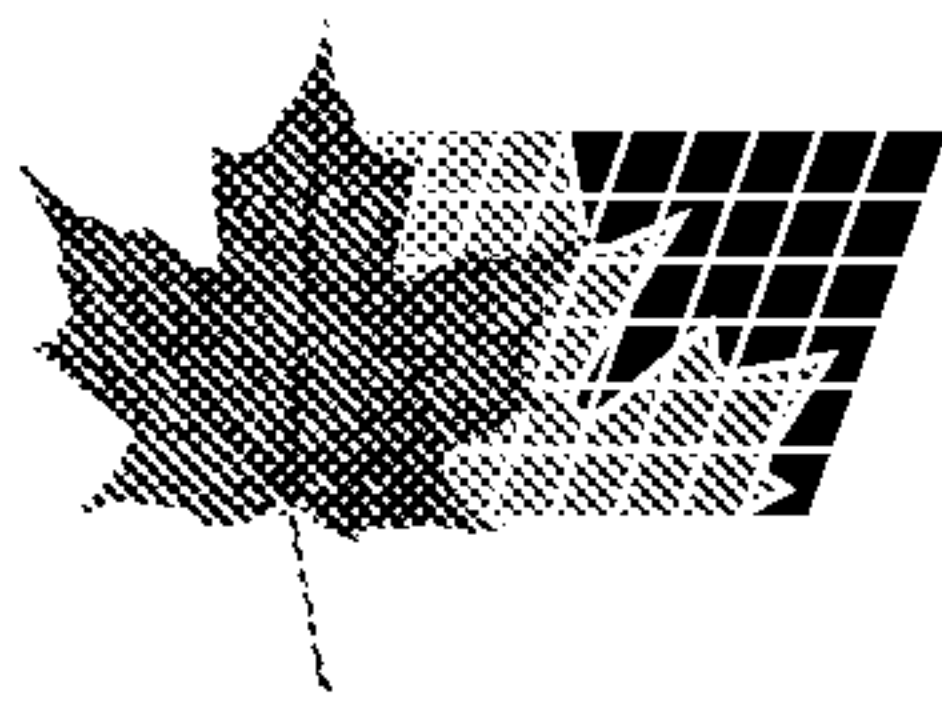




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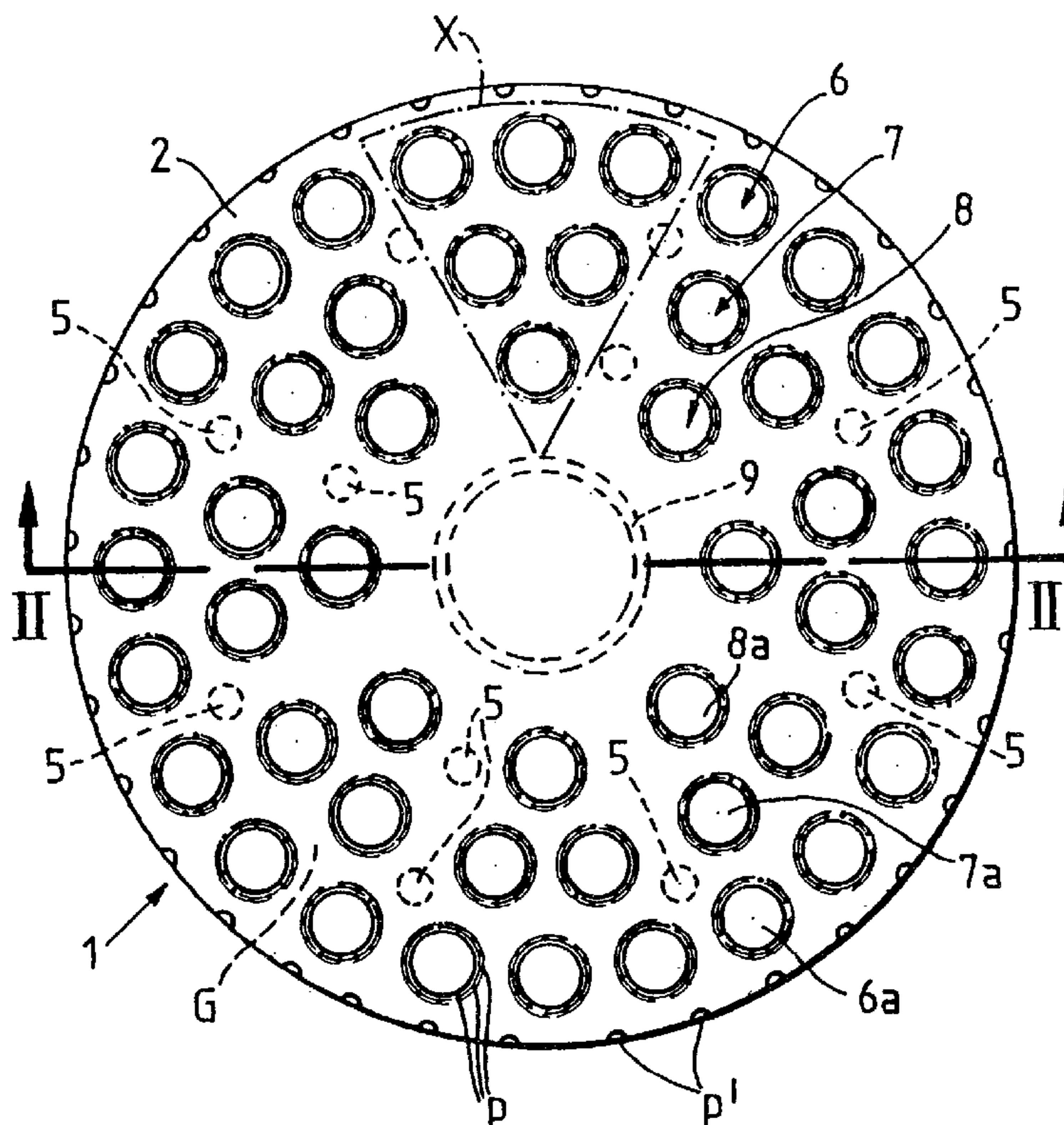
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(54) **BRULEURS**

(54) **BURNERS**



(57) Une tête de brûleur (1), adaptée pour être utilisée dans un four comporte un réseau ou une matrice d'orifices d'air de combustion divisé en trois (extérieur, milieu et intérieur) anneaux d'orifices (6, 7, 8). Du combustible gazeux est transporté jusqu'à un conduit (9) de combustible central passant dans une galerie (G) jusqu'à des orifices individuels brochés (6a, 7a, 8a) d'anneaux d'orifices (6, 7, 8), ledit combustible se mélange alors à de l'air de combustion aspiré par le centre desdits orifices. La matrice d'orifices est configurée pour éliminer les "points chauds" anormaux qui pourraient accélérer la corrosion, ainsi que pour égaliser la répartition de l'écoulement à travers la galerie (G) jusqu'aux orifices (6a, 7a, 8a).

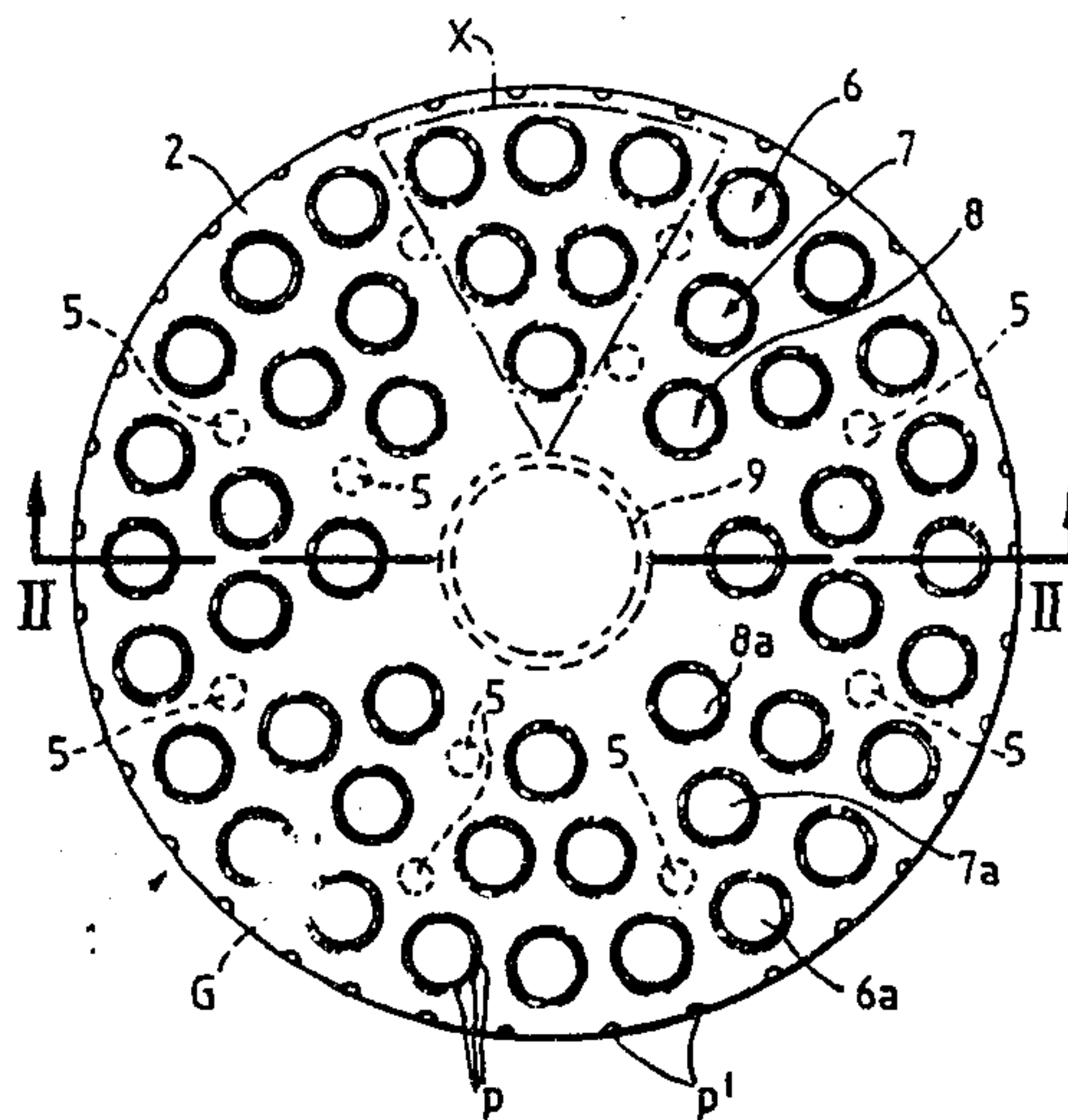
(57) A burner head (1), suitable for use in a furnace, has an array or matrix of combustion air apertures divided into three (outer, middle and inner) aperture rings (6, 7, 8). Gaseous fuel is conveyed down central fuel pipe (9) which flows through gallery (G) to individual broached apertures (6a, 7a, 8a) of aperture rings (6, 7, 8), which fuel mixes with combustion air being drawn up through the centre of said apertures. The aperture matrix is configured to eliminate anomalous "hot spots" which would accelerate corrosion as well as equalising flow distribution through the gallery (G) to the apertures (6a, 7a, 8a).



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(21) International Application Number: PCT/GB91/00973 (22) International Filing Date: 17 June 1991 (17.06.91) (30) Priority data: 9013368.7 15 June 1990 (15.06.90) GB (71) Applicant (for all designated States except US): LANE-MARK LIMITED [GB/GB]; Queens House, Queens Road, Coventry CV1 3DR (GB). (72) Inventor; and (75) Inventor/Applicant (for US only) : KIRK, David, Thomas [GB/GB]; 9 Spiers Close, Knowle, Solihull, West Midlands B93 9ES (GB). (74) Agent: H.N. & W.S. SKERRETT; Charles House, 148/9 Great Charles Street, Birmingham B3 3HT (GB).		(81) Designated States: AT (European patent), BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), LU (European patent), NL (European patent), SE (European patent), US. Published <i>With international search report.</i>

(54) Title: IMPROVEMENTS IN OR RELATING TO BURNERS



(57) Abstract

A burner head (1), suitable for use in a furnace, has an array or matrix of combustion air apertures divided into three (outer, middle and inner) aperture rings (6, 7, 8). Gaseous fuel is conveyed down central fuel pipe (9) which flows through gallery (G) to individual broached apertures (6a, 7a, 8a) of aperture rings (6, 7, 8), which fuel mixes with combustion air being drawn up through the centre of said apertures. The aperture matrix is configured to eliminate anomalous "hot spots" which could accelerate corrosion as well as equalising flow distribution through the gallery (G) to the apertures (6a, 7a, 8a).

