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(54) **Heating apparatus using catalytic combustion.**

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Description

This invention relates to an infrared-radiation heating apparatus which can in particular be used in the various applications in the home owing to its safety, reliability, convenience and low-consumption properties.

In order to illustrate the invention by way of non-limiting example, it is assumed that the apparatus is installed on a cooking surface, and therefore a burner with a typical circular shape is represented to this purpose, although it can of course be developed into any desired, practical shape and application without impairing its good operating reliability and efficiency.

It is of course acknowledged that the invention is not limited to the afore mentioned utilization scope, since it can be used to generate thermal energy in any other application.

Cooking surfaces are well-known in household appliance burners with related caps, pan-support ribs and a underlying hob made of stainless steel or enamelled steel sheet. These cooking surfaces usually have serious drawbacks in connection with both safety and cleanability considerations, since their operation is generally associated with a considerable release of carbon and nitrogen oxides into the atmosphere and, furthermore, they are notoriously connected with a substantial risk of their flames extinguishing due to food overflowing from pans placed thereupon, or a number of different causes, with the well-known, very dangerous consequence of toxic and flammable gas escaping unburnt into closed rooms or spaces.

From the US 4,189,294 it is known a flamless combustion burner which includes an ignition zone, a catalyst zone and a plenum.
However the catalyst is a thick annular body, and the exhaust gas contacts the surface 24 with different temperatures.
Furthermore excess temperatures are reached in the catalyst body 21, and the gas burning is not evenly carried out as the gases are not uniformely expanded.

The Italian patent application no. IT-A-1 234 476 published 18.05.92, filed by the same applicant, discloses heating apparatuses, which are intended in particular for food cooking purposes and are embodied through the use of closed-type conduits that are filled with catalytic material and are flowed through by a gas mixture. That enables a combustion apparatus to be obtained which, at least as far as the combustion of fuel gas is concerned, eliminates or reduces to a minimum the afore mentioned environmental pullution effects.

However, such a heating apparatus, while undeniably offering the required safety level, has major peculiar drawbacks deriving from the particular structure of the catalytic combustion reactor, which is substantially in the form of a closed-type shaped pipe configuration and ensures a poor uniformity in the emission of heat and in the dstribution of the temperature, since combustion at each point along the mass of said reactor actually depends on its distance from the gas inlet port, with clearly negative consequences for the quality of the cooking process.

Furthermore the invention according to the afore mentioned patent application appears to be quite expensive, time-consuming and painstaking to make in practice, since an infrared-transparent material has to be processed and bent. A third serious drawback derives from such a heating apparatus having a greater height than traditional gas burners, whereas cooking surfaces are under strict dimensional constraints throughout their application range.

Last, but not least, the afore mentioned heating apparatuses cannot be installed into existing cooking appliances, but in newly and specially designed appliances only, which thing is instrumental in greatly limiting their diffusion owing to clearly apparent marketing reasons.

It would therefore be quite desirable to achieve a heat-emitting apparatus which maintains the advantages of the apparatus disclosed in the afore mentioned patent application, while doing away with its described drawbacks.

Such an aim and further objects are reached through this invention in the heating apparatus which will be further described by way of non-limiting example with reference to the accompanying drawings in which:

- Figure 1 is an overall view of the central, vertical cross-section of the heating apparatus according to this invention;
- Figure 2 is a view of the same assembly shown in Fig. 1, but with the individual components of the assembly separated from each other;
- Figure 3 is an exploded view of the assembly of the same heating apparatus;
- Figure 4 is an enlarged view of a part of Figure 1, where the flow path of the fuel gas mixture is indicated.

The basic idea behind this invention is described hereinafter: since high combustion temperatures (up to approx. 2000 deg C) are the actual cause of increased emission of polluting substances into the environment, in order to reduce such emissions high-temperature combustion processes are avoided wherever feasible or practical, for example by having resort to catalytic combustion processes when heat at a relatively low temperature is desired.

