoir be replenished by input of energy to the heat mass between the pulses. To achieve this function, the heat mass must have a heat capacity large enough to store a suitable

15 amount of heat energy. To permit this, it would be desirable for the material forming the heat mass to have a large specific heat capacity, such as a heat insulator, except that such materials generally have a low thermal conductivity and so would be inefficient in transferring

20 heat energy to the fluid. In order to achieve good heat transfer it is preferable that the thermal conductivity of at least the part of the heat mas adjacent the surface to be contacted by the fluid is sufficiently high, normally at least $30 \text{ Wm}^{-1}\text{K}^{-1}$, more preferably $50 \text{ Wm}^{-1}\text{K}^{-1}$.

25 This limits the materials which may be used for the heat

mass, and hence prevents maximisation of the specific heat capacity.

The desired heat capacity depends on a number of parameters:

- 5 1. The temperature at which the heat mass is to be operated (the higher the temperature the more energy stored).
2. The desired temperature of the fluid during a fluid pulse (the higher the desired temperature the more
10 energy which must be transferred).
3. The permissible drop in temperature of the fluid during a fluid pulse (since more energy is being taken from the heat mass than is being supplied to it, the temperature of the heat mass will cool during the pulse
15 and hence so will the fluid).
4. The desired size of the heater (this limits the mass of the heat mass).
5. The desired output volume of the fluid during the pulse (the longer and more powerful the pulse the more
20 energy is removed and hence the more heat capacity needed).
6. The degree of insulation of the heat mass (this affects the heat losses from the heat mass).

These parameters must be selected in accordance
25 with the desired properties of the heater and since all

are inter-related the limits on the ranges of values which are suitable for any particular use depend on that use.

For shrink wrapping applications, the desired
5 temperature of the gas must be about 80°C to 200°C and the permissible drop in temperature is less than 10% (usually about 2%). A suitable temperature for the heat mass is about 500°C to 700°C and at least 100 kJ (preferably 800 kJ) of energy should be stored. Thus the
10 heat capacity is desirably at least 200 JK⁻¹, preferably 1600 JK⁻¹.

The limitation on the thermal conductivity of the heat mass means that the material is desirably a metal. A metal with high thermal conductivity such as aluminium
15 may be used, although steel has been found suitable. A mass of about 3.1 kg of steel is needed to achieve the heat capacity stated above.

The insulation of the heat mass must limit the energy lost. This may be calculated by noting the
20 initial rate of temperature drop from the operating temperature with no energy supplied to the heat mass and no fluid being expelled from the heater. The rate, with an operating temperature of about 500°C should preferably be less than 5 Ks⁻¹ (preferably about 0.3 Ks⁻¹).

25 By suitable choice of these parameters the mean

energy supplied to the mass may be made less than the mean energy transferred to the fluid during a fluid pulse. Preferably the mean energy transferred to each pulse is more than ten times the mean energy supplied.

5 The present invention is applicable both to the heating of gases and to the heating of liquids.

 The heating element and the means for generating pulses of gas or other fluid are preferably located in a housing which is movable to enable the hot gas output to
10 be directed in any desired direction. For example, a heater according to the present invention in the form of a hot air gun may be located over a conveyor belt carrying articles to be shrink wrapped, the hot air output being produced only when an article is below the
15 heater.

 Preferably the input(s) for fluid and the output(s) of the heater are close together so that hot fluid may be recirculated past the heating element. This may be achieved by providing inlets radially spaced by
20 equal distances from a central outlet. Alternatively, a linear array of inlets may be provided adjacent a corresponding array of outlets, or an elongate inlet and an elongate outlet may be provided side by side.

 Embodiments of the invention will now be
25 described in detail, by way of example, with reference to

the accompanying drawings in which:

Figure 1 shows a heater being a first embodiment of the present invention;

Figure 2 shows a sectional view through the
5 heater of Fig. 1;

Figure 3 shows an alternative housing configuration for the heater of Fig. 2;

Figure 4 shows an alternative inlet and output arrangement for a heater according to the present
10 invention;

Figure 5 shows a second alternative inlet and outlet arrangement for a heater according to the present invention; and

Figure 6 shows a sectional view through a heater
15 being a second embodiment of the present invention, along the line V-V in Fig. 4.