IMPROVEMENT IN OR RELATING TO BURNERS

This invention relates to improvements in or relating to burners more particularly of a type known in the art as a "Matrix burner".

Matrix burners are versatile in application and can be used both in domestic and in industrial plants or installations. Relatively large numbers of these burners may be employed in industrial furnaces and can be used to burn off waste gases with the potential of recycling the energy back into the processing plant.

Therefore, the efficient and continued operation of burners employed in such conditions is of the utmost importance because the task of repairing or replacing burners deployed on such a large scale would be expensive and highly inconvenient in delaying the processing operations of the plant.

Thus, any improvements in the design of the matrix burners leading to a more efficient or versatile operation or extended lifespan are of very considerable importance in this field. The applicant owns several patents in this field, including British Patent Specification Nos. 1325443 and 1548388.

With the design of matrix burner as shown in Patent Specification No. 1548388 problems have been encountered where the burners have undergone heavy and continued usage for a long period of time (for example 7 years or so) more particularly where the burners have been employed in the petrochemical field. These problems involve the degree of corrosion of the metal of the burner head, which head comprises two parallel plate portions provided with a number of apertures for combustion gases. This corrosion has taken the form of a chemical attack causing the burners to fail. Since the cost of the burners for a petrochemical plant may be of the order of £250,000 or so the advantages in providing a longer lasting burner should be readily apparent.

Therefore, there tends to be a problem with matrix burners in that corrosion can take place despite the previous work done in the burner design field and there tend to be additional problems encountered where such burners may be utilised in a dual fuel, e.g., gas/liquid, situation.

Accordingly, it is an object of the present invention to at least alleviate one or more of the aforementioned, or other, problems associated with matrix burners or their application.

According to a first aspect of the present invention there is provided a burner having a head provided with an array or matrix of combustion air apertures, said burner head having spaced plate portions defining a fuel supply gallery or passageway to said apertures, said plate portions including an aperture ring which closely follows an outer boundary of the burner head, and which is adjacent to said boundary to thereby prevent or restrict localised regions of the plate portions, at least near

said boundary, becoming subject to temperatures which are higher than any other region of the plate or becoming subject to a corrosion or deterioration rate higher than any other region of the plate portions and/or to prevent or restrain substantially anomalous flow patterns of the fuel supply in the gallery at least around said aperture ring and adjacent said boundary.

Preferably, the matrix of apertures is configured to prevent or restrict any anomalous high temperature or high corrosion regions occurring on the plate portions by giving substantially the same freedom of access of the fuel supply in the gallery to each of the apertures. The plate portions may be spaced from one another by spacers and, accordingly, the aperture matrix may be configured to allow for substantially even flow characteristics of the fuel supply through the gallery around said spacers.

Preferably, the aperture ring comprises a series of combustion air apertures, at least half or the majority of which are spaced at a distance from said boundary by an amount which is less than or equal to the spacings between one another.

One embodiment of the burner of the present invention has a head with circular shaped plate portions and said aperture ring consists of a circle of apertures spaced closely to one another and close to said boundary. The apertures in the circular ring are, preferably, spaced equidistantly from one another and are preferably of circular form. Preferably each aperture is spaced from the boundary by a distance not more than two (and preferably not more than three) times the distance in between each aperture. Preferably, the burner head has second and third aperture rings arranged radially inwardly of the first aperture ring and each of the

second and third aperture rings may consist of a series of circular apertures. Preferably the third, innermost aperture ring comprises a series of circular apertures which are arranged concentrically with the first outermost aperture ring so that each of the apertures in the innermost ring is radially aligned with respective apertures in the outermost ring, said innermost and outermost ring apertures being concentrically aligned with the circular plate portions of the burner head. The second aperture ring may comprise a series of circular apertures which are displaced circumferentially relative to the outer and innermost aperture rings and preferably such that the aperture configuration results in an array of substantially triangular shaped sector regions extending around the circumference of the plate portions with spacers being provided in between the triangular shaped sectors. It is believed that such an aperture matrix substantially eliminates anomalous hot spots on the plate portions and indeed test results have confirmed this and a much more equal fuel distribution to the apertures is provided. Preferably the burner is provided with radial ports at said boundary for radial discharge of the fuel and many other advantageous features of the burner will be apparent from the following description and drawings. The radial ports may be spaced equally around said boundary in between said apertures in the outer ring.

Corrosion problems have occurred with previous designs of burners as aforementioned and the burner plates are generally made from an austenitic chromium alloy steel. It has been realised that at operating temperatures in excess of 500°C, when burning carbon based gases, corrosion occurs from the inside of the burner plate portions by carbon from the fuel gas penetrating into the metal material of the burner plates.

The structure of the plate metal is granular and the carbon penetrates into the grain boundaries and reacts with the chromium in the alloy, causing individual grains of the material to be loosened and to eventually drop away from the metal. Consequently, it has been realized that the degree of corrosion is greater where the size of the grains is large and the degree of corrosion could be reduced by using a fine grain material. The applicant presently manufactures burners from a high nickel/chromium fine grain material reference NSU No. 800800 (referred to as alloy 800).

However, for high temperature applications and in order to extend the burner-life expectancy the applicant has realized the importance of developing the burner out of "higher grade" materials (i.e. materials which are less prone to physical and chemical attack under various operating conditions).

Therefore, according to a second aspect of the present invention there is provided a burner having a head with an array or matrix of apertures for combustion air, and said head comprising two plate portions defining a gallery or passageway to said apertures, said plate portions being constructed from one or more of the following materials:

- a. Inconel™ 600, Nicrofer™ 7216, Haynes™ 750
 - b. Inconel 601, Nicrofer 6023, (UNS 06601)
 - c. Inconel 617, (UNS 06617)
 - d. Inconel 625, Nicrofer 6020hMO, Haynes 625 (UNS 06625)
 - e. Haynes 214
 - f. Haynes 230
 - g. Alloy RA 330 (UNS 08330)
- and preferably in which the plate portions are

constructed from one of the following:

1. UNS 06617
2. UNS 06625
3. UNS 08330

The manufacture of the plate portions from any one of the alloys referred to above should give a more equal fuel flow distribution to the burner apertures and reduce the temperature. The plate portions will normally be of 16 gauge metal.

According to a further aspect of the present invention there is provided a dual fuel burner having a burner head with an array or matrix of combustion air apertures and plate portions defining a gallery or passageway therebetween for a main fuel supply to be fed to said apertures, the arrangement being such that the burner can be run on the first or main fuel supplied along the gallery to said apertures and may alternatively be operated on a second fuel mixed with combustion air supplied through said apertures.

The burner may be operated on a mixture of the first main fuel and the secondary fuel.

The need for a convenient, efficient dual fuel burner has been recognised by the Applicant and once again has substantial applications in the petrochemical field geared to the least wastage of energy. It may be convenient, for example, to begin the plant processing on natural gas and as more waste carbon dioxide and hydrogen is produced the natural gas could be reduced and recycled carbon dioxide and hydrogen used as a fuel for the burner. Sometimes processing plants produce oil by-products (Naphthalene) and therefore, a dual fuel process

which could utilise oil as a second fuel for the burner is also desirable.

It should also be noted that use of a burner in a dual fuel capacity should also reduce the corrosion effects already explained since a large contributory factor to said corrosion is attributed to the use of carbon based gases, which use would be avoided whilst running on a secondary fuel such as oil.

In a preferred embodiment of the dual fuel burner the secondary fuel is introduced into the burner by way of a supply line arranged within the supply line of the main fuel supply. The secondary fuel may be oil and accordingly an oil lance may be inserted in the main fuel supply line to the burner. Thus the oil lance may have a tip which extends beyond said plate portions in order to spray fuel oil above said plate portions for mixing with combustion air drawn through said apertures for ignition at the burner, preferably by a spark ignitor. The amount by which the lance tip extends beyond the burner head is, preferably, adjustable. Preferably, separate controls are provided for delivery of either or both fuels to the burner.

Advantageously, the same burner may be employed in a single fuel situation or in a double fuel situation, an inner pipe (e.g., guide pipe for the oil lance where applicable) being used for the secondary supply merely being closed off where the burner is to be used in a single fuel application only.

An advantage of such a dual fuel system is the production of a desirable and controllable flame shape which is most important in a furnace application, e.g. a hydrocarbon cracking process in the petrochemical

industry, where, for example, £500,000 worth of ceramic tube equipment may be needed to constrain the flame production by the burners.

Further advantageous features of the dual fuel burner will be apparent from the following description and drawings.

An embodiment of a matrix burner in accordance with the present invention and of a dual fuel burner in accordance with the present invention will now be described by way of example only with reference to the accompanying simplified drawings in which:

FIGURE 1 is a plan view of a burner head of the matrix burner;

FIGURE 2 is a diametrical section of the burner head shown in FIGURE 1, and taken on line II-II;

FIGURE 3 shows a part sectional side view of a dual fuel burner assembly;

FIGURE 4 shows a section view taken on line IV-IV of FIGURE 3;

FIGURES 5 and 6 show views similar to 1 and 2 of a burner adapted for dual fuel operation; and

FIGURE 7 shows a plan view of an alternative burner head for dual fuel application.

Referring to FIGURES 1 and 2 of the drawings a matrix burner head 1, suitable for use in a furnace, or for example a petrochemical plant, has an upper circular metal plate portion 2 joined to a lower circular metal plate portion 3 at the circumferential boundary wall 4, for example by welding. Boundary wall 4 provides an outer boundary of the burner head 1. The upper and lower plate portions 2 and 3 are spaced apart from one another by spacers 5 in a generally known manner in order to

provide a gallery or passageway G in between the plate portions 2 and 3 leading to individual apertures 6a, 7a, 8a, of outer 6, middle 7, and inner 8 aperture rings. In use a gaseous fuel is conveyed down the central fuel pipe 9 and flows through the gallery G to the apertures 6a, 7a, 8a where it mixes with combustion air being drawn up through the centre of said apertures 6a, 7a, 8a providing a mixture for burning. In this instance, the apertures 6a, 7a and 8a are of the broached or pierced type in which small holes or ports P (see FIGURE 1) are provided around the circumference of the individual apertures 6a, 7a, 8a to allow fuel gas to flow therethrough into the apertures. The apertures 6a, 7a, 8a are formed by a downwardly depending tubular portion a of the upper plate 2 snugly overlapping with an upwardly depending tubular portion b of the lower plate as shown best in FIGURE 2. The present invention is not confined to the apertures 6a, 7a, 8a being of the broached type and could instead be of the "annular gap" form in which the gas escapes from the gallery G into the apertures via an annular gap left in between the overlapping tube portions a,b of the upper and lower plates, which overlapping tube portions form the individual apertures. Both the broached and annular gap type apertures are known generally. In this embodiment the burner 1 is also provided with radial ports P' around the circumference or boundary 4 between the two plate portions 2,3. The radial ports P' are formed on the upper plate portion and allow a radial discharge of gaseous fuel around the boundary of the burner head 1.

The outer aperture ring 6 consists of a series (in this case 24) of apertures 6a of the same size and spaced equiangularly around the centre of the burner and following the boundary 4 and arranged closely adjacent thereto. The array of apertures 6a, 7a, 8a, form a matrix

which has been produced in order to seemingly optimise fuel flow characteristics within the gallery G to the individual apertures, whilst also taking into account the resistance to flow afforded by the spacers 5. The aperture matrix is configured in order to substantially eliminate anomalous hot spots which could ultimately give rise to corrosion in the burner, as well as to equalise flow distribution to the apertures 6a, 7a, 8a.

