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[54] **COMBUSTION CHAMBER CLUSTERING STRUCTURE**

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[52] **U.S. Cl.** **60/39.37,** 60/39.31, 60/39.65

[51] **Int. Cl.** **F02c 7/20**

[58] **Field of Search** 60/39.37, 39.65, 39.31

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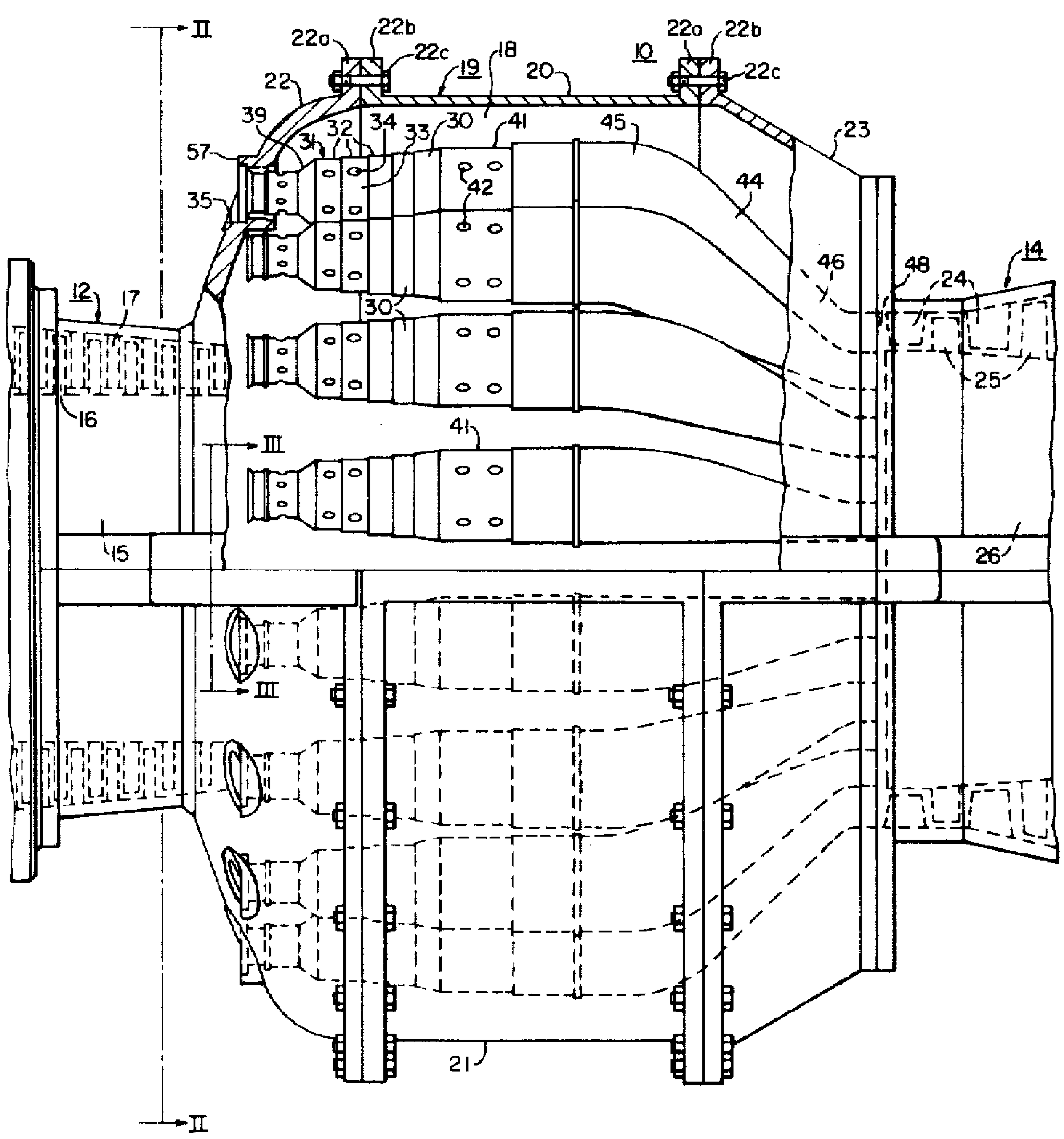
[57] **ABSTRACT**

A gas turbine power plant having a combustion section defined by a casing structure divided into upper and lower semi-cylindrical casing halves along a horizontal plane. The casing halves encompass an annular array of combustion chambers equally spaced from the central axis of the turbine. The end wall of the casing structure has an annular array of equally spaced openings, at least one of the openings having a smaller diameter than the maximum diameter of the associated combustion chamber. This enables a closer clustering of the combustion chambers and a corresponding decrease in the diameter of the casing structure.