Referring to Fig. 1 a heater in the form of a hot air gun 1 being a first embodiment of the present invention is positioned above a conveyor belt 2 on which
20 are carried articles 3 to be enclosed within a plastics film 4 which is shrunk around the article 3 by heating the film 4. The conveyor 2 carries the article 3 to a position directly below the outlet 5 of the gun 1 and the gun 1 is activated. The conveyor may stop with the
25 article directly below the outlet 5 or the article may be

heated as it moves past the gun 1. Hot air is directed from the output 5 onto the film 4. This heats the film and causes it to shrink. The hot air is reflected by the film and the conveyor belt and is drawn back into the gun 1 through inlets 6.

Referring now to Fig. 2 the gun 1 has an outer casing 7 and contains a heating element having an outer heat mass 8 and an inner heat mass 9.

The heat mass is formed from a material having a thermal conductivity of at least $30 \text{ Wm}^{-1}\text{K}^{-1}$. Most metals satisfy this parameter, and aluminium has a particularly high specific heat capacity, so a small mass would be needed. However, aluminium also has a low density and hence the gun 1 would be bulky. The preferred material is therefore stainless steel, because it has suitable thermal conductivity, specific heat capacity, density, emissivity and enthalpy and also is resistant to corrosion at high temperatures e.g. 500°C . With an operating temperature of 500°C and an air output temperature of about 100°C a mass of 3.1 kg of steel has been found to provide a suitable heat mass. The mean energy transferred to each air pulse may then be more than 10 times the mean energy supplied.

Another possibility is that the heat mass is a liquid encased in a metal shell, the metal transforming

10.

heat rapidly to the gas and the liquid acting as the main heat reservoir due to its high specific heat capacity.

If metal is used it may be a bulk material, a spiral or spirals, or a tube, but is preferably formed by clamping plates of the metal to square section heating sources 13. The heating sources may supply heat energy at the same rate, or at different rates, so that using either one or both gives three different heat inputs.

Inlet conduits 10 are formed between the outer and inner heat masses 8 and 9 extending from the inlets 6 to plenum chamber 11. An outlet conduit 12 extends from the plenum chamber 11 to the outlet 5 through the centre of the inner heat mass 9. The outlet conduit 12 is flared towards the outlet 5 to form a flared jet of hot air. A plurality of inlet conduits 10 with corresponding inlets 6 may be provided spaced around a circle centred on a central outlet conduit 12.

The heating sources 13 extend through the outer and inner heat masses 8 and 9 and are thermostatically controlled to maintain the heat mass at a uniform temperature, e.g. 500°C to 700°C.

The movement of air through the gun may be achieved in a number of ways. As shown in Fig. 1, the air mover may be a venturi 14 powered by a supply of compressed air through a duct 15. The compressed air

passes into the inlet conduit 12 and the flow 16 of compressed air entrains air from the plenum chamber 11 thereby creating a jet of air in the outlet conduit 12. Alternatively the air mover may be a vaned pump as will be discussed later with reference to Fig. 5, or a fan. If a pump or fan is used, it is preferably made of stainless steel. Additional fans may be provided in the inlet conduits. The speed of such pumps and/or the speed of the venturi may be controlled to vary the volume and pressure of the hot air jet from the outlet 5.

The pressure of the air pulses is also effected by the angle of flare of the outlet conduit 12. When the gun 1 is activated the pump or venturi 14 pumps hot air from the plenum chamber 11 through the outlet conduit 12 to the outlet 5. Simultaneously, air is drawn into the inlets 6 and through the inlet conduits 10 to the plenum chamber 11. Because both the inlet conduits 10 and the outlet conduit 12 are surrounded by the heat mass, the air passing through the blower is heated both in its passage from the inlets 6 to the plenum chamber and its passage from the plenum chamber to the outlet 5.

To control the temperature of the plastics film 4 sensors may be provided adjacent the article 3 which control a valve 17 in a passage 18 from the outside of the gun 1 through the plenum chamber 11. When this valve

is open, air is drawn into the plenum chamber 11 thereby reducing the temperature of the output. the casing 7 is formed by insulation 19 of a cast refractory material such as calcium silicate adjacent the outer portion 8 of the heat mass and outer skin 20 of e.g. polyester resin. The insulation 19 enables the heat mass to be maintained continuously at a high temperature with only a small energy input.