The benefits of this matrix design are considerable and:

- a. provides much greater temperature uniformity and energy/release across the burner is greatly improved,
- b. a lower burner heat operating temperature can be achieved under similar operating conditions with prior art burners, by virtue of the improved combustion air distribution system of the burner,
- c. areas of high metal content at the periphery of the burner have been minimized as far as can reasonably be envisaged,
- d. a lower burner heat operating temperature combined with reduction areas of high metal content, more particularly around the outer periphery of the burner should considerably reduce corrosion rates and extend the life expectancy of the burner accordingly,
- e. an improved flame profile is provided by this type of burner,
- f. general combustion characteristics and performance of the burner are also improved.

It is envisaged that at least four basic sizes of burner will be provided namely with diameters of 26 cm, 22.4 cm, 17.7 cm and 14 cm. The thermal output from the burners can, advantageously be suitably varied and is

largely a function of the gaseous fuels and air pressures available, burners can be individually designed to meet specific site requirements.

It is an important feature of the design that lower burner head operating temperatures achievable may enable manufacture of the burner to be of a "lower grade" cheaper material, hence reducing manufacturing costs, where higher operating temperatures are not required. However, where higher temperature applications are required or where extended burner life expectancy is of primary importance it is proposed that the burner will be manufactured from higher grade materials less prone to physical and chemical attack. A list of these materials has been given earlier on in the Patent Specification.

An important aspect of the design is the fuel flow distribution throughout the gallery G and as previously stated the apertures 6a, 7a, 8a have been developed selectively for the particular burner as shown with its spacer configuration 5 in order to seemingly optimize flow characteristics.

It is possible that differently sized apertures could be provided to the ones as shown and indeed the design may incorporate two or three or more sets of differently sized apertures. However, in this particular design the aperture matrix comprises 8 circumferentially spaced triangular sector regions (one of these regions is outlined by a chain dotted line X) consisting of 6 individual apertures, one aperture 8a being from the innermost ring 8, two apertures 7a being from the middle ring and three apertures 6a being from the outer ring 6. Spacers 5 are provided inbetween the triangular sectors and alternate from the provision of two spacers to one spacer on a circumferential path around the burner. The

more equal distribution of fuel flow to the apertures 6a, 7a, 8a itself brings with it a reduction in temperature of the burner plate portions 2,3. These type of burners are very versatile and can be run for example to produce 2 million B.T.U.'s per hour or 100 B.T.U.'s per hour. As shown in this embodiment the apertures 6a are positioned very close to the boundary line and indeed are closer to the boundary wall 4 than they are to one another. Each aperture 8a aligns radially with the centre aperture 6a of the arcuate line of 3 apertures of a particular triangular shaped sector X. The centre of the upper plate portion 2 may be slightly dished (not shown here) as is known in this type of burner. This design of burner head 1 seeks to obviate any anomalous flow patterns or resistances to flow which could substantially affect the equal distribution of fuel to the individual apertures 6a, 7a, and 8a to thereby provide a more even temperature distribution and extend the burner life.

FIGURES 3 and 4 show a dual fuel burner assembly 100 for use in a furnace (not shown). The burner assembly 100 may be utilised to burn a main, gaseous fuel and/or a secondary fuel in the form of oil or oil by-products produced by processing plant incorporating a plurality of such burner assemblies. In this way the efficiency of the processing plant can be upgraded by the utilisation of the oil by-products.

The burner assembly 100 has a burner head B which may or may not be identical or similar to the burner head 1 shown in FIGURES 1 and 2 of this specification. The overall layout of the assembly 100 is generally known in the provision of a gas inlet to the burner head which is surrounded by a refractory quarl. As shown in FIGURE 3 the assembly 100 has a gas inlet 103 leading to a central main fuel supply delivery tube or pipe 104 positioned

centrally of the burner head B. The main fuel supply passes up this pipe 104 to the gallery system of the burner head B and to the matrix of apertures as previously discussed in relation to FIGURES 1 and 2 of the drawings. The assembly 100 further includes an air inlet 105, a windbox 106 with windbox top plate 107 and generally cylindrical refractory quarl 108 surrounding the burner head B. As shown, an oil lance 109 is positioned centrally and coaxially with the gas supply pipe 104. The oil burner tip 110 has a conical end which extends beyond the front plate portion f of the burner B and joins the oil burner station pipe 111 at the other end thereof. Provision may be made to adjust the position of the oil lance longitudinally of the supply pipe 104 in order to attempt to optimise flame profile above the burner head B and the oil lance will be received in a guide tube T (not shown in FIGURE 3 - see FIGURES 5 and 6) running along the length of gas pipe 104. FIGURE 4 shows the location of the U.V. detector mounting tube 112, view port 113 and igniter tube and cap 114, the operation of which should be readily apparent; 115 (see FIGURE 3) designates the purge interlock safety valve of the fuel oil lance 109.

In use of the burner assembly 100, a main gaseous fuel supply is delivered by the gas inlet 103 and flows upwardly (in use) through the gas pipe 104, through the annular space provided inbetween the guide tube T and wall of the pipe 104. Since the assembly 100 incorporates a fuel lance 109 running along the axis of the burner B the width of the pipe 104 is subsequently greater than required for single fuel burners because of the physical space taken up in the pipe 104 by the lance 109. Thus the gaseous fuel is delivered to the gallery system of the burner head B in a similar manner as in a single fuel burner and is delivered to the aperture

matrix through the gallery system either in a generally known manner or in the manner as previously described in relation to FIGURES 1 and 2 of the Specification.

Additionally, or alternatively, a secondary fuel oil is delivered from the station pipe 111 along the fuel lance 109 to the oil burner tip 110 which sprays oil above the upper burner plate for ignition thereabove by an igniter which is of a form generally known per se. Thus the burner may run on a main gaseous fuel alone, or on the oil alone, or alternatively on a mixture of both. The position of the oil lance 109 can be varied along the length of the gas supply pipe 104 in order to optimize the flame profile produced when the burner is operating on both fuels or on oil alone. The burner head B in this instance is 22.4 cm diameter. The aforescribed dual fuel burner allows the shape of the flame and control of the flame to be determined fairly critically.

FIGURES 5 and 6 show more detailed views of a burner head 1' of a dual fuel supply type. In this instance the burner head 1' has plate portions 2', 3' showing the same matrix configuration of apertures as in FIGURE 1 of this specification. However, the apertures 6'a, 7'a, 8'a are formed from downwardly depending portions a' and upwardly depending portions b' which overlap one another to leave an annular gap g for fuel gas to enter the aperture 6a, 7a, 8a, rather than being provided with ports as in FIGURE 1. Either design may be used in the dual fuel application. The central gas supply pipe 104 has a central guide tube T (not shown in FIGURES 3 and 4) for the fuel lance 109. Item C represents a locating collar for the guide tube T and the pipe 104 is much wider than in prior art arrangements in order to allow the main gaseous fuel to enter the gallery G whilst also providing a housing for the oil lance 109. The burner head

aperture matrix 6a, 7a, 8a may be modified to that shown to take into account the wider pipe 104, for example by omission of the inner aperture ring 8a. The dual fuel burner could be provided in a single gaseous fuel application in which case the open end of the tube T protruding from the burner head 1' would be blocked off. To assemble the burner head 1' the inlet pipe 104 and guide tube T comprises a subassembly and the burner head 1' is screwed to the pipe 104, after lock nut N is fitted with guide tube T entering locating collar C. The burner head is screwed down until approximately 2mm of guide tube protrudes from the upper plate when it is locked tightly with locking nut N. A circular stabiliser plate Y is shown positioned on top of the upper plate portion 2.

The dual fuel burner assembly may be provided with any convenient burner head design and accordingly FIGURE 7 shows a burner head 1' corresponding more closely with prior art designs of the applicant. The arrangement of combustion air apertures follows a general hexagonal shape which is known (and which burner head design has at least some of the disadvantages outlined at the beginning of the specification) but the apertures A (shown in chain dotted lines) which are present in a single fuel application are omitted in the dual fuel application. The stabilizing plate is hexagonal and weld lines are shown in this view.

The Applicant has carried out test analysis of a prior art burner head of hexagonal matrix pattern and a burner head in accordance with the present invention (circular matrix pattern) in order to illustrate the dramatic reduction in temperature of the plate portions near the boundary of the burner head.

This test analysis is shown in FIGURES 8 to 16 in which:

FIGURE 8 shows a hexagonal matrix burner head and thermocouple locations in conjunction with a lower view showing graphical data in relation to the thermocouples;

FIGURES 9 to 11 shown burner performance test results for the hexagonal burner head shown in FIGURE 8;

FIGURE 12 shows a burner head in accordance with the present invention (circular matrix) indicating thermocouple positions identical with those in FIGURE 8 and additionally graphical data in relation to those thermocouples; and

FIGURES 13 to 15 shown burner performance test results for the burner head shown in FIGURE 12.

As will be seen from FIGURES 8 to 15 and more particularly from FIGURES 8 and 12, thermocouples 1 to 4 were located to measure the temperature occurring in different regions of the plate portions. Thermocouple 1 was located in the centre of the burner head, thermocouples 2 and 3 in mid regions of the plate portions with thermocouple 3 being located at one of the inner spacers and thermocouple 4 located at the outer boundary region of the plate.

It should be stressed that the burner test results whilst meaningful in showing the general pattern of temperature distribution between the prior art burner head design and the burner head design of the present invention are not identical to operating conditions in the field. For example, due to the presence of the refractory quarl as well as other factors, the temperature at the boundary of the burner head is significantly increased to that shown in the test results.

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Referring specifically to the graphical data in FIGURE 12, it will be seen that after some minutes the temperature registered by thermocouple 1 has reached the value of about 800°C (see upper part of trace 1), whilst
5 the temperature of thermocouple 4 is also at about the same level i.e. the temperature at the centre of the burner is in the same order as the temperature at the boundary. This indicates that in the field the temperature of the boundary area that will be registered
10 by thermocouple 4 would be very significantly higher (for example 150 to 200°C or more higher). The difference would be enough for the centre region to be emitting effectively a black heat radiation with the outer boundaries emitting a dull red radiation. The temperature
15 measured by thermocouple 2 is the lowest at about 660°C (see upper part of trace 2).

Comparing this data to the data given in FIGURE 15 shows that the temperature at the boundary regions
20 (measured by thermocouple 4) has dramatically dropped to about 660°C (see upper part of trace 4) and there is also a slightly lower operating temperature at the middle of the burner which is measured by thermocouple 1. Thus the temperature at the boundary has been lowered to within
25 about 30° of the temperature measured by thermocouple 2 and the temperature measured by thermocouple 2 has also been lowered by about 30° or so.

Thus, it can be seen that under like for like
30 conditions, the overall operating temperature of the burner head has been lowered but most significantly the temperature has been reduced very significantly at the boundary regions so that in the field the temperature of the middle of the burner and of the boundary will be of
35 the same order. It should be remembered that even where the temperature of the boundary regions is the same as

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the temperature of the centre of the burner head, the centre of the burner may in some circumstances not be subject to an accelerated corrosion rate because of the speed of gas flow through to the apertures, whereas the corrosion rate is accelerated abnormally at elevated temperatures where there is a lingering presence of the gas i.e. particularly inbetween the hexagonal matrix configuration termination and the boundary of the burner (i.e. in the segmental regions of the hexagonal shape burner head).

Furthermore, in comparing the burner performance test results it will be seen that improved combustion characteristics are apparent from the burner head in accordance with the present invention, this being indicated by the generally lower carbon monoxide and higher nitrous-oxide emissions at 1%, 2% and 3% oxygen at comparable furnace temperatures (flue temperatures).

Thus, it can be seen that even under the test conditions the temperature of the boundary region is not substantially higher than any other region of the plate portion (as shown in FIGURE 12 the temperature of the boundary region is only approximately 30° higher than the region of the plate detected by thermocouple 2).