12 Claims, 11 Drawing Figures



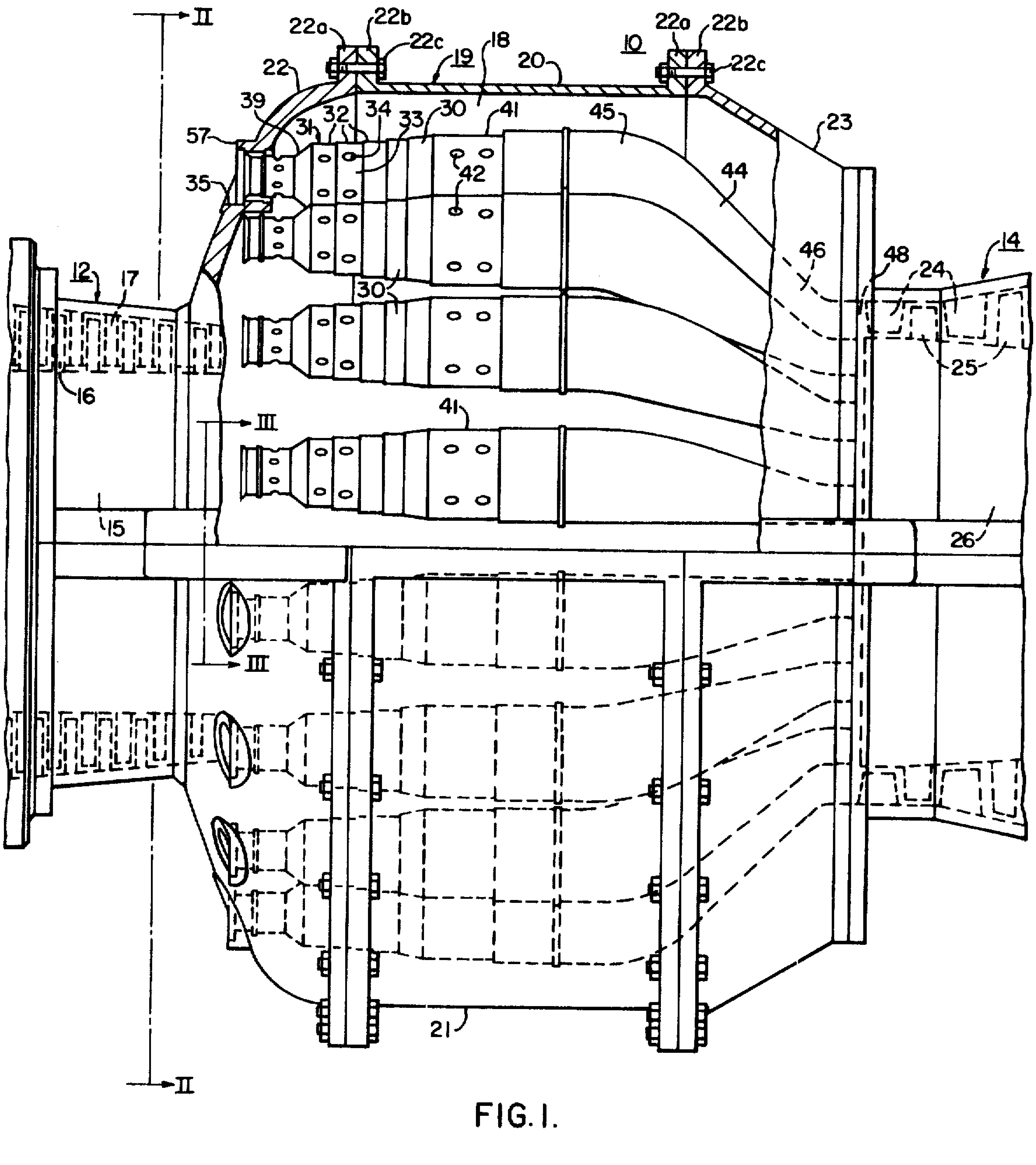


FIG. I.