A catalytic combustion process is used also in the apparatus according to this invention. However, instead of having this catalytic combustion activated in a reactor formed in the shape of a conduit, the fuel gas, already duly pre-mixed with air to stoichiometric proportions, is introduced in a preferably flat and hor-

izontal expansion pre-chamber 9, from which said fuel gas mixture propagates in a uniform and continuous way, along the desired path, into a diffusion chamber 10, a face of which, preferably the upper one, is defined by the catalyst element 6. Any desired pattern or shape of the combustion surface can be brought about by simply acting on the shape and the size of the diffusion chamber 10 and, therefore, on the flame distributor 5 which forms a wall thereof.

The catalyst element 6, the structure of which can be compared with the one of a wire-gauze with a suitably selected mesh-size, is treated with a process of the so-called "WASH COAT" type for the deposition of the catalytic material. It is also preferable for said element 6 to be flat and horizontal and it is of importance that it has a high thermal conductivity in order to ensure a uniform heat distribution.

From said diffusion chamber 10, the fuel gas mixture diffuses into said catalyst element 6, which can for example be made in the form of a thin wire-gauze and which shall be brought to its activation temperature in order to initiate the reaction and start the combustion.

In order to initiate the reaction, it is necessary for the catalyst element 6 to be heated up to its activation temperature.

To this purpose, a variously shaped, electrically fed incandescence-type ignition device 20, which is located near the inlet ports for the air/gas mixture and in contact with the wire-gauze catalyst element 6.

The high thermal conductivity of the wire-gauze structure ensures an affective heating of the area involved in the initial activation of the catalytic material.

After the reaction process has been initiated in this way, the ignition device is de-energized, or switched off. This whole system provided to ensure ignition (from cold conditions) completes its start-up cycle within a few seconds. If, on the other hand, it is desired to re-ignite the burner within a few minutes from its extinction, the ignition process will take place also without an intervention of the ignition device, since a minimum residual heat of the wire-gauze structure (ie. a temperature of 250 to 300 deg C) will be perfectly sufficient to re-initiate the reaction and, therefore, the combustion process.

The reaction initiation temperature should be as low as possible. A palladium and/or platinum-based catalyst is preferred.

After its initiation, the reaction will quickly propagate all over the catalytic surface due to its high thermal conductivity.

The heat generated and released by the catalyst element 6 is then collected by the inner face of an intercepting surface 8 which encloses said catalyst element 6 that is possibly kept in its position by a holding ring 7.

Said intercepting surface 8 conducts heat towards the outside and, therefore, its outer face acts as the actual, final heating element.

Said surface 8, further to acting as the intercepting and heat-transmitting element, can be formed to tightly cover and seal the catalyst element 6 and, as a consequence, is adapted to at the same time acts also as a "cover" to retain flue gases and convey into flue exhaust channels that will be provided appropriately. The same surface 8 is closed by having its outer edge fitting against a retaining cap 3 which, through a manifold chamber 16, conveys flue gases into an exhaust fitting 2.

By appropriately combining the shape and the arrangement of the walls of the various afore mentioned chambers and conduits, it is possible to achieve a particularly compact, efficient and low-cost structure.

For example, as it becomes apparent from the Figures in the accompanying drawings, the air/gas mixture inlet fitting 1 splits open in such a way as to form the partition 4 which delimitates the expansion pre-chamber 9 on the one side and the flue gas collecting chamber 16 on the other one.

The expansion pre-chamber 9 itself can be delimitated, on its other side, by the flame distributor 5, which in turn delimitates, with its opposite face, the diffusion chamber 10.

Some parts of said flame distributor 5 can be made to adhere to the catalyst element 6, thereby masking the combustion zones at will and, therefore, achieving any desired combustion pattern.

A very particular advantage thereof, which anyone skilled in the art would have no difficulty in implementing, resides in the possibility of achieving a heating element having just the desired heat emission properties, in terms of thermal power emitted by said element either in a concentrated form or distributed in specific areas, by simply implementing a plurality of individual diffusion chambers of appropriate shape, size and input rating, as well as arranged according to a corresponding pattern.