It has been found by way of experiment on prior art burner heads having a matrix configuration as shown in FIGURE 7 of this specification that high temperature(s) may exist over portions of the burner head top plates during operation. During tests on burners operating on a furnace at approximately 1000°C in flue it has been observed that temperatures may range from 800-850°C in the central regions of the plate and at the periphery of the burner in areas of higher metal content. In the field, often temperatures result in the majority of the

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burner emitting a black heat radiation whilst dull red heat radiation is emitted from areas near the periphery, said areas being defined between the periphery of the burner and the aperture matrix (refer FIGURE 7). It is
5 at temperatures of 700°C or above that the corrosion rate of the plate portions, subjected to that heat, is very significantly accelerated (particularly where gas flow is restricted) i.e. decarbonisation of the plate material may be dramatically increased.

10

Test experiments with burner heads of the present invention (e.g. see FIGURE 1) illustrate significant temperature variation between boundary regions of the plate and middle or central regions i.e. a very
15 significant reduction in temperature of the boundary regions (reduction of approximately 150°C). This indicates that the boundary temperature in the field will be substantially lower than with the prior art hexagonal burner configuration. This is due to improved gas and
20 air cooling achieved by the burner in accordance with the present invention. Thus, the matrix array adopted in accordance with the present invention effectively prevents any part of the burner plate reaching an elevated temperature which would result in excess
25 corrosion when compared with any other area of the plate.

The burner of hexagonal matrix design and the circular matrix burner were tested under identical conditions on the same test furnace and conditions were
30 maintained under very close tolerances throughout the duration of the tests.

To summarise as will be seen from the "Burner Performance Test Data", major benefits have been obtained
35 from the burner head in accordance with the present invention as embodied in FIGURE 1 and FIGURE 12, namely:-

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1. Substantially improved air and gas flow patterns and mixing characteristics as a direct result of the redesign and distribution of the matrix system resulting in a lower temperature operating burner head.
5
2. Areas of higher metal content namely at the periphery of the prior art burner based on a hexagonal design matrix have been eliminated which, combined with lower temperatures of operation,
10 dramatically reduce potential corrosion of the burner head and by virtue of this can considerably extend life expectancy.
3. Due to the symmetrical arrangement of the circular matrix design the flame shape has also been improved
15 resulting in a shorter compact and more precise flame profile (flame profile is approximately 15% smaller). This new compact/precise flame profile provides clear advantages in certain process applications.
- 20 4. Combustion characteristics have also been considerably enhanced by virtue of the improved intimate mixing patterns of the air and gas mediums, resulting in slightly higher outputs being achieved from the same size burner head combined with higher
25 turn down ratios before instability occurs. This improved combustion performance is clearly indicated on the burner performance test results illustrated.
5. The redistribution of burner ports in accordance with FIGURES 1 and 12 facilitates a larger centre to
30 the burner on a "like for like" basis. This larger area at the centre of the burner provides an additional benefit in the formation of a "Dual-Fuel" version of the burner in which an oil lance is located straight through the centre of the burner
35 via a sealed guide tube (see FIGURE 5).

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6. As outlined in 5 above, the design of the circular matrix burner facilitates a larger area free of discharge ports at the centre of the burner enabling a fuel oil lance to be located at this point. The gas supply pipe diameter can be increased without adversely affecting the gas distribution/flow to individual discharge ports. This is not the case with the original hexagonal design matrix burner head.
7. The oil lance providing the second fuel source is also centrally and symmetrically located relative to the main matrix system and thereby enhances the overall symmetrical/radial arrangement of the burner assembly. The less combustible fuel is located at the centre of the flame and therefore affords greater flame stability.
8. The Dual-Fuel burner is designed to enable either gaseous or liquid fuels to be burnt together or independently in varying percentages.
9. The fuel oil lance can also be withdrawn or relocated whilst the gas burner remains in operation.

The central and symmetrical location of these two burner elements combined with adjustability in itself seems to provide major improvement.

In the burner according to the present invention, gas in the burner head develops pressure as its velocity reduced. As the gas flows outwards, radially, its velocity reduces due to an expanding flow area. The flow through the gas ports is proportional to the pressure developed at the port. Hence to achieve even flow of gas per port, all ports must be at the same position relative to the source of supply. With a single ring of ports gas flow will be even from port to port.

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If a second ring of ports is added in order to increase the gas/air flow in and through the burner head, then the geometry of the inner ring of ports also becomes important.

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As a result of detailed test and development work, the spacing between these ports (which creates the gallery) has been carefully selected to allow the correct flow of gas past the inner rings of ports for the supply to the outer ring. This proportioning of gas flow applies at full fire (maximum gas flow). At lower gas flows, the gallery offers less resistance and hence the gas is transmitted to the outer areas of the burner head and discharged at the outer ports.

15

The hexagonal matrix port spacing does not totally meet this criteria as port positions vary radially and the port spacing (gallery size) is not optimum for the sharing of gas between inner and outer ports.

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The burner head in accordance with the present invention has many beneficial aspects on burner performance and application, a number of which are listed below:-

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1. The optimised flow arrangement provides increased burner output for a given burner size.
2. The flame profile (gases released) across the burner head is uniform resulting in a shorter more compact flame thus widening its field of application.
3. Under low fire conditions, the design achieves:-
 - 3.1. Improved and more intimate mixing with combustion air.
 - 3.2 Gas flow is maintained to the outside of the burner head providing "gas cooling" and avoiding the development of "hot spots" and

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resultant corrosion.

3.3. Higher turn down ratio as the concentration of gas at the outer ports permits smaller gas flows before flame instability occurs.

5 4. Substantially reduced potential corrosion.

On the burner head of hexagonal matrix arrangement, the gas flow does not properly reach and hence cool the outer periphery of the burner head, particularly in areas of higher metal content. This can result in "hot spots" that lead to metal failure due to excessive carbonisation. The burner head avoids this by providing gas flow and hence "gas cooling" to all parts of the burner head.

15 5. Combustion characteristics are improved as a direct result of a better and more even air/gas mixing system (reference is made to the burner performance test results).

20 6. Increased turn down ratios, the circular matrix burner also exhibits greater flame stability under all operating conditions.

25 7. The radial arrangement of discharge ports gives more space/area at the centre of the burner. This allows the gas supply pipe diameter to be increased without affecting the gas distribution within the burner gallery system. Gas being evenly distributed to each discharge port. This is not possible on the burner head of hexagonal matrix design.

30 This larger area at the centre of the burner enables the production of a "Dual-Fuel" burner head, in which an oil lance can be fitted through its centre. Both gaseous and liquid fuels can be burnt either separately or together in varying percentages in a uniform and symmetrical formation. The less
35 combustible fuel (ie oil being placed at the centre of the burner surrounded by an air and gaseous

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medium) thus ensuring efficient combustion.

Still further according to the present invention there is provided a burner element as claimed in Claim 1
5 of U.K. Patent Specification No. 1325443 in which a ring of said combustion air apertures closely follows an outer boundary of the burner head.

It is to be understood that the scope of the present
10 invention is not to be unduly limited to the particular choice of terminology and that a specific term may be replaced by any equivalent or generic term where sensible. Further it is to be understood that individual features, methods, uses or functions related to the
15 burner head or parts of the burner assembly might be individually patentably inventive. The singular may include the plural where sensible. Additionally, any range mentioned herein for any variable or parameter shall be taken to include a disclosure of any derivable
20 sub-range within that range or of any particular value of the variable or parameter arranged within, or at an end of, the range of sub-range.

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THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A burner head provided with an array or matrix of combustion air apertures, said burner head having spaced plate portions defining a fuel supply gallery or passageway to said apertures, said plate portions including an aperture ring of said array or matrix which closely follows an outer boundary of the burner head, and which is adjacent to said boundary to thereby prevent or restrict localised regions of the plate portions, at least near said boundary, becoming subject to temperatures which are substantially higher than any other region of the plate, or becoming subject to a corrosion or deterioration rate higher than any other region of the plate portions, or to prevent or restrain substantially anomalous flow patterns of the fuel supply in the gallery at least around said aperture ring and adjacent said boundary, or a combination thereof.
2. A burner head as claimed in claim 1 in which the array or matrix of apertures is configured to prevent or restrict anomalous high temperature or high corrosion regions occurring on the plate portions by giving substantially the same freedom of access of the fuel supply in the gallery to each of the apertures.
3. A burner head as claimed in claim 1 or 2 in which the plate portions are spaced from one another by spacers.
4. A burner head as claimed in claim 1 or 2 arranged to operate at operating temperatures near the boundary region below about 650° to 700°C, or below dull red heat radiation levels.
5. A burner head as claimed in claim 4 which provides said operating temperatures at boundary regions of the plate portions while central regions of the plate portions are also at the same or higher operating temperatures.

6. A burner head as claimed in any one of claims 1, 2 and 5 having circular shaped plate portions and said aperture ring consists of a circle of apertures spaced closely to one another and close to said boundary.

7. A burner head as claimed in claim 6 in which the apertures in the circular ring are spaced equidistantly from one another.

8. A burner head as claimed in claim 6 in which said apertures are of circular form.

9. A burner head as claimed in any one of claims 1, 2, 5, 7 and 8 in which the aperture ring comprises a series of combustion air apertures, at least half or the majority of which are spaced at a distance from said boundary by an amount which is less than or equal to the spacings between one another.

10. A burner head as claimed in either one of claims 7 or 8 in which each aperture is spaced from the boundary by a distance not more than three times the distance in between each aperture.

11. A burner head as claimed in claim 10 in which each aperture is spaced from the boundary by a distance not more than twice the distance in between each aperture.

12. A burner head as claimed in any one of claim 7, 8 and 11 having second and third aperture rings arranged radially inwardly of the first aperture ring.

13. A burner head as claimed in claim 12 in which each of the second and third aperture rings consists of a series of circular apertures.

14. A burner head as claimed in claim 13 in which the third, innermost aperture ring comprises a series of circular apertures which are arranged concentrically with

the first, outermost aperture ring so that each of the apertures in the innermost ring is radially aligned with respective apertures in the outermost ring, said innermost and outermost ring apertures being concentrically aligned with the circular plate portions of the burner head.

15. A burner head as claimed in either one of claims 13 or 14 in which the second aperture ring comprises a series of circular apertures which are displaced circumferentially relative to the outer and innermost aperture rings.

16. A burner head as claimed in claim 15 wherein the aperture configuration results in an array of substantially triangular shaped sector regions extending around the circumference of the plate portions.

17. A burner head as claimed in claim 16 in which spacers are provided in between the triangular shaped sectors.

18. A burner head as claimed in any one of claims 1, 2, 5, 7, 8, 11, 13, 14, 16 and 17 provided with radial ports at said boundary for radial discharge of the fuel.

19. A burner head as claimed in claim 18 in which second and third aperture rings are arranged radially inwardly of a first aperture ring and in which the radial ports are spaced equally around said boundary in between said apertures in the outer ring.

20. A burner head as claimed in any one of claims 1, 2, 5, 7, 8, 11, 13, 14, 16, 17 and 19 in which the apertures are broached or pierced.

21. A burner head as claimed in any one of claims 1, 2, 5, 7, 8, 11, 13, 14, 16, 17 and 19 in which the burner plates are generally made from an austenitic chromium alloy steel.

22. A burner head as claimed in claim 21 in which the burner is manufactured from a high nickel/chromium fine

grain material reference NSU No. 800800 (referred to as alloy 800).

23. A burner having a burner head as claimed in any one of claims 1, 2, 5, 7, 8, 11, 13, 14, 16, 17, 19 and 21.

24. A burner head with an array or matrix of apertures for combustion air, and said head comprising two plate portions defining a gallery or passageway to said apertures, the plate portions including an aperture ring which closely follows, and is adjacent to, an outer boundary of the burner head, said plate portions being constructed from one or more materials selected from the group consisting of:

InconelTM 600, NicroferTM 7216, HaynesTM 750, Inconel 601, Nicrofer 6023 (UNS 06601), Inconel 617 (UNS 06617), Inconel 625, Nicrofer 6020hMO, Haynes 625 (UNS 06625), Haynes 214, Haynes 230, Alloy RA 330 (UNS 08330), and Fine grain Incoloy 800 (UNS 8000800).