WITNESSES

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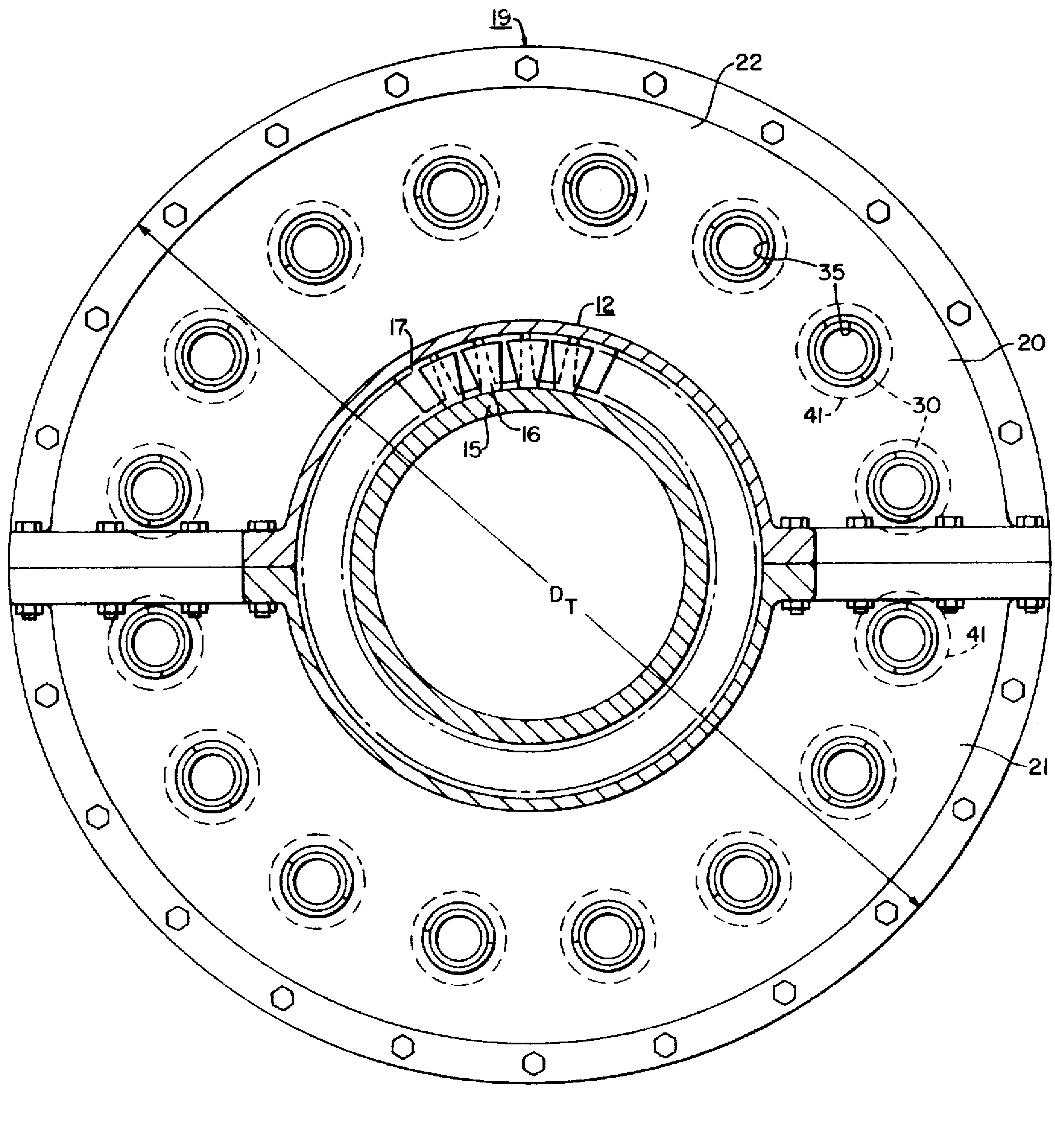
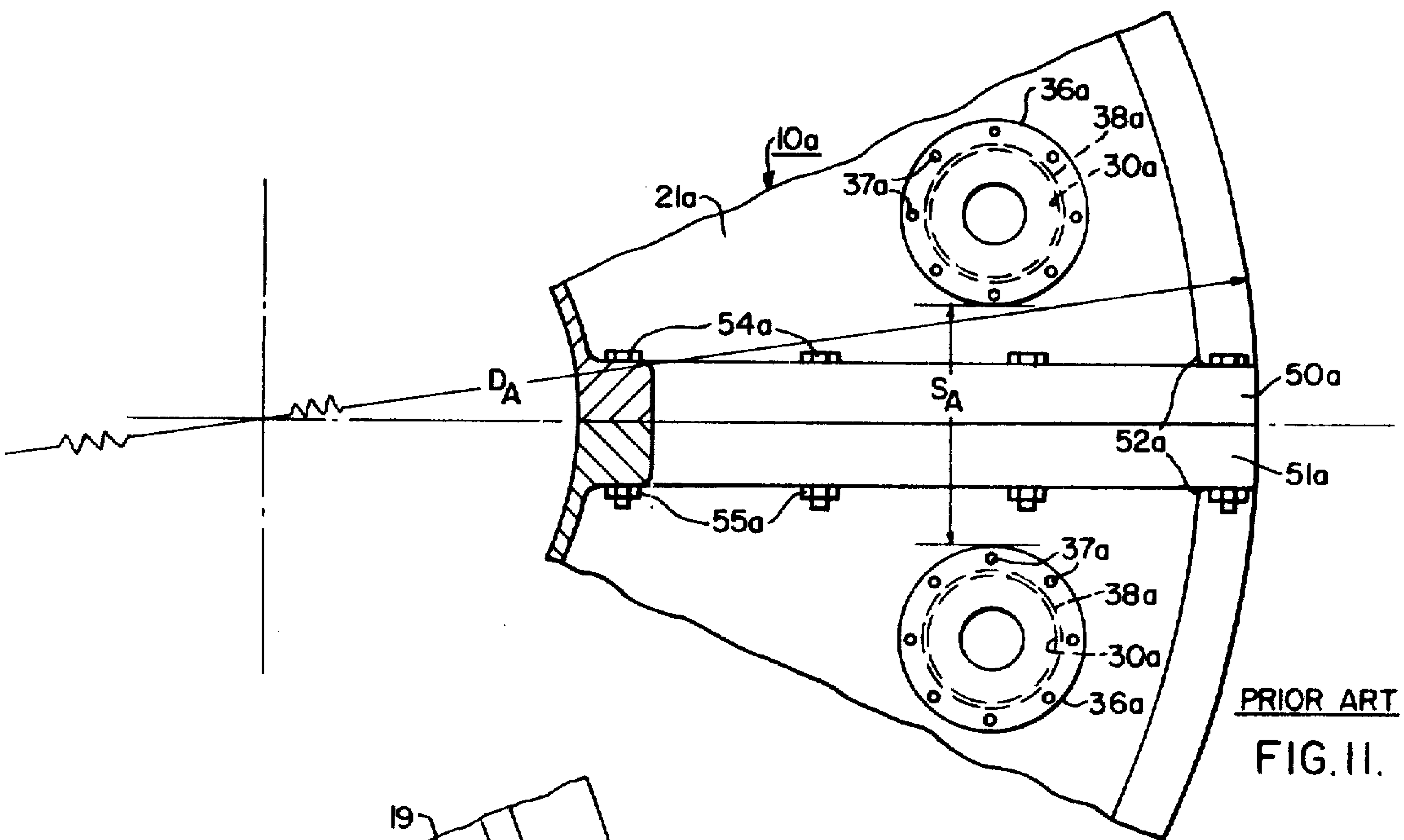


FIG.2.