In an advantageous way, the flue gases collected by the intercepting surface 8 can be exhausted through appropriately drilled holes or openings 12 along the outer edge of the partition 4.

The inlet of the air/gas mixture is governed by a valve which is controlled from the outside. An appropriate Venturi tube can be used to obtain the correct air and gas mixture or, as an alternative solution, a fan can be used in view of overcoming the flow resistance opposed by the catalyst material.

In the example illustrated by the Figures in accompanying drawings, an apparatus is shown in which, in corrispondence of a single expansion pre-chamber 9, two circular sets of holes or openings 14 and 15 are provided through which the fuel gas is conveyed into the two corresponding diffusion chambers 10 and 11, respectively.

With the construction form and design of the ap-

paratus exemplified in the accompanying Figures, two distinct, flat combustion areas are therefore achieved. One of these two combustion areas, having a ring-like circular shape, is located in correspondence of the upper face of the diffusion chamber 10, while the other one, having a full-size circular shape, is located in correspondence of the diffusion chamber 11.

The flue gas temperature is intrinsecally relatively low. However, through an appropriate design it can be further reduced and kept at approx. 100 deg C.

At this point of the description, a number of further advantages offered by this invention become apparent to anyone skilled in the art, ie.:

- possibility to easily and quickly replace traditional burners with burners according to this invention in existing appliances in the field;
- easily implemented automation, eg. through robots, of the assembly process for both the apparatuses according to this invention and the whole gas appliances in which said apparatuses are used;
- reduced height, overall compactness and solidity of the whole assembly;
- wide flexibility and freedom in designing the pattern of the catalytic surface;
- possibility of recovering heat from flue gases before these are exhausted outside through accordingly provided channels.

Claims

1. Infrared-radiation heating apparatus operating by means of catalytic combustion, comprising a gas inlet conduit (1), a catalytic reaction initiation activator, one or more catalyst elements (6), characterized in that it also includes a gas expansion chamber (9) and a diffusion chamber (10), both delimitated on at least one side by said catalyst elements (6), a heating surface (8) facing said catalyst element (6) and a cap (3) collecting or intercepting flue gases.

2. Infrared-radiation heating apparatus operating by catalytic combustion according to claim 1, characterized in that said heating surface (8) is substantially flat.

3. Infrared-radiation heating apparatus operating by catalytic combustion according to the preceding claims, characterized in that said catalyst element (6) is substantially flat.

4. Infrared-radiation heating apparatus operating by catalytic combustion according to any one of the preceding claims, characterized in that the catalyst material consists of rhodium, palladium or platinum deposited onto a surface with a high thermal conductivity in a percentage varying from 0.1 to 0.2.

5. Infrared-radiation heating apparatus operating by catalytic combustion according to any one of the preceding claims, characterized in that the expansion chamber (9) and the diffusion chamber (10) are separated by a flame distributor (5) which features one or more pluralities (14, 15) of openings arranged in a ring-like, concentric way to let the gas flow through.

6. Infrared-radiation heating apparatus operating by catalytic combustion according to claim 5, characterized in that the combustion areas in the catalyst element (6) are achieved by masking the other complementary areas by giving the flame distributor (5) an appropriate shape.

7. Infrared-radiation heating apparatus operating by catalytic combustion according to any one of the preceding claims, characterized in that the heating surface (8) is closed and sealed through its outer edges tightly fitting against the cap (3) provided to collect and exhaust the flue gases.

8. Infrared-radiation heating apparatus operating by catalytic combustion according to claim 7, characterized in that the passage of flue gases towards the inside of said cap (3) occurs through appropriate openings (12) that are drilled along the extension of the partition (4) separating said expansion chamber (9) from the exhaust chamber provided to let out said flue gases collected in the enclosed space formed by said cap (3).

9. Infrared-radiation heating apparatus operating by catalytic combustion according to any one of the preceding claims, characterized in that the catalytic reaction initiation element (20) essentially consists of a resistance circuit, preferably of a coil or ring type, located in contact with said catalyst element (6).