The conductivity of the heat mass and the insulating properties of the insulation 19 determine the rate of cooling of the heat mass. A high conductivity permits rapid transfer of heat to the air when the gun 1 is in operation but increases the heat loss, and hence the energy input necessary, when the gun 1 is not in use. The temperature drop at the operating temperature (with no heat energy supplied and no air being expelled) needs to be less than 5°C per second (5 Ks^{-1}) if the energy input is to be kept low, and a suitable figure is 20°C per minute (0.3 Ks^{-1}). The insulation may be if approximately uniform thickness as shown in Fig. 2, but preferably is thicker in the part surrounding the plenum chamber 11 as shown in Fig. 3. Thus the casing 7, consisting of the insulation 19 and the outer skin 20 forms a horse-shoe shape with a central cavity 21 which houses the heat mass etc. which may be identical to that

shown in fig. 2. An aperture 22 is provided in the casing 7 for wires to connect the heating sources to an external power supply. To support the heater 1, trunnions 23 may be provided on the casing 7. Also shown in Fig. 3 is an outer flange 24 at the bottom of the casing 7 which constrains the hot air reflected from an object into the vicinity of the inlet to the heater. The transit time of the article 3 through the hot air jet or jets may be controlled by varying the speed of the conveyor, or the conveyor may be stopped below the blower for a suitable time.

Instead of a radial arrangement of inlets around a central outlet, a linear array of inlets and outlets may be used as shown in Figure 4. Inlets 6 and outlets 5 extend in in two rows along the bottom of the blower 1 in a series of adjacent pairs. Each pair may communicate with a corresponding plenum chamber, or all the inlets and outlets may have a common plenum chamber. When used for shrink wrapping, the blower 1 extends across the conveyor belt to form a hot air curtain through which the article must pass. If desired the array of inlets and outlets may be combined into two adjacent elongate slots, one of which is an inlet 6 and one an outlet 5. This arrangement is shown in Fig. 5. Again, a hot air curtain is formed.

In the sectional view of Fig. 6 a second embodiment of a hot air gun 1 according to the present invention has an inlet 6 and an outlet 5 as shown in Fig. 4. An inlet conduit 10 from the inlet 6 and an outlet conduit 12 to the outlet 5 communicating with a common plenum chamber 11 are arranged on either side of a central heat mass 25. Fins 26, 27 may be provided in the inlet conduit 10 and the outlet conduit 12 respectively to improve heat transfer from the heat mass 25 to the air in those conduits.

A pump 28 is provided in the plenum chamber 11 to draw air from the inlet 6 to the outlet 5. As shown, the pump comprises a vaned cylinder which entrains air and carries it from the inlet side of the plenum chamber 11 to the outlet side. By suitable design of the plenum chamber 11, the pump 28 and the part 24 of the heat mass adjacent the pump, it is possible to minimise the back-flow of air so that most of the air entrained by the pump is expelled through the outlet conduit 12. As in the embodiment of Fig. 2, casing 7 formed by insulation 19 and an outer skin 20 is provided around the conduits 10, 12 and the plenum chamber 11.

The present invention is particularly applicable to shrink wrapping processes, but may find application wherever an efficient source of hot air, gas or other

fluid is required.

As shown in Fig. 1 the dimensions of the article are preferably of the same order of magnitude as the width of the gun 1 and the distance between the gun 1 and the conveyor 2. If a much smaller article 3 is shrink-wrapped, the advantages of the present invention are also achieved but with reflection of hot air being primarily from the conveyor 2. When the dimensions of the article 3 are less than the width of the outlet 5, the hot air jet completely surrounds the article 3 improving the efficiency of the system.

In a given installation several hot air guns of the same or differing sizes with the same or differing hot air flows may be grouped to provide the required heat pattern.

Although described in connection with a heater for gas, the present invention is also applicable to the heating of liquids. This is particularly true of the embodiment of Fig. 6 where the pump 23 may pump liquids easily.

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CLAIMS

1. A heater (1) comprising a heating element (8,9) adapted to receive heat energy from a heat source (13), and to transfer heat energy to a fluid by contact of that fluid with at least a part of the heating element (8,9), and a pumping means (14) for intermittently expelling heated fluid from the heater (1) in a series of fluid pulses;
characterised in that:
the heat capacity of the heating element (8,9) is such that it is capable of storing heat energy from the heat source (13) between fluid pulses, and the thermal conductivity of at least the part of the heating element (8,9) to be contacted by the fluid is such that the mean heat energy transferred to the fluid during a fluid pulse is greater than the mean heat energy received by the heating element (8,9) from the heat source.
2. A heater according to claim 1, having an outlet (5) from which heated fluid is expelled, and a plurality of inlets (6) for fluid to be heated, the inlets (6) being disposed radially around the outlet (5).