PRIOR ART

FIG. 11.

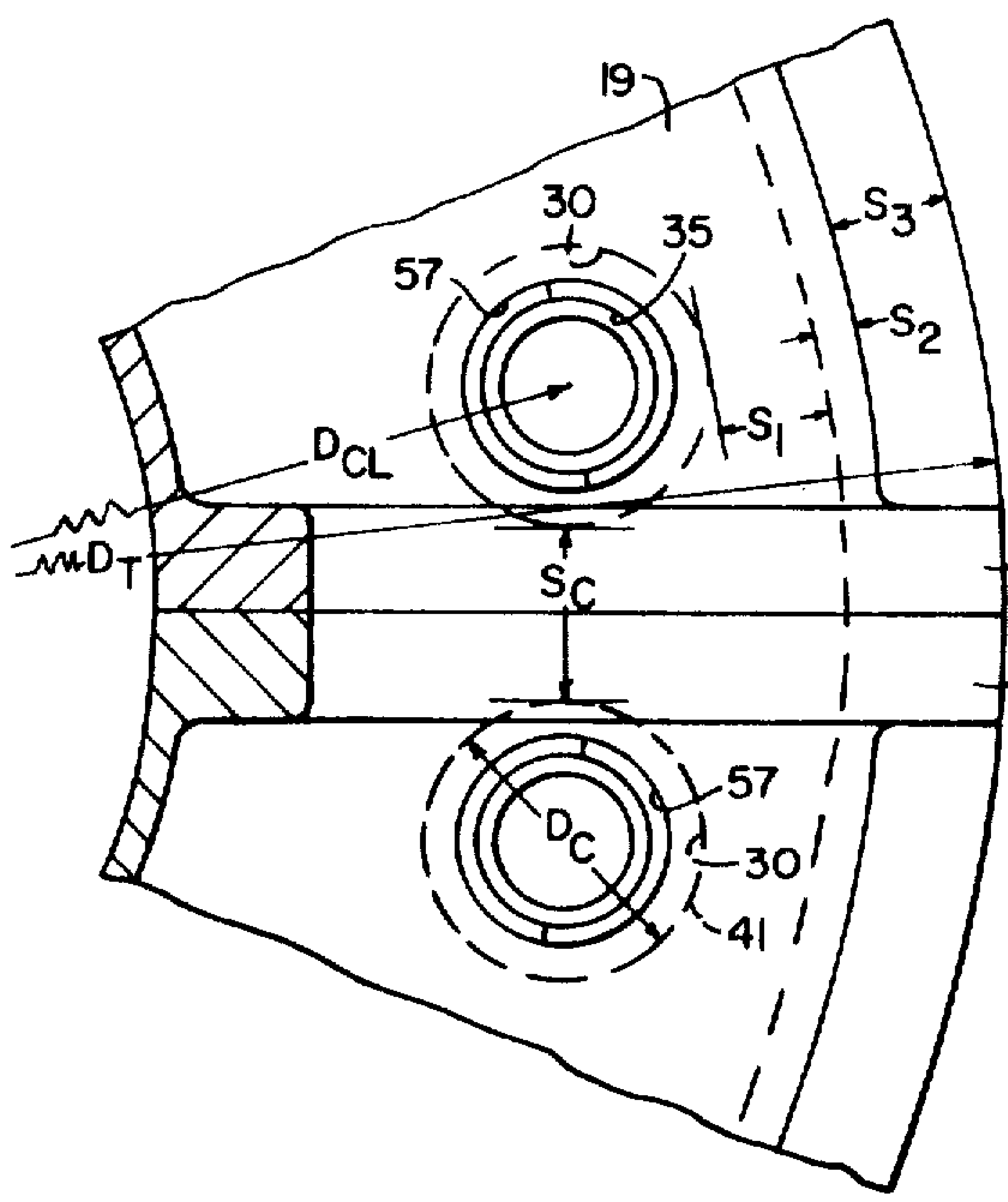
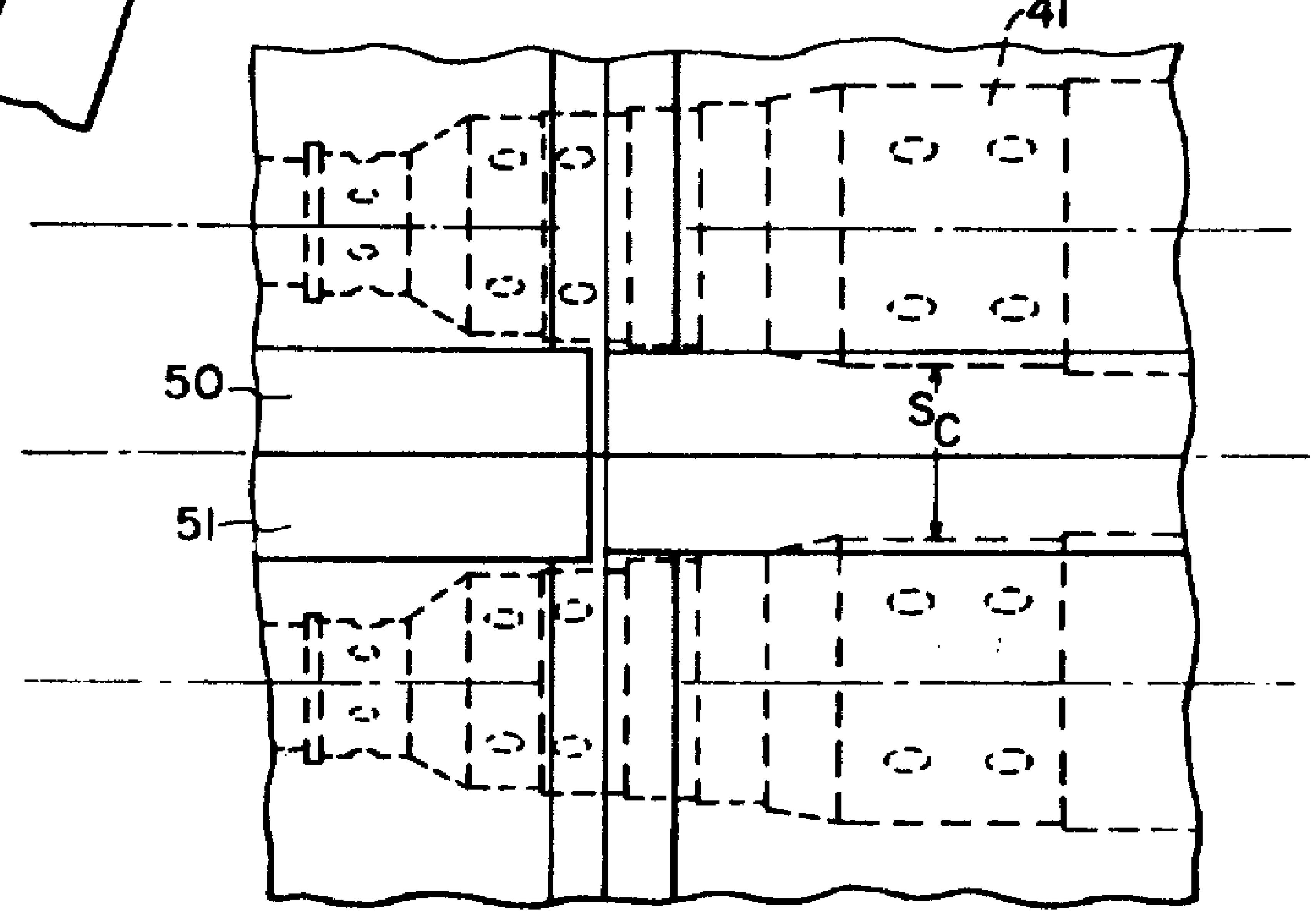