Patentansprüche

1. Infrarot-Heizapparat mit katalytischer Verbrennung, im wesentlichen bestehend aus einer Gaszufuhrleitung (1), einem Aktivator zur Auslösung der katalytischen Reaktion, sowie einem oder mehreren katalytischen Elementen (6), **dadurch gekennzeichnet**, **daß** er auch eine Gasentspannungskammer (9) und eine Diffusionskammer (10) umfaßt, wobei beide solche Kammern zumindest auf einer Seite durch die genannten katalytischen Elementen (6), eine gegenüber dem genannten katalytischen Element (6) angeordne-

te Heizfläche (8) und eine Kappe (3) zum Auffangen der Verbrennungsabgase abgegrenzt sind.

2. Infrarot-Heizapparat mit katalytischer Verbrennung nach Anspruch 1, **dadurch gekennzeichnet, daß** die genannte Heizfläche (8) im wesentlichen flach ausgestalt ist.

3. Infrarot-Heizapparat mit katalytischer Verbrennung nach den vorhergehenden Ansprüchen, **dadurch gekennzeichnet, daß** das genannte katalytische Element (6) im wesentlichen flach ausgestalt ist.

4. Infrarot-Heizapparat mit katalytischer Verbrennung nach irgendeinem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** das angewendete Katalysatormaterial aus Rhodium, Palladium oder Platin besteht, das auf einer Fläche mit erhöhter Wärmeleitfähigkeit im Verhältnis von 0,1 bis 0,2 Prozent abgeschieden wird.

5. Infrarot-Heizapparat mit katalytischer Verbrennung nach irgendeinem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** die Entspannungskammer (9) und die Diffusionskammer (10) durch einen Flammenverteiler (5) voneinander getrennt sind, Welcher eine oder mehrere Pluralitäten (14, 15) von zum Durchfluß des Gases vorgesehenen, ringförmig und konzentrisch angeordneten öffnungen aufweist.

6. Infrarot-Heizapparat mit katalytischer Verbrennung nach Anspruch 5, **dadurch gekennzeichnet, daß** die Verbrennungszonen im genannten katalytischen Element (6) durch Verdecken der anderen Komplementärzonen unter zweckentsprechender Formgebung des Flammenverteilers (5) herausgewonnen sind.

7. Infrarot-Heizapparat mit katalytischer Verbrennung nach irgendeinem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** die Heizfläche (8) mit ihren gegen die für das Auffangen und die Abführung der Abgase vorgesehene Kappe (3) dichtend aufgesetzten Außenrändern hermetisch herumgeschlossen ist.

8. Infrarot-Heizapparat mit katalytischer Verbrennung nach Anspruch 7, **dadurch gekennzeichnet, daß** die Zuströmung der Abgase nach dem Innern der genannten Kappe (3) durch speziell vorgesehene öffnungen (12) stattfindet, welche entlang der Ausdehnung der die genannte Entspannungskammer (9) vom zur Abführung der im durch die genannte Kappe (3) gebildeten, geschlossenen Raum aufgefangegenen Abgase dienenden Auslaßraum trennenden Scheidewand (4) vorgesehen sind.

9. Infrarot-Heizapparat mit katalytischer Verbrennung nach irgendeinem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** das zur Auslösung der katalytischen Reaktion bestimmte Aktivatorelement (20) im wesentlichen aus einem vorzugsweise ring- oder spiralförmigen Widerstandsstromkreis besteht, der in enger Berührung mit dem genannten katalytischen Element (6) steht.

Revendications

1. Appareil de chauffage par rayonnement infrarouge utilisant la combustion catalytique, comprenant un conduit (1) d'admission du gaz, un activeur amorçant la réaction catalytique, ainsi qu' un ou plusieurs éléments catalytiques (6), **caractérisé en ce qu'**il comprend aussi une chambre de détente (9) du gaz ét une chambre de diffusion (10), toutes les deux étant délimitées sur au moins un côté par lesdits éléments catalytiques (6), une surface chauffante (8) en face dudit élément catalytique (6) et une calotte (3) pour collecter ou intercepter les produits de la combustion.