25. A burner head as claimed in claim 24 in which the plate portions are constructed from a material selected from the group consisting of: UNS 06617, UNS 06625 and UNS 08330.

26. A burner head as claimed in claim 24 in which the plate portions are constructed from fine grain Incoloy 800 (UNS 8000800).

27. A burner head as claimed in any one of claims 24, 25 and 26 in which the plate portions are of 16 gauge metal.

28. A dual fuel burner having a burner head with an array or matrix of combustion air apertures and plate portions defining a gallery or passageway therebetween for a main fuel supply to be fed to said apertures, the plate portions including an aperture ring which closely follows, and is adjacent to, an outer boundary of the burner head, the arrangement being such that the burner can be run on the first or main fuel supplied along the gallery to said apertures and may alternatively be operated on a second fuel

mixed with combustion air supplied through said apertures.

29. A burner as claimed in claim 28 which can be operated on a mixture of the first main fuel and the secondary fuel.

30. A burner as claimed in claim 28 or 29 in which the secondary fuel is introduced into the burner by way of a supply line arranged within the supply line of the main fuel supply.

31. A burner as claimed in claim 30 in which the secondary fuel is oil.

32. A burner as claimed in claim 31 in which a fuel lance is insertable in the main fuel supply line to the burner.

33. A burner as claimed in claim 32 in which the lance has a tip which extends beyond said plate portions in order to spray fuel oil above said plate portions for mixing with combustion air drawn through said apertures for ignition at the burner.

34. A burner as claimed in claim 33 having spark ignition.

35. A burner as claimed in any one of claims 32, 33 and 34 in which the lance tip extends beyond the burner head.

36. A burner as claimed in any one of claims 32, 33 and 34 in which the lance tip is adjustable.

37. A burner as claimed in any one of claims 28, 29, 31, 32, 33 and 34 in which separate controls are provided for delivery of either or both fuels to the burner.

38. A burner as claimed in any one of claims 28, 29, 31, 32, 33 and 34 which can be employed in a single fuel situation or in a double fuel situation, an inner pipe being used for the secondary supply merely being closed off where the burner is to be used in a single fuel application only.

39. A burner element comprising two sheet metal members in a spaced superimposed relationship relative to each other and sealed around their edges to form a fuel supply gallery therebetween, the sheet members being provided with a plurality of pairs of combustion air apertures, each pair comprising one aperture in each sheet member, the sheet metal surrounding each aperture of each pair extending in a tubular projection towards and into interfitting relationship with a tubular projection extending from the material surrounding the other aperture of each pair, one tubular projection of each pair co-operating with the other projection of each pair to form a plurality of fuel escape openings for the flow of fuel from the supply gallery and in which a ring of said combustion air apertures closely follows an outer boundary of the burner element.

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FIG.1.

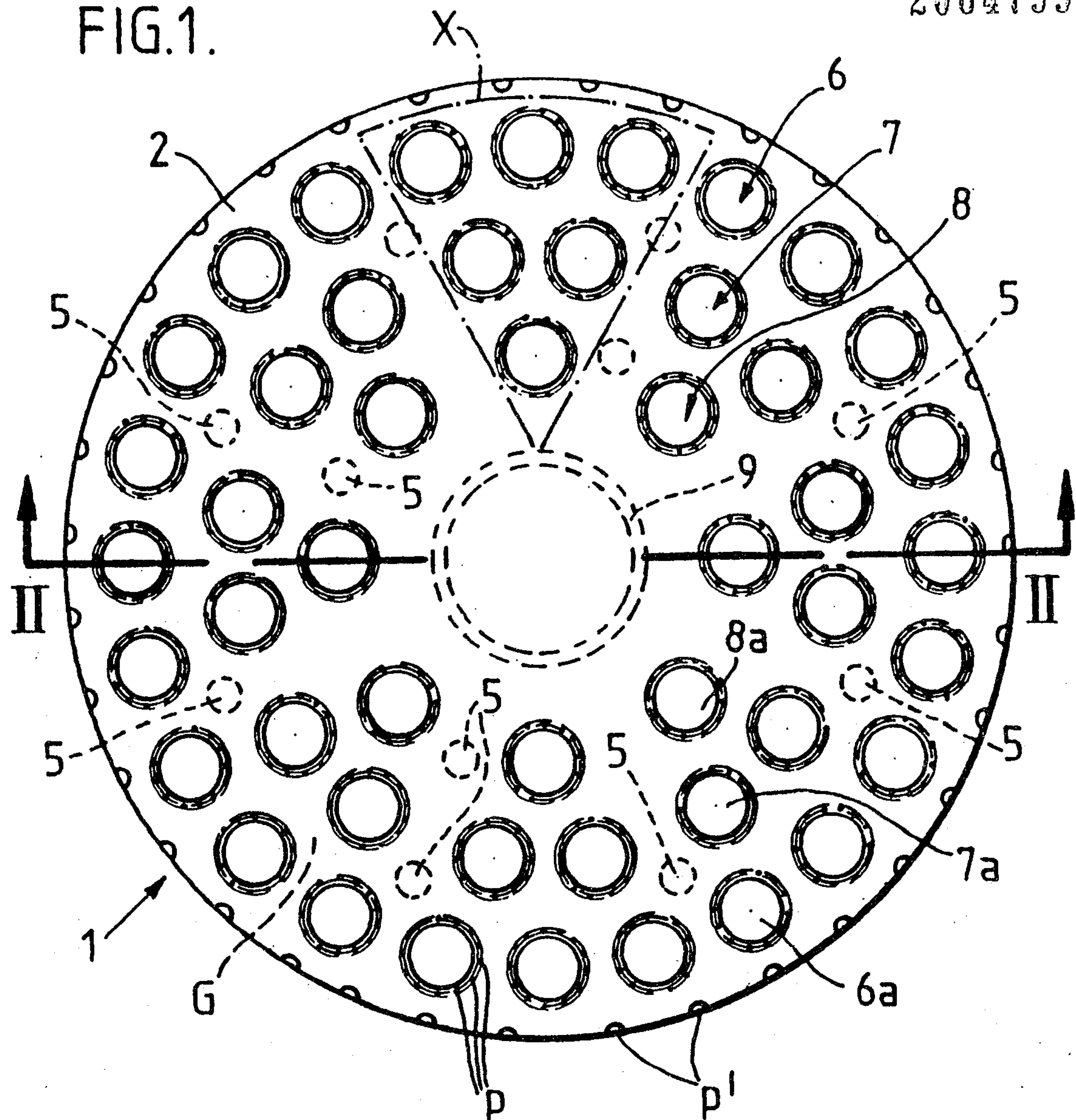


FIG. 2.

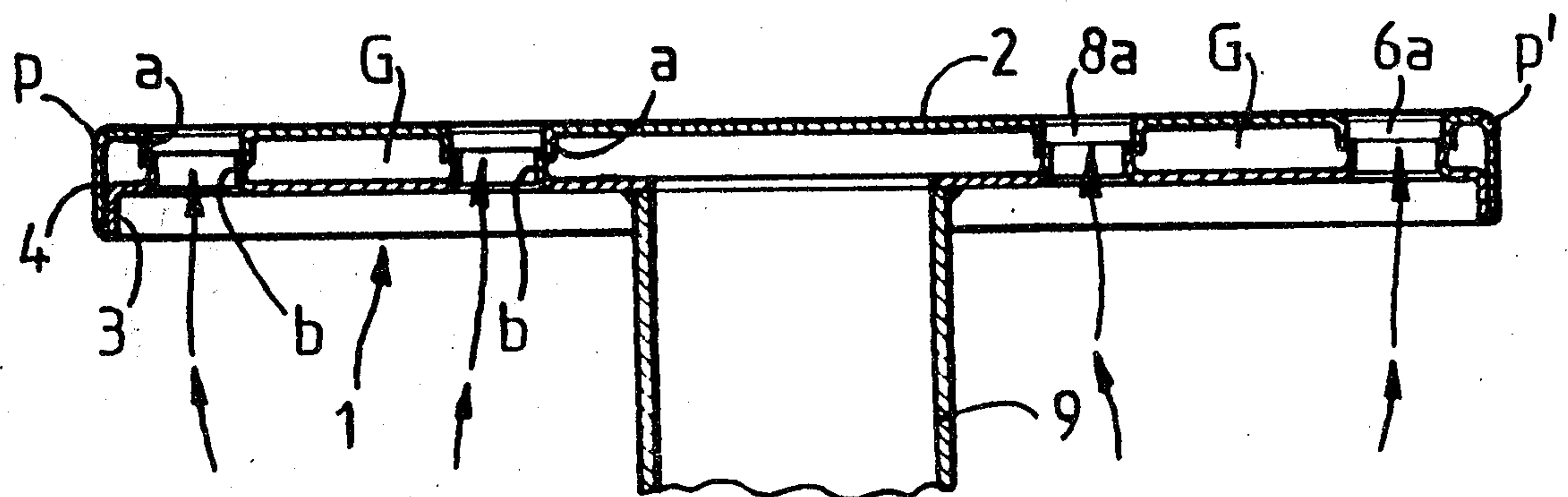


FIG. 3.