FIG. 3.

FIG. 4.



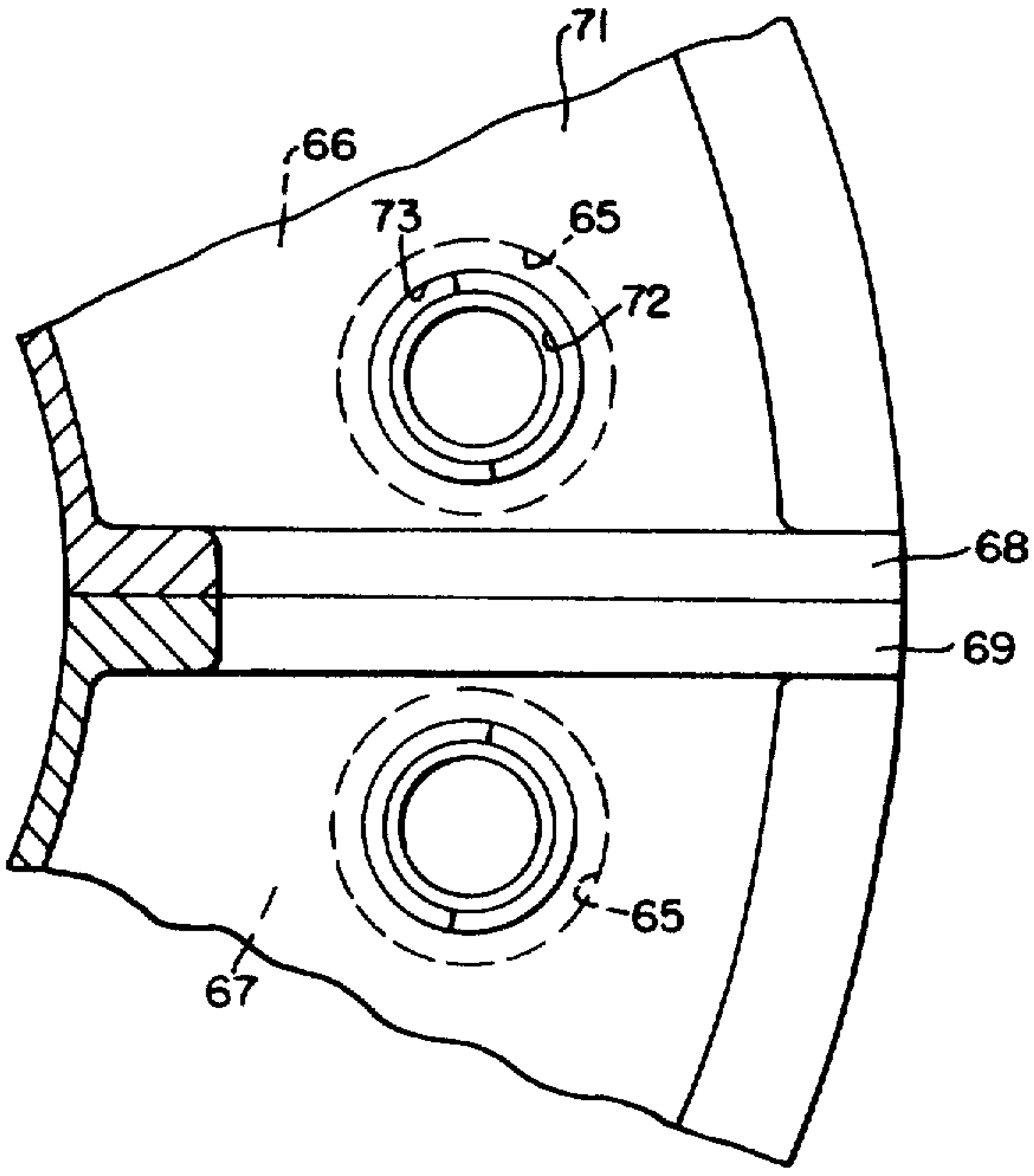


FIG. 5.

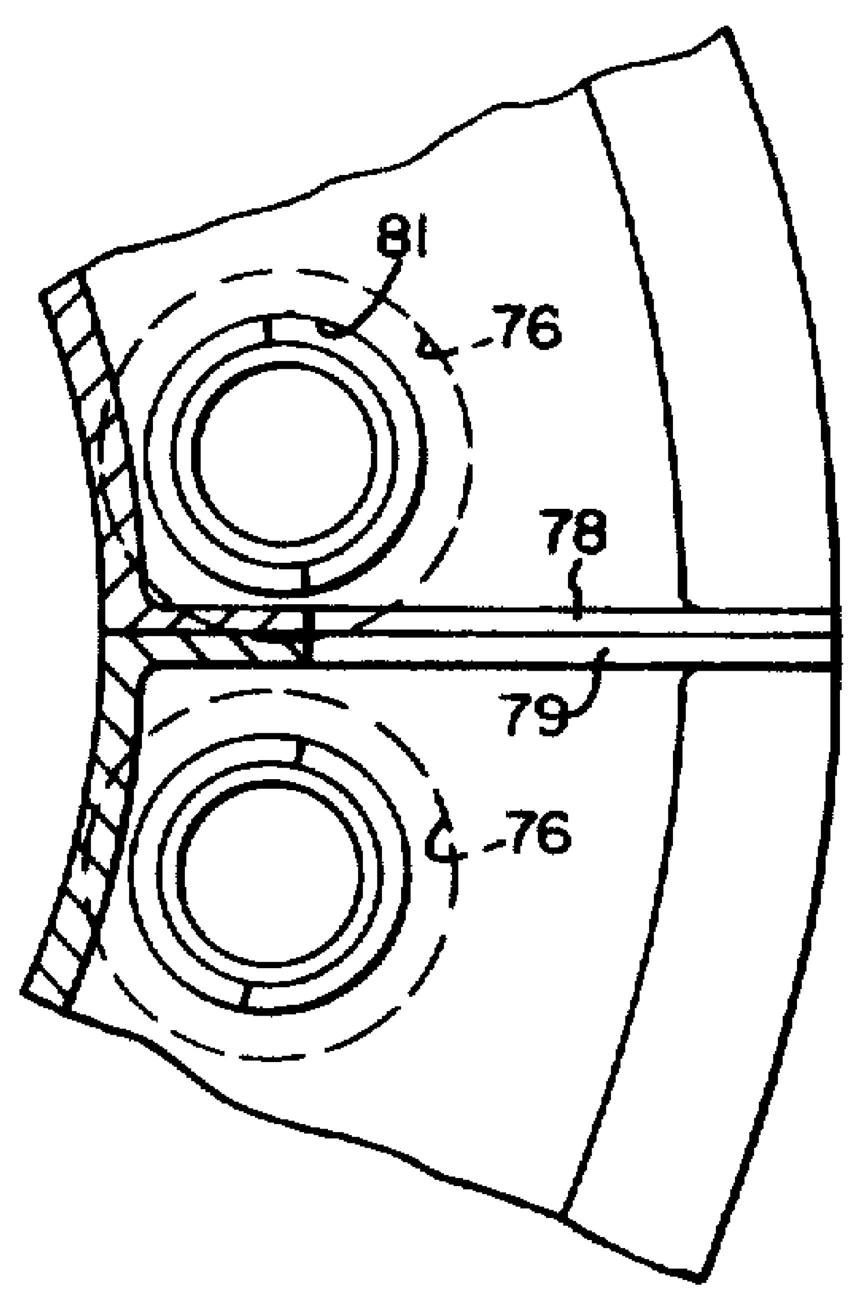


FIG. 6.