2. Appareil de chauffage par rayonnement infrarouge utilisant la combustion catalytique selon la revendication 1, **caractérisé en ce que** ladite surface chauffante (8) est essentiellement plane.

3. Appareil de chauffage par rayonnement infrarouge utilisant la combustion catalytique selon les revendications précédentes, **caractérisé en ce que** ledit élément catalytique (6) est essentiellement plan.

4. Appareil de chauffage par rayonnement infrarouge utilisant la combustion catalytique selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le matériau catalyseur est formé par rhodium, palladium ou platine déposé sur une surface à haute conductibilité thermique dans une pourcentage se situant entre 0,1 et 0,2 pourcent.

5. Appareil de chauffage par rayonnement infrarouge utilisant la combustion catalytique selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ladite chambre de détente (9) et ladite chambre de diffusion (10) sont séparées par un distributeur de flamme (5) présentant une ou plusieurs pluralités (14, 15) d'orifices disposés circulairement et concentriquement pour le passage du gaz.

6. Appareil de chauffage par rayonnement infrarouge utilisant la combustion catalytique selon la revendication 5, **caractérisé en ce que** les zones de combustion dans l'élément catalytique (6) sont obtenues en cachant les autres zones complémentaires en donnant au distributeur de flamme (5) une forme appropriée.

7. Appareil de chauffage par rayonnement infrarouge utilisant la combustion catalytique selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la surface chauffante (8) est fermée hermétiquement par ses bords extérieurs approchés d'une façon étanche contre la calotte (3) y pourvue pour collecter et évacuer les gaz brûlés.

8. Appareil de chauffage par rayonnement infrarouge utilisant la combustion catalytique selon la revendication 7, **caractérisé en ce que** l'écoulement des gaz brûlés vers l'intérieur de ladite calotte (3) se produit à travers des orifices (12) appropriés qui sont pratiqués tout au long de l'extension de la cloison (4) séparant ladite chambre de détente (9) de la chambre d'échappement pourvue pour l'évacuation des gaz brûlés collectés dans l'espace renfermé qui est formé par ladite calotte (3).

9. Appareil de chauffage par rayonnement infrarouge utilisant la combustion catalytique selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'élément (20) pourvu en tant qu'activeur pour amorcer la réaction catalytique est formé essentiellement par un circuit à résistance, de préférence du type à spirale ou à bague, placé en contact avec ledit élément catalytique (6).