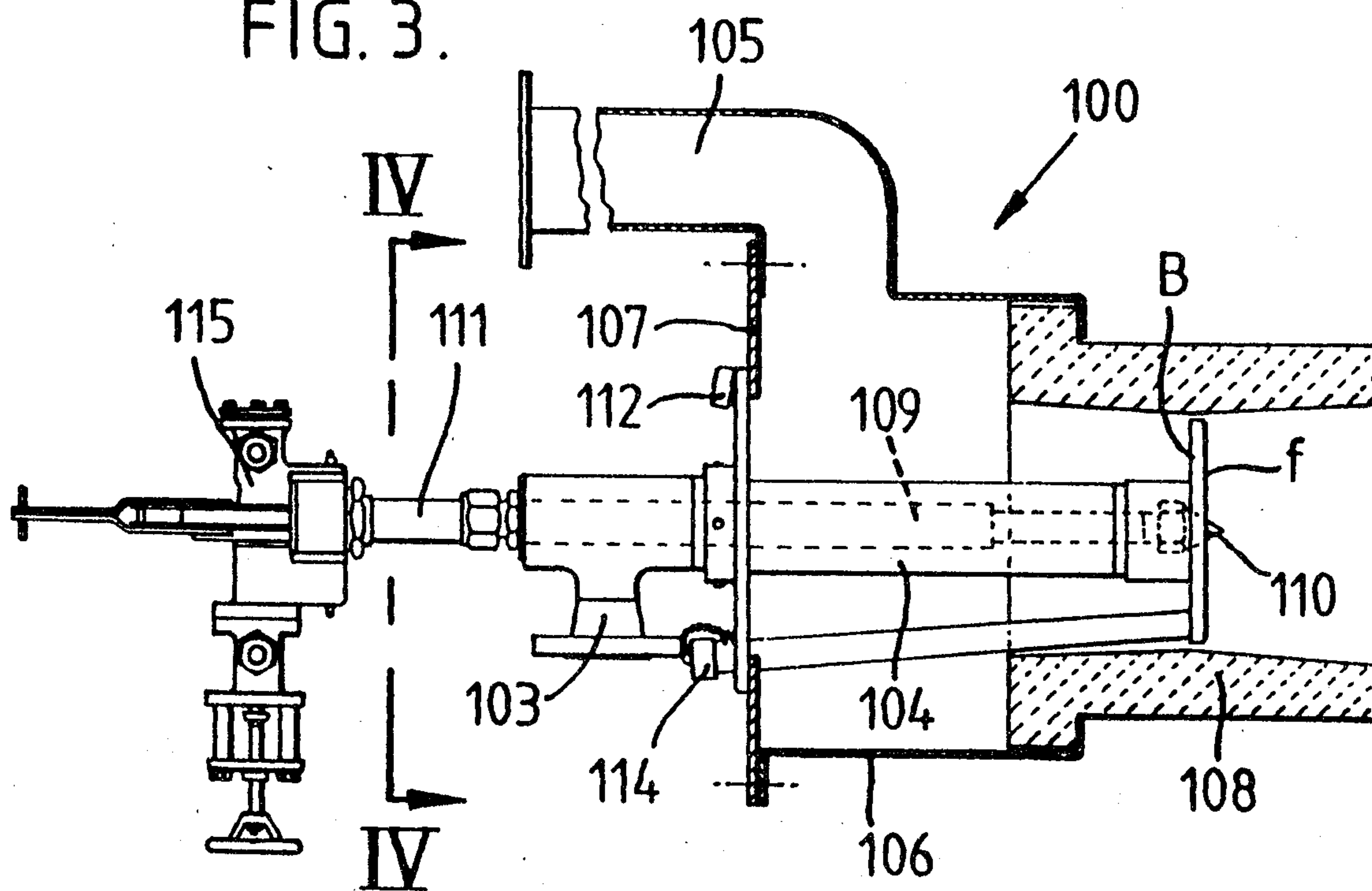
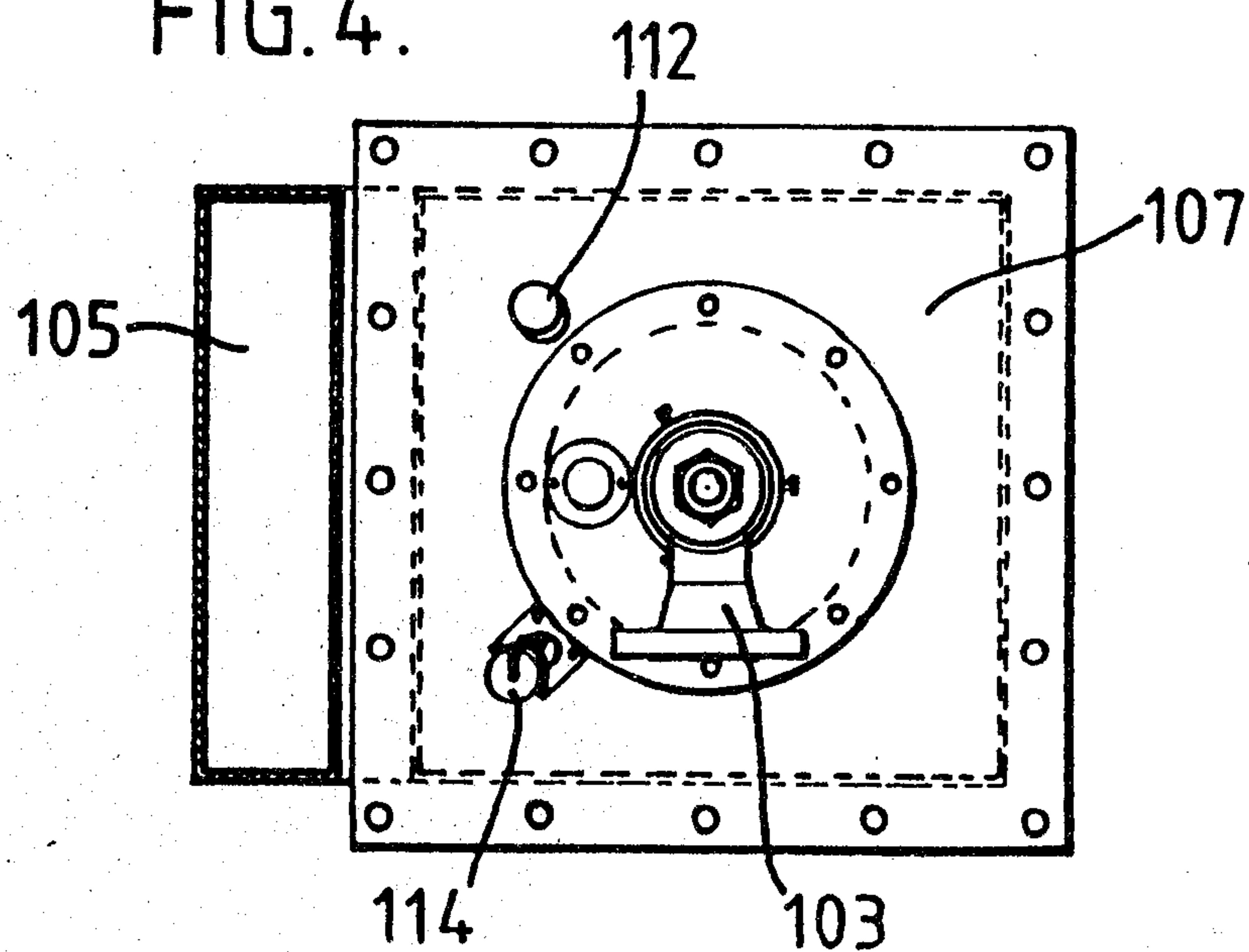


FIG. 4.



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FIG. 5.

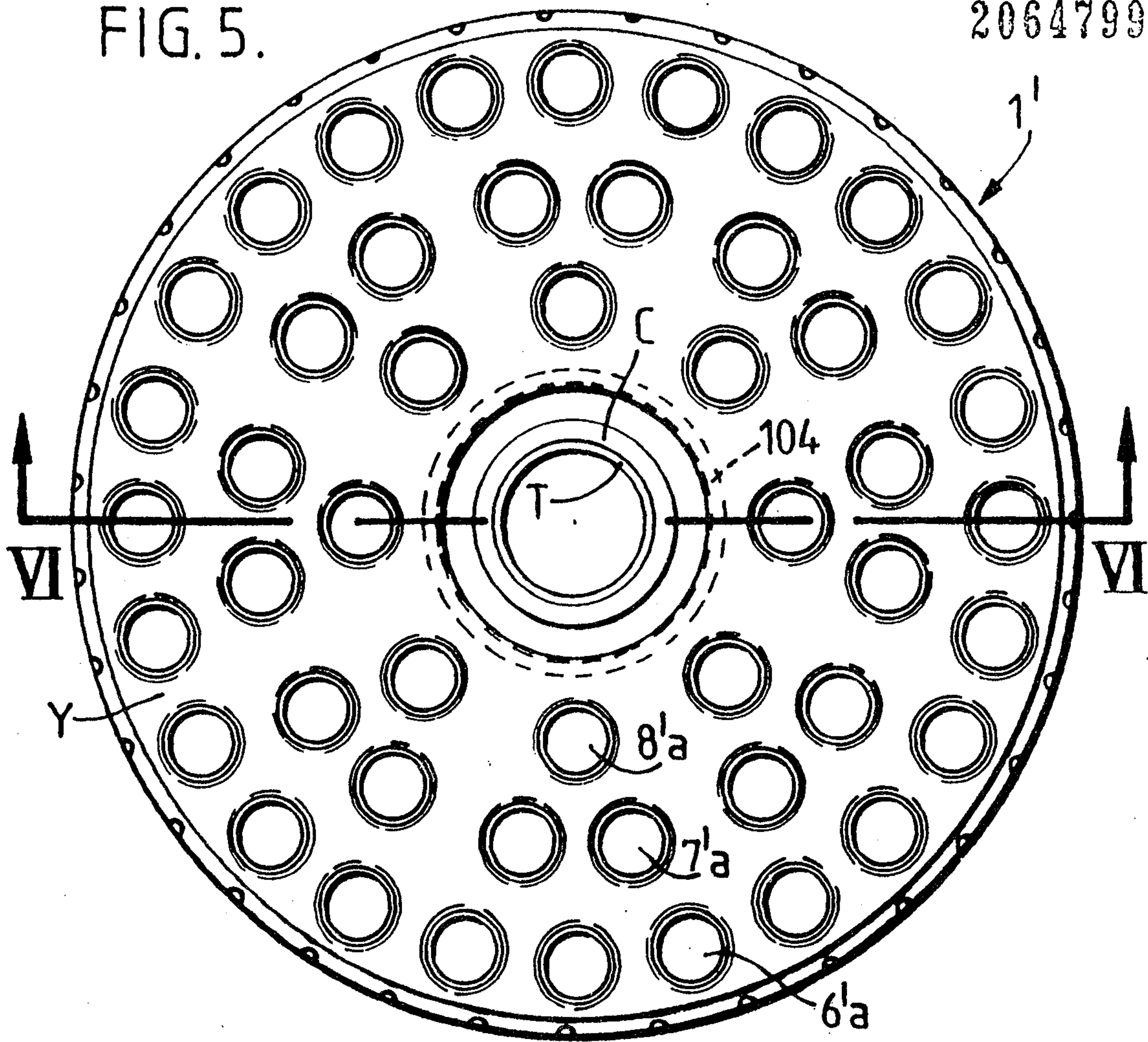


FIG. 6.

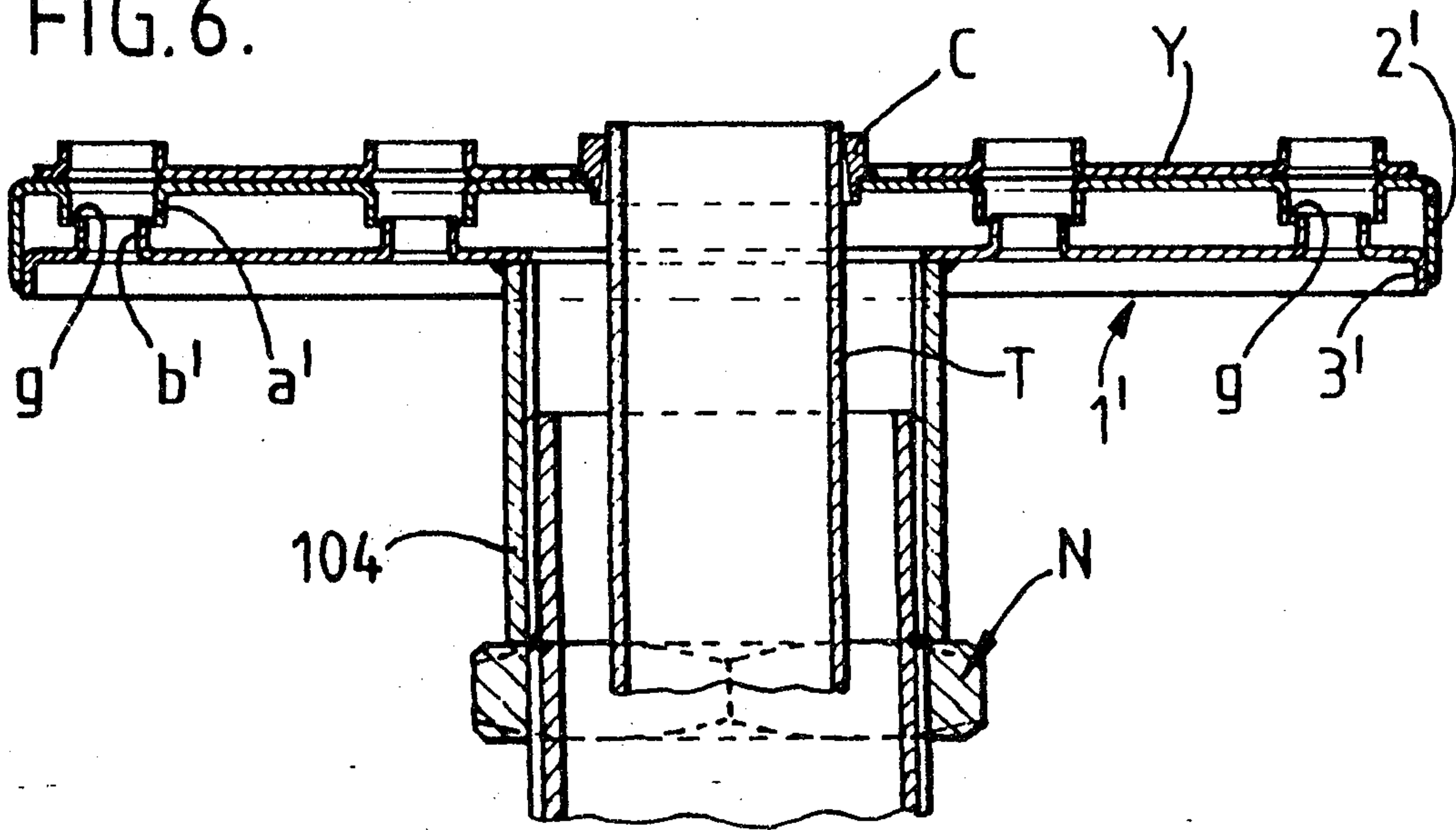


FIG. 7.