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3. A heater according to claim 1 having a plurality of outlets from which heated fluid is expelled, and a plurality of inlets for fluid to be heated, the plurality of outlets and plurality of inlets being in at least two substantially parallel rows.
4. A heater according to claim 1, having at least one elongate outlet from which fluid is expelled and at least one elongate inlet for fluid to be heated, the outlet(s) and inlet(s) being substantially parallel in the direction of their length.
5. A heater according to any one of the preceding claims wherein the heating element (8,9) comprises an inner heat mass (9) and an outer heat mass (8), the inner heat mass (9) having at least one outlet conduit (12) therethrough for fluid to be expelled from the or an outlet (5), and at least one inlet conduit (10) for fluid from the or an inlet (6) is formed between the inner (9) and the outer (8) heat mass.
6. A heater according to any one of the preceding claims, wherein the pumping means (14) is a venturi.
7. A heater according to any one of claims 1 to 6 wherein the pumping means is a vaned pump.
8. A heater according to any one of the preceding claims wherein at least the part of the heating element (8,9) to be contacted by the fluid to be heated is

formed by a material having a thermal conductivity
of at least $30 \text{ Wm}^{-1} \text{ K}^{-1}$.

9. A heater according to any one of the preceding
claims wherein at least the part of the heating element
5 (8,9) to be contacted by the fluid to be heated is
made of metal.

10. A heater according to any one of the preceding
claims wherein a layer of heat insulation material
(19) at least partially surrounds the heating element
10 (8,9).

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Fig. 1.

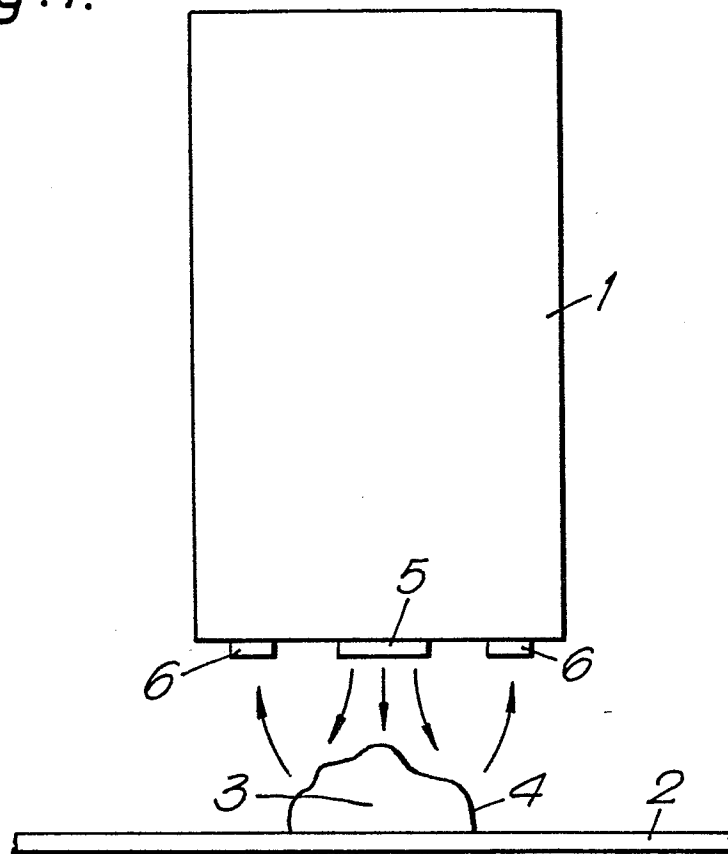


Fig. 3.