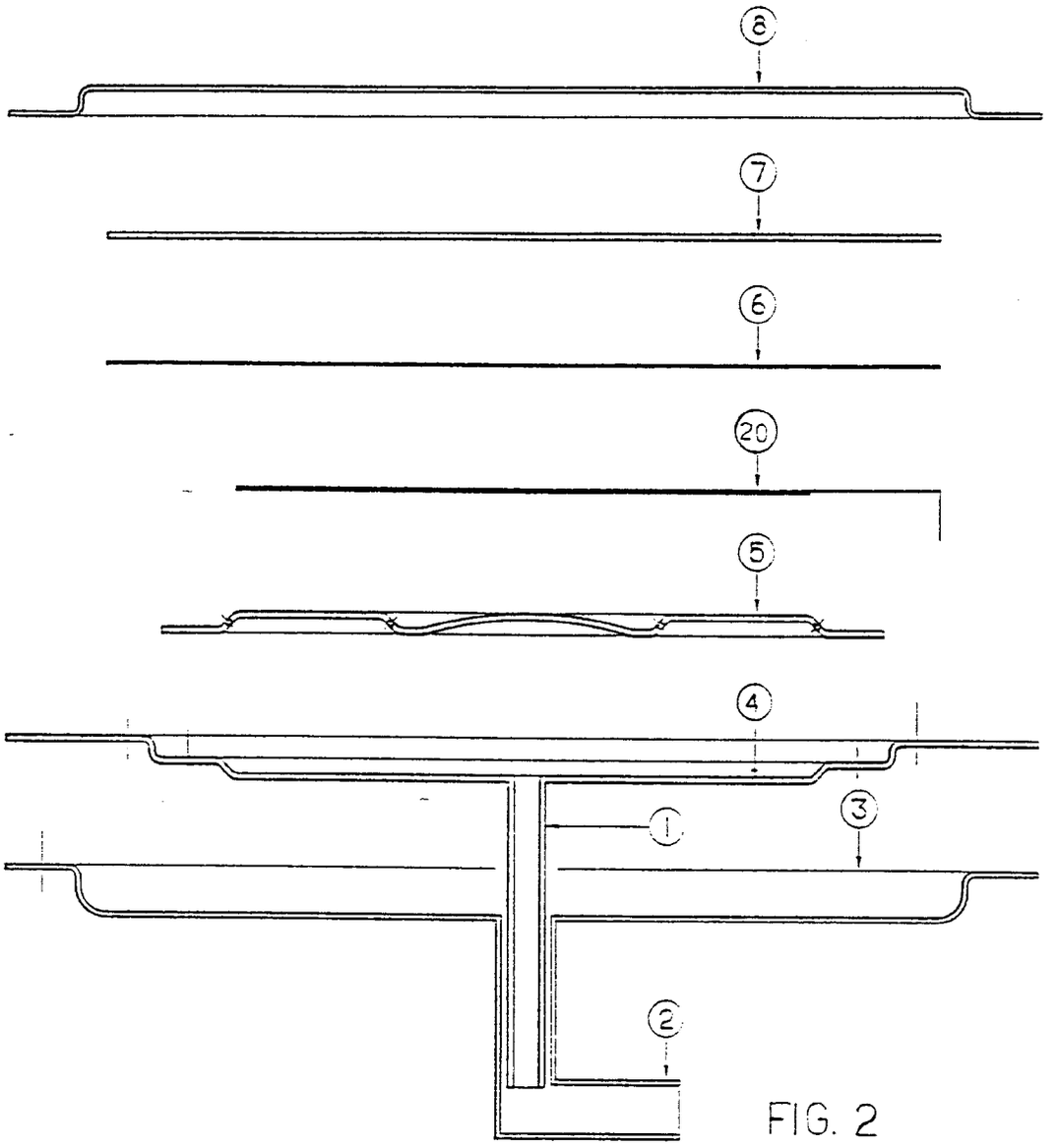

FIG. 2