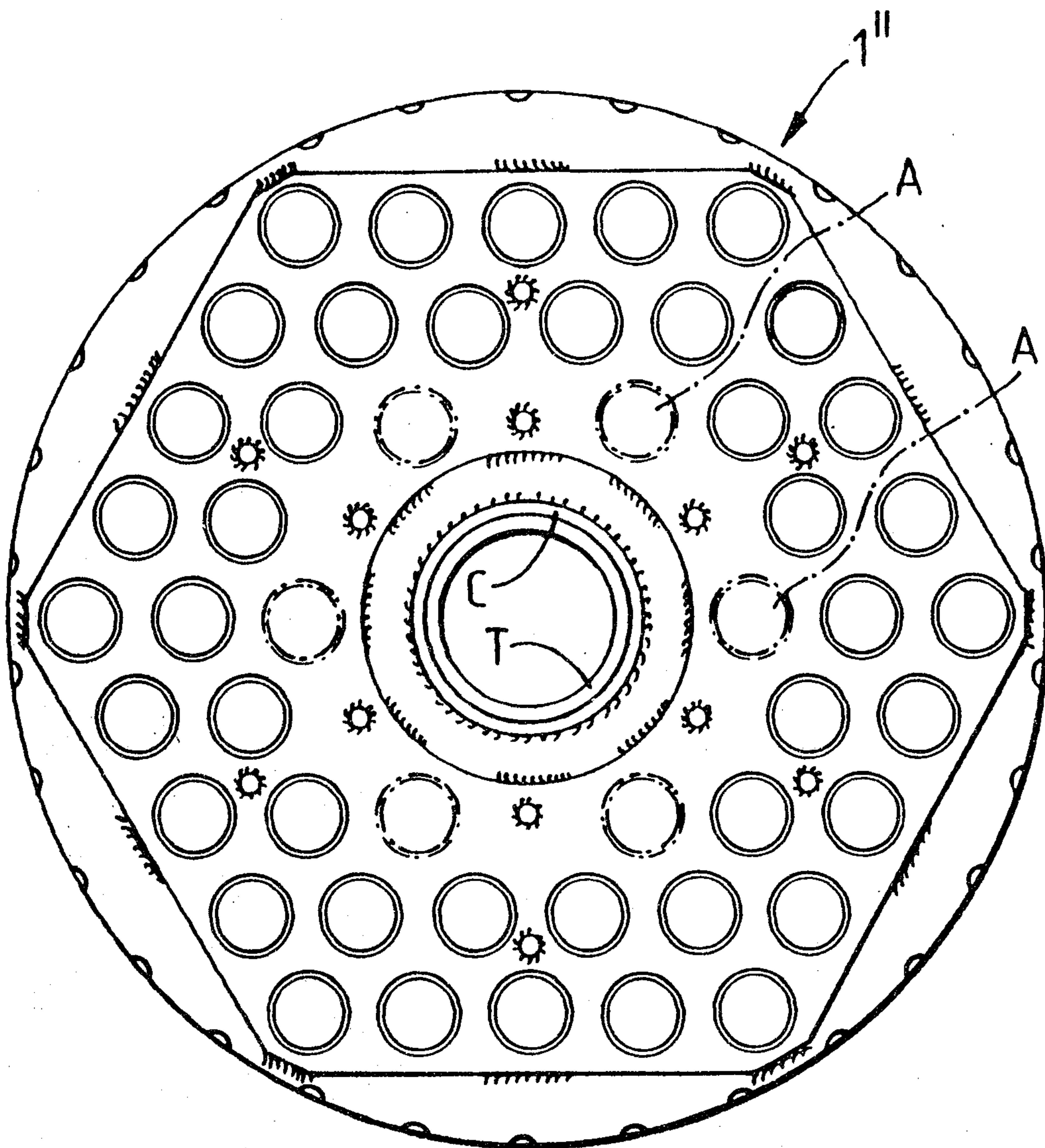
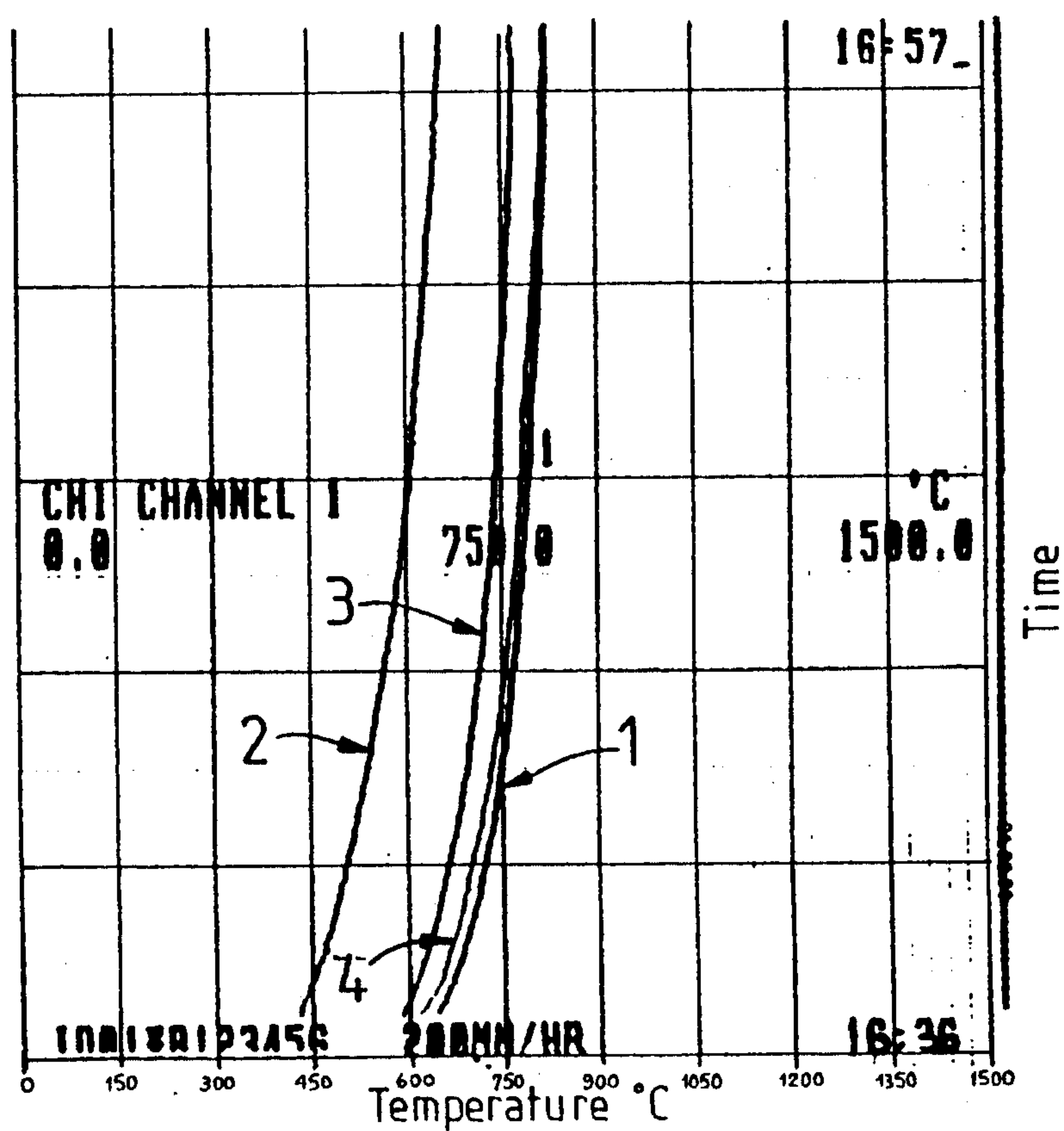
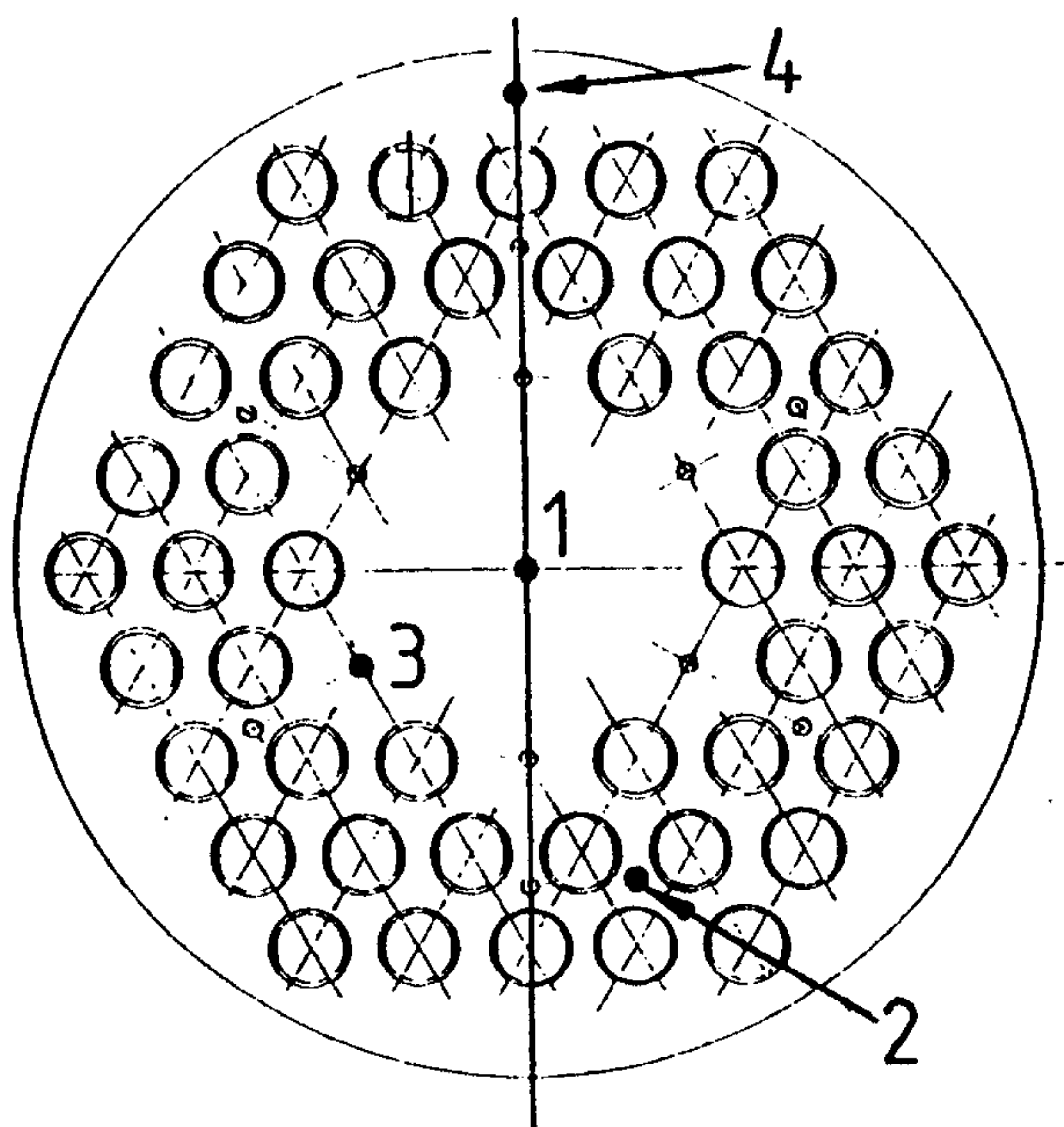


FIG.8.

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Temperature profile at four positions on burner head top plate.

Burner Head Type : 224RB12 (Hexagonal Matrix Pattern)
 Burner Heat Release : 1.0×10^6 Btu/h
 Oxygen Content in Flue Gas : 7%



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FIG.9.