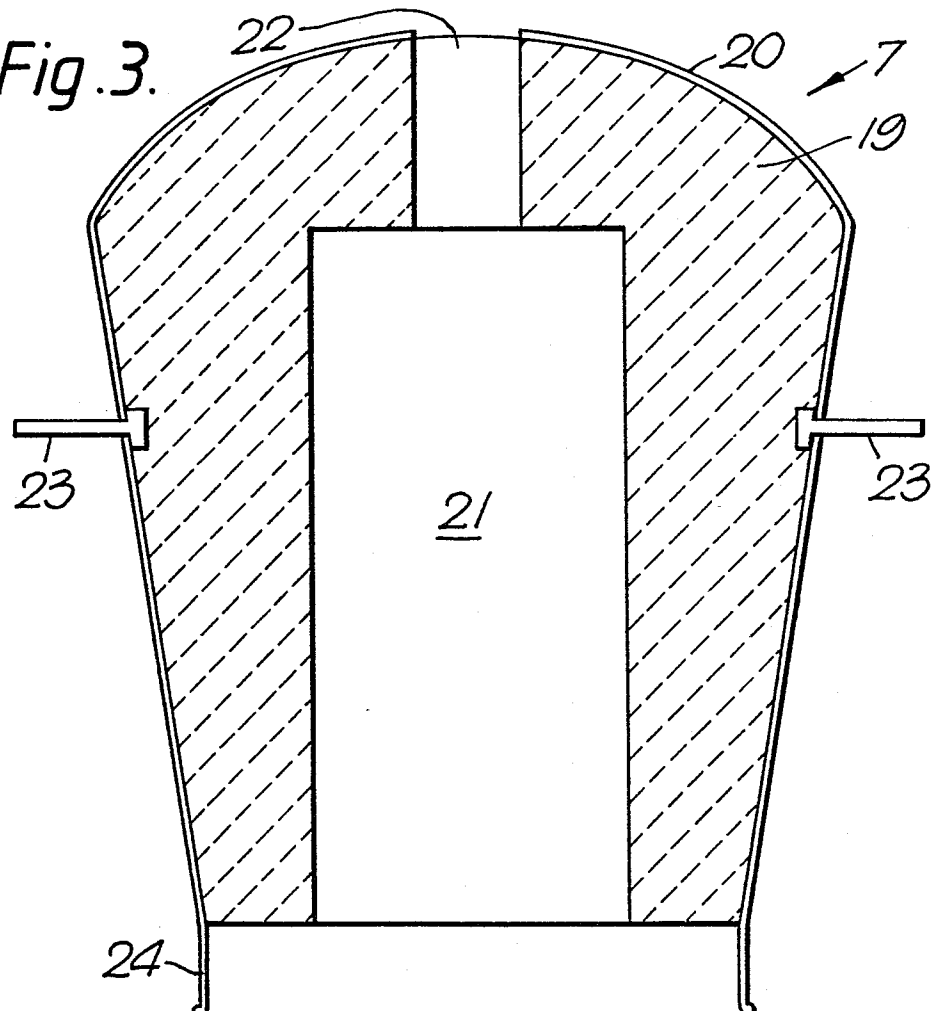


Fig. 2.