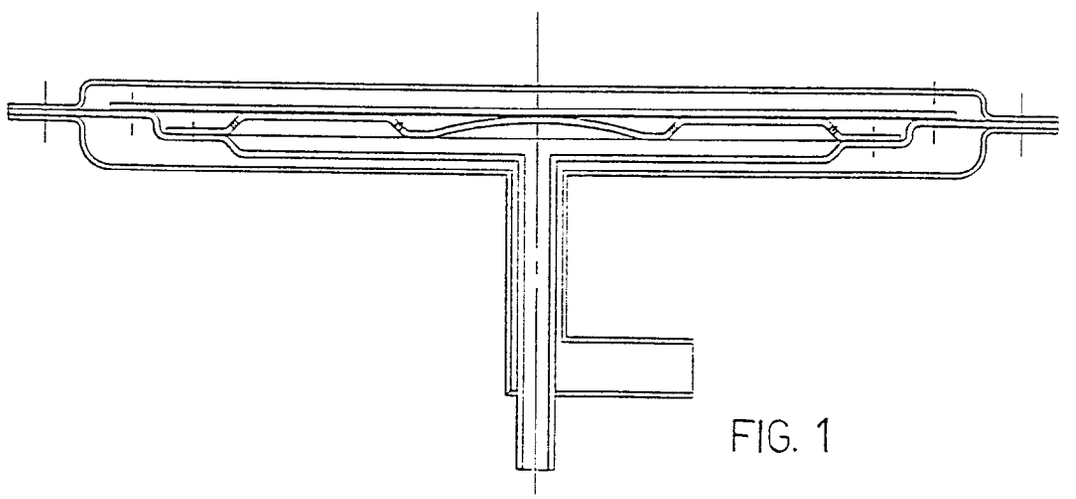

FIG. 1

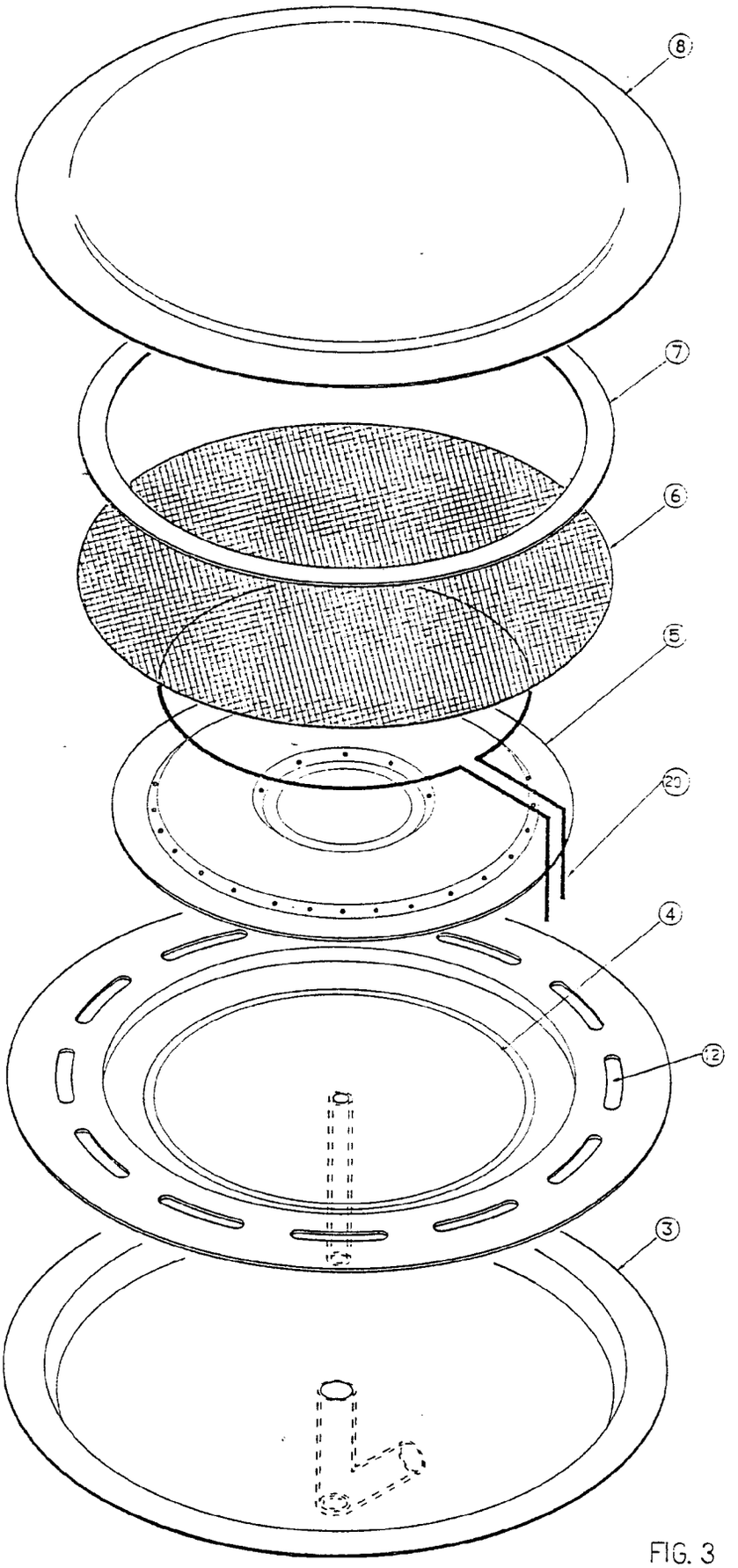