BURNER TYPE : 224RB-12 (Hexagonal Matrix)
MANUFACTURER : Lanemark
GAS TYPE : Natural
COMBUSTION AIR TEMPERATURE : 20°C

TEST NO.	BURNER HEAT RELEASE BTU/HR	COMBUSTION ANALYSIS			FLUE TEMP °C
		O ₂ %	CO ppm	NO _x ppm	
1	1.0 x 10 ⁶	1	12	125	966
2	1.0 x 10 ⁶	1	31	168	1017
3	1.0 x 10 ⁶	1	21	186	1043
4	1.0 x 10 ⁶	1	47	196	1053

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FIG.10.

BURNER TYPE : 224RB-12 (Hexagonal Matrix)
MANUFACTURER : Lanemark
GAS TYPE : Natural
COMBUSTION AIR TEMPERATURE : 20°C

TEST NO.	BURNER HEAT RELEASE BTU/HR	COMBUSTION ANALYSIS			FLUE TEMP °C
		O ₂ %	CO ppm	NO _x ppm	
1	1.0 x 10 ⁶	2	0	123	933
2	1.0 x 10 ⁶	2	1	180	1020
3	1.0 x 10 ⁶	2	3	200	1038
4	1.0 x 10 ⁶	2	4	212	1049
5	1.0 x 10 ⁶	2	10	252	1082



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FIG.11.

BURNER TYPE : 224RB-12 (Hexagonal Matrix)
MANUFACTURER : Lanemark
GAS TYPE : Natural
COMBUSTION AIR TEMPERATURE : 20°C

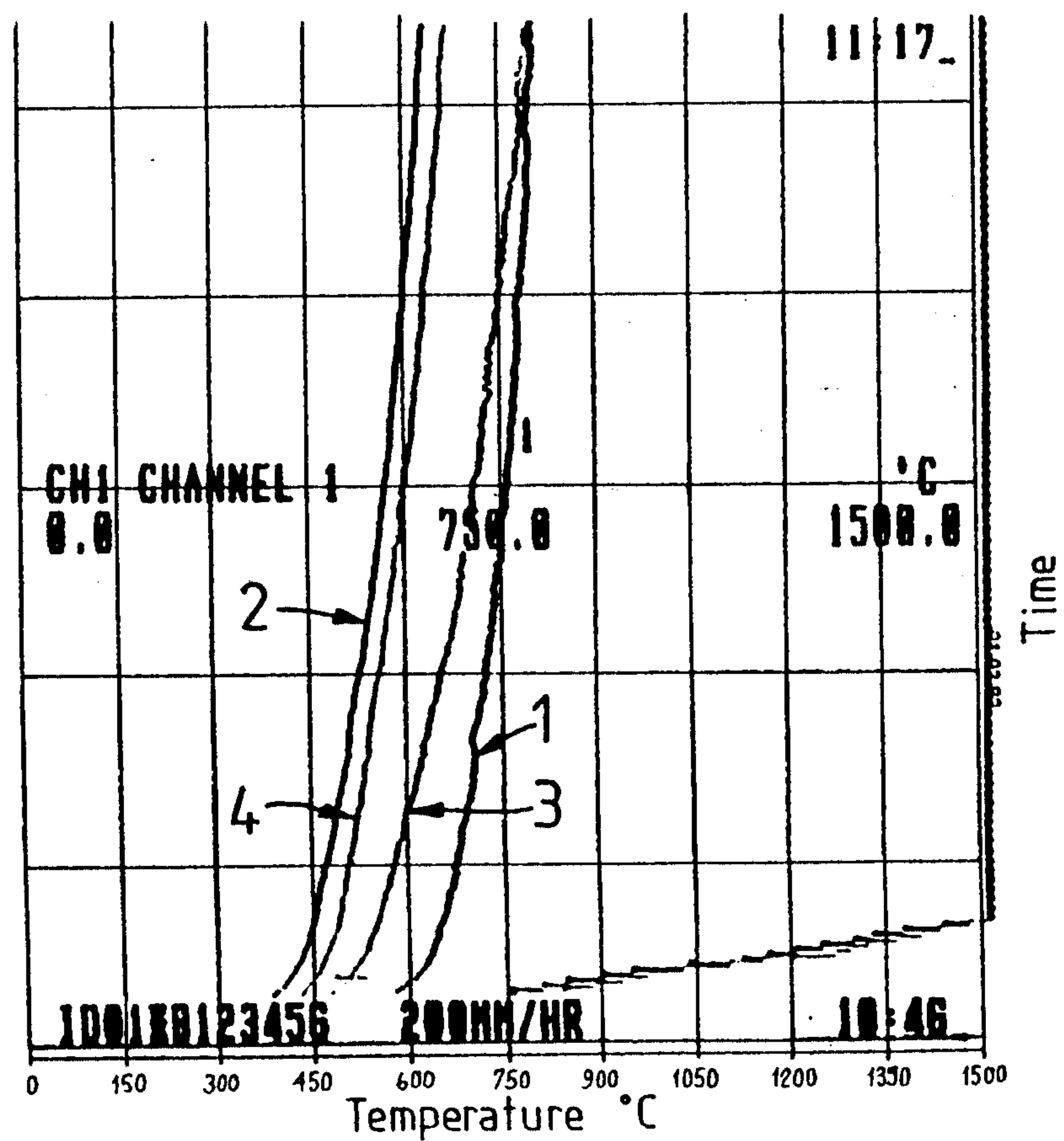
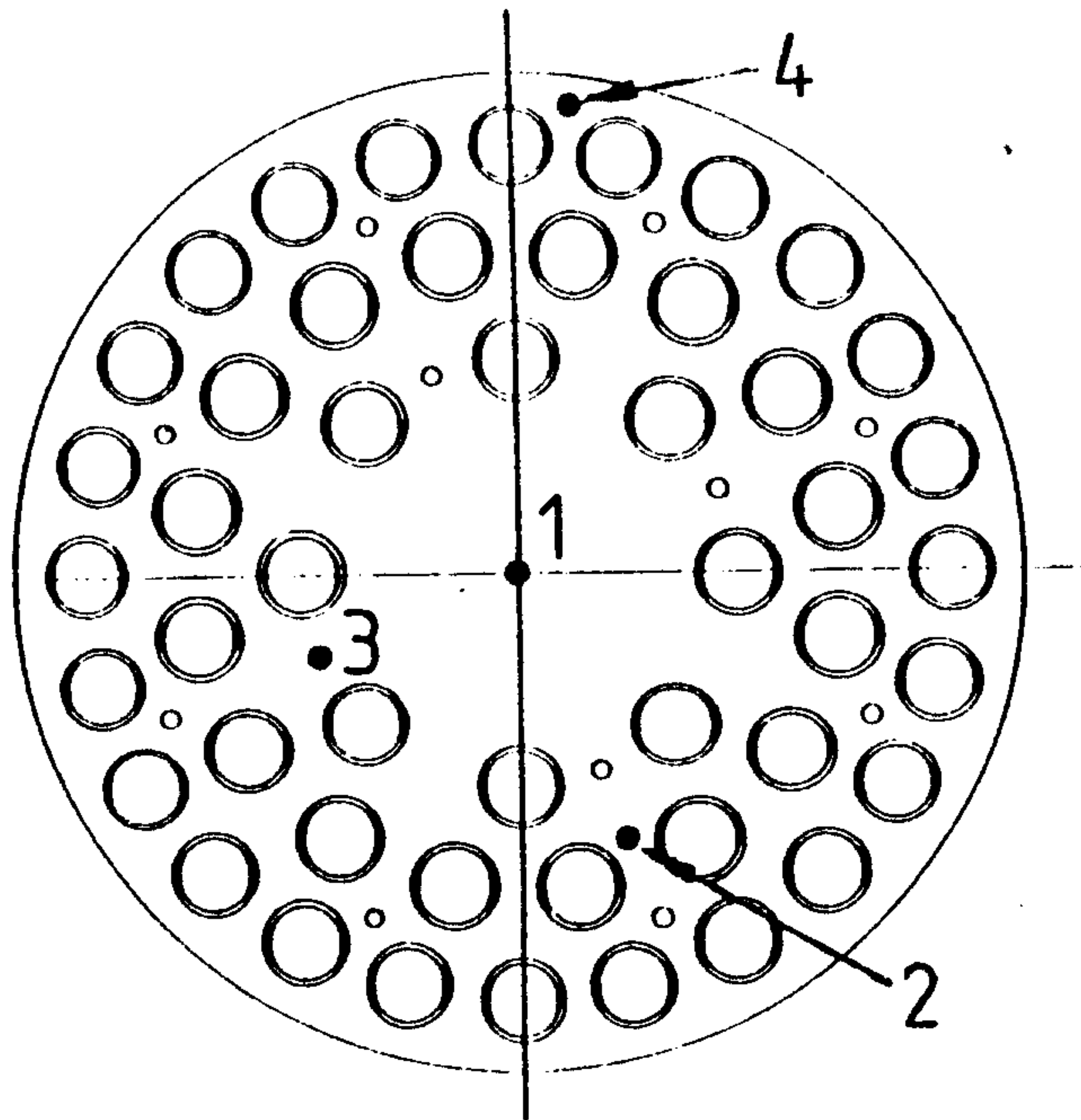
TEST NO.	BURNER HEAT RELEASE BTU/HR	COMBUSTION ANALYSIS			FLUE TEMP °C
		O ₂ %	CO ppm	NO _x ppm	
1	1.0 x 10 ⁶	3	0	139	985
2	1.0 x 10 ⁶	3	0	157	1013
3	1.0 x 10 ⁶	3	0	167	1035
4	1.0 x 10 ⁶	3	1	184	1061
5	1.0 x 10 ⁶	3	1	194	1068

FIG.12.

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Temperature profile at four positions on burner head top plate.

Burner Head Type : 224RB12 (Circular Matrix)
 Burner Heat Release : 1.0×10^6 Btu/h
 Oxygen Content in Flue Gas : 7%



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FIG.13.

BURNER TYPE : 224RB-12 (Circular Matrix)
MANUFACTURER : Lanemark
GAS TYPE : Natural
COMBUSTION AIR TEMPERATURE : 20°C

TEST NO.	BURNER HEAT RELEASE BTU/HR	COMBUSTION ANALYSIS			FLUE TEMP °C
		O ₂ %	CO ppm	NO _x ppm	
1	1.0 x 10 ⁶	1	12	140	966
2	1.0 x 10 ⁶	1	9	171	1015
3	1.0 x 10 ⁶	1	13	180	1036
5	1.0 x 10 ⁶	1	14	207	1069
6	1.0 x 10 ⁶	1	20	222	1080

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FIG.14.

BURNER TYPE : 224RB-12 (Circular Matrix)
MANUFACTURER : Lanemark
GAS TYPE : Natural
COMBUSTION AIR TEMPERATURE : 20°C

TEST NO.	BURNER HEAT RELEASE BTU/HR	COMBUSTION ANALYSIS			FLUE TEMP °C
		O ₂ %	CO ppm	NO _x ppm	
1	1.0 x 10 ⁶	2	3	133	931
2	1.0 x 10 ⁶	2	1	161	985
3	1.0 x 10 ⁶	2	3	176	1019
4	1.0 x 10 ⁶	2	3	187	1036
5	1.0 x 10 ⁶	2	4	199	1048
6	1.0 x 10 ⁶	2	5	210	1068

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FIG.15.

BURNER TYPE : 224RB-12 (Circular Matrix)
MANUFACTURER : Lanemark
GAS TYPE : Natural
COMBUSTION AIR TEMPERATURE : 20°C

TEST NO.	BURNER HEAT RELEASE BTU/HR	COMBUSTION ANALYSIS			FLUE TEMP °C
		O ₂ %	CO ppm	NO _x ppm	
1	1.0 x 10 ⁶	3	0	152	965
2	1.0 x 10 ⁶	3	0	165	986
3	1.0 x 10 ⁶	3	0	176	1014
4	1.0 x 10 ⁶	3	0	190	1034
5	1.0 x 10 ⁶	3	0	202	1052
6	1.0 x 10 ⁶	3	3	210	1068