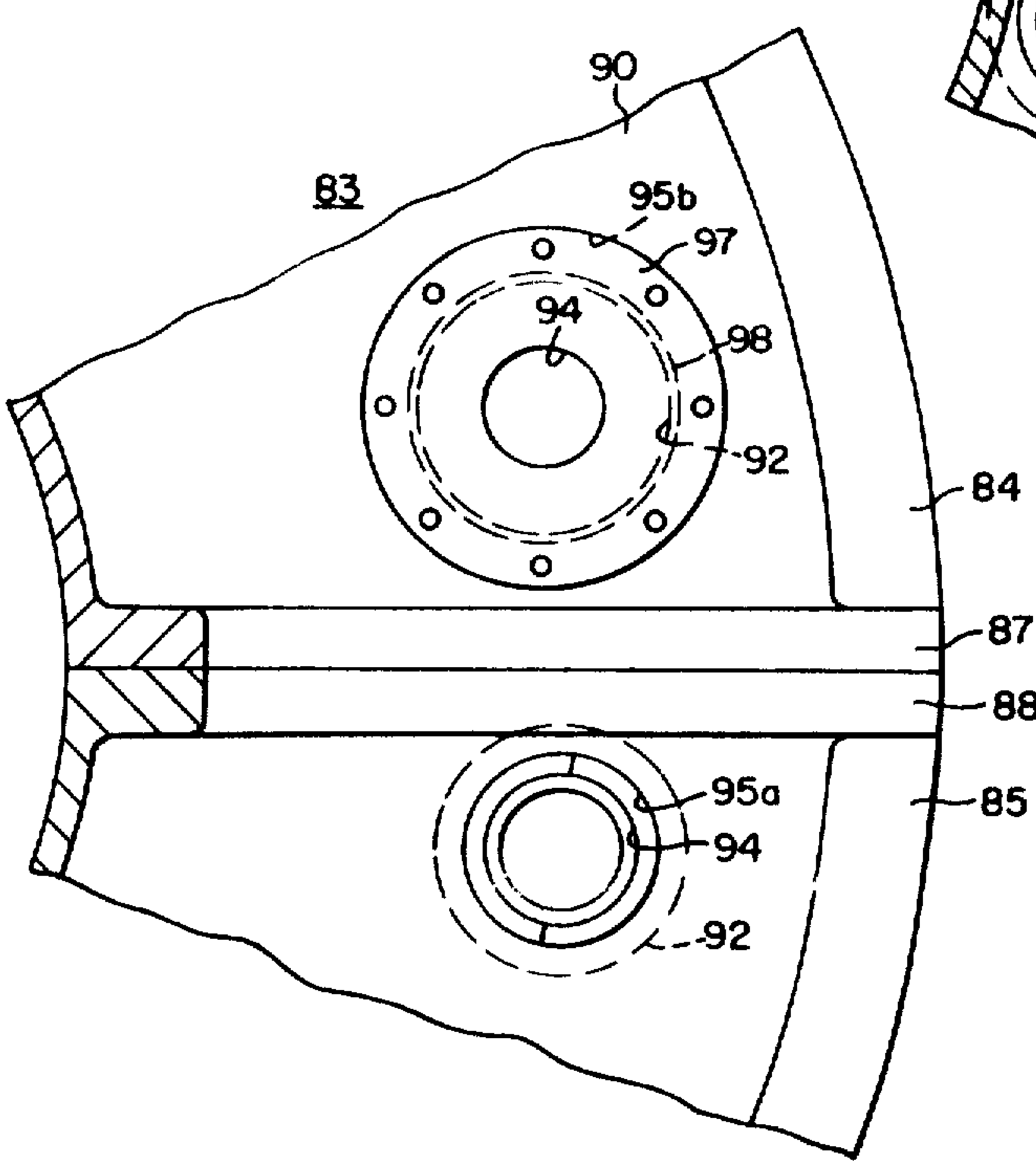


FIG. 8.