FIG. 3

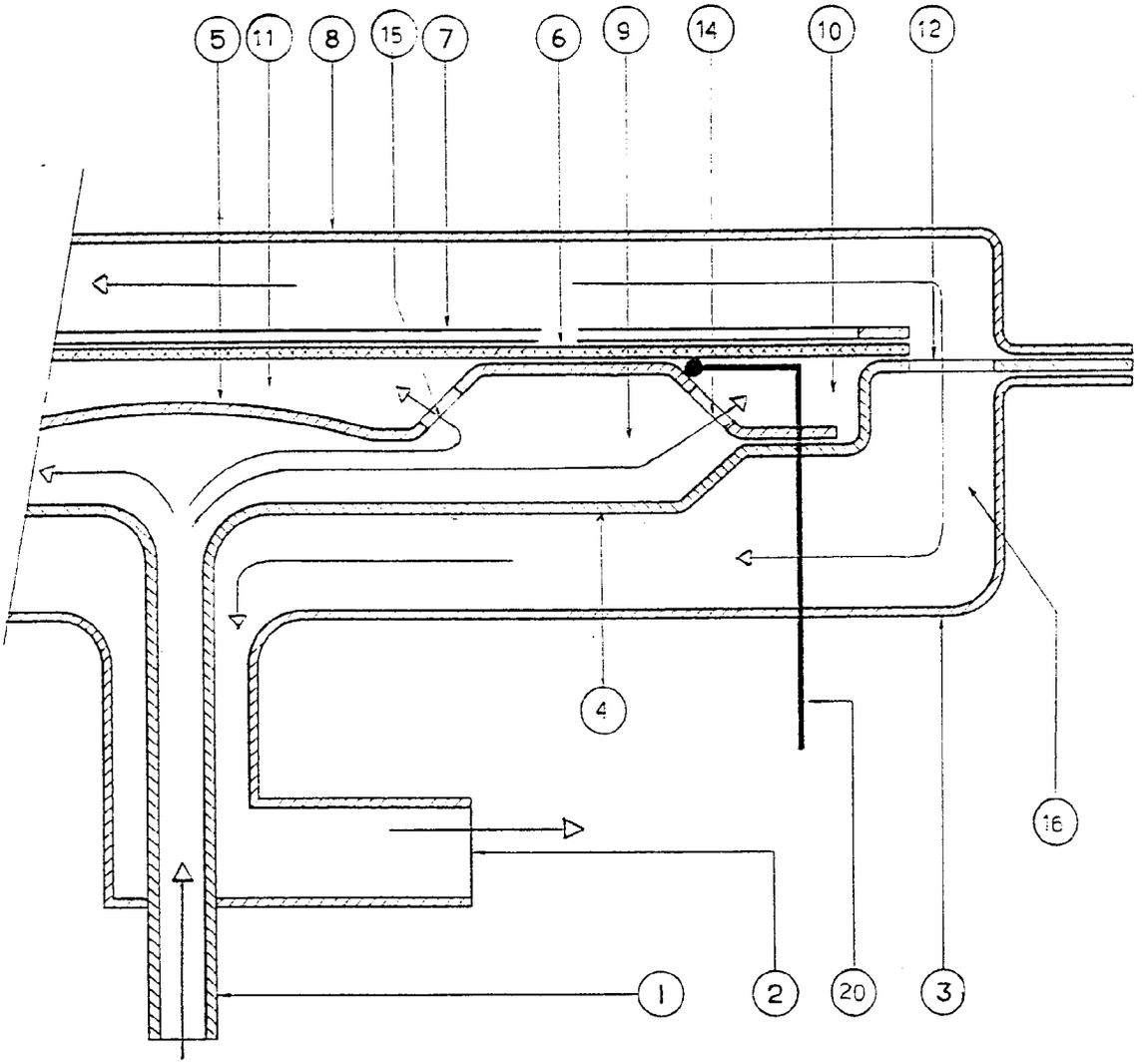

FIG. 4