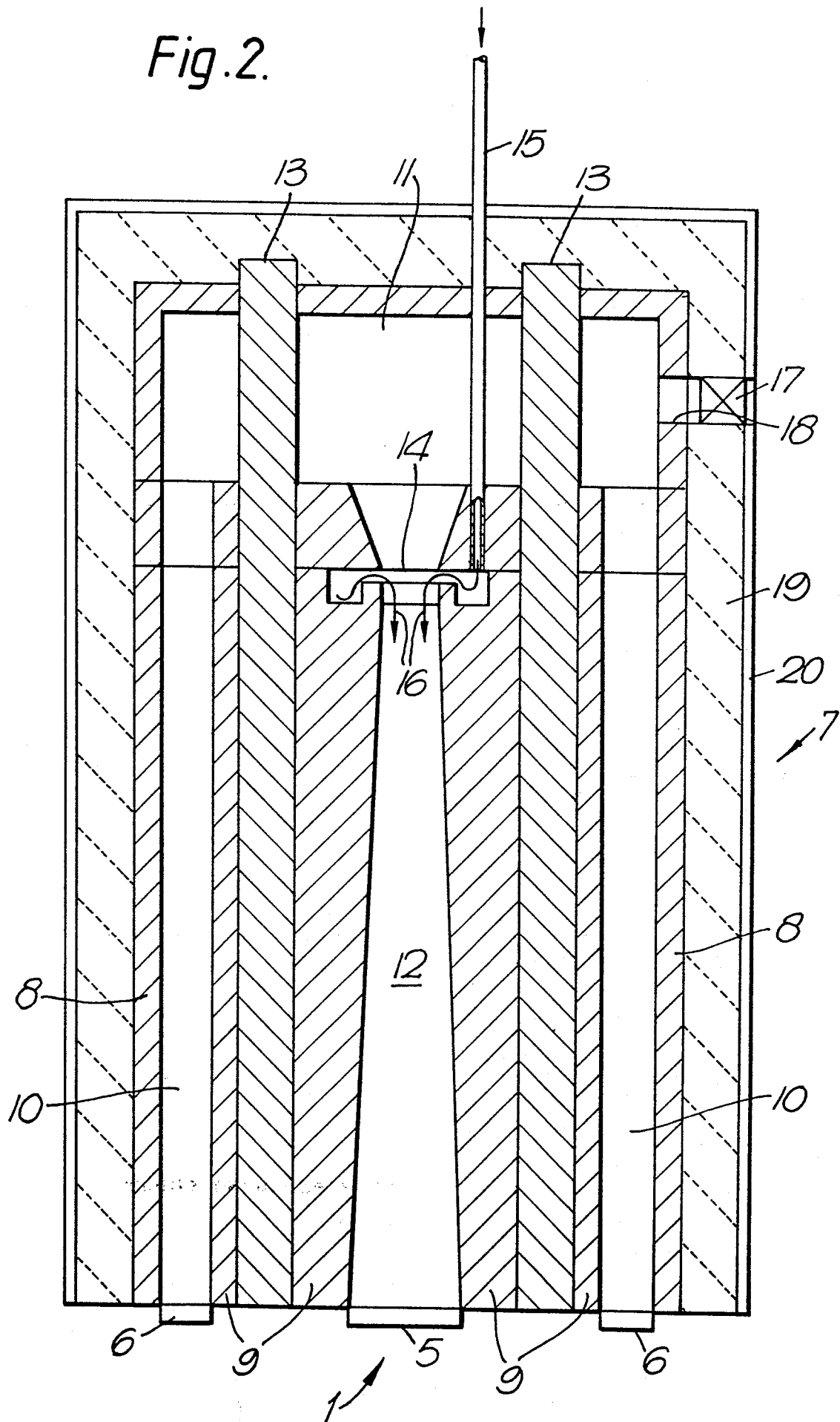


Fig. 4.

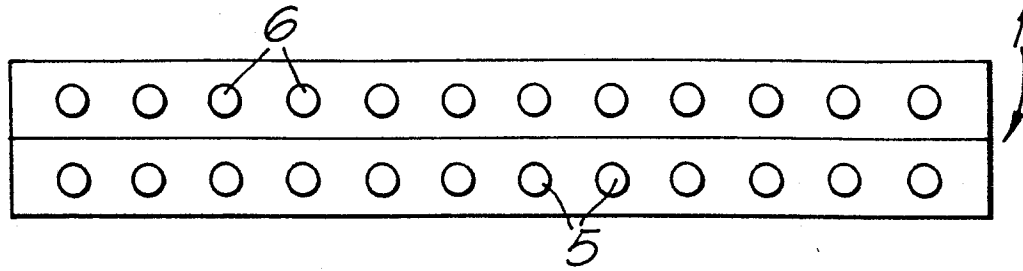


Fig. 5.

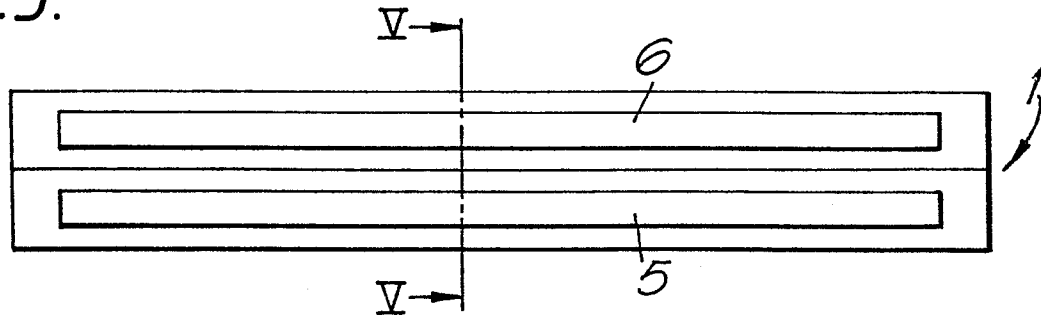


Fig. 6.