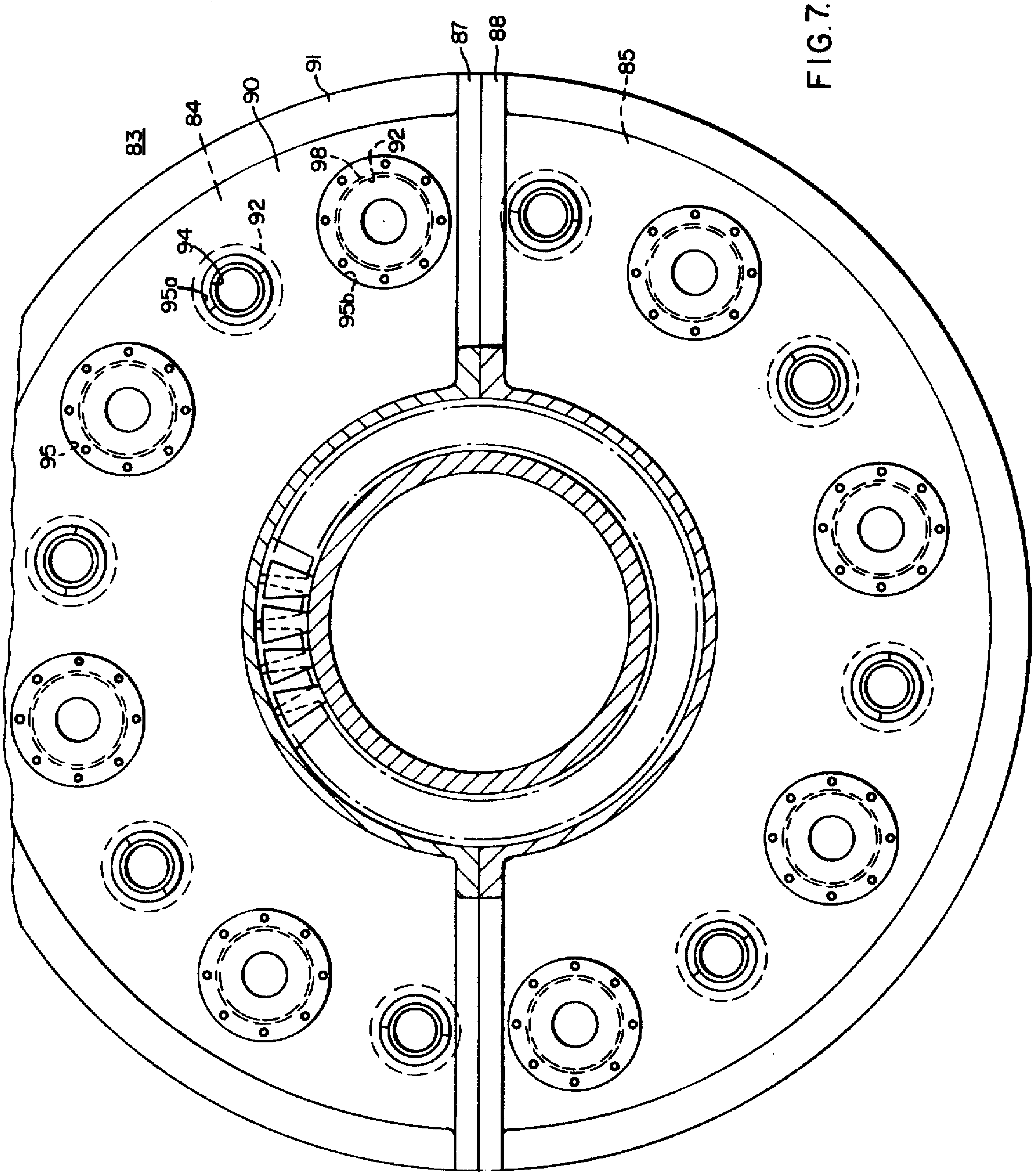
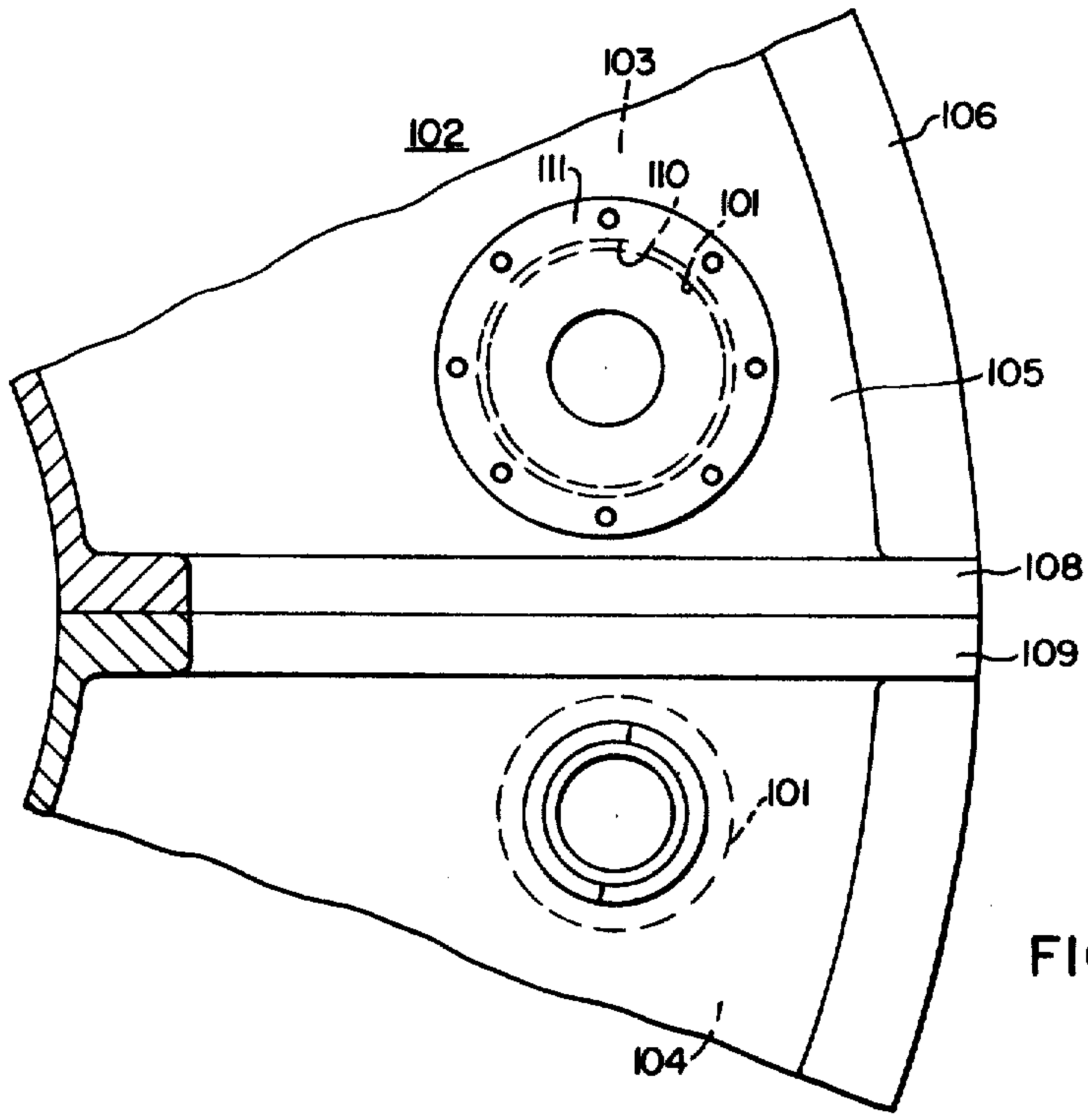


FIG.7.


102
103
106
111
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108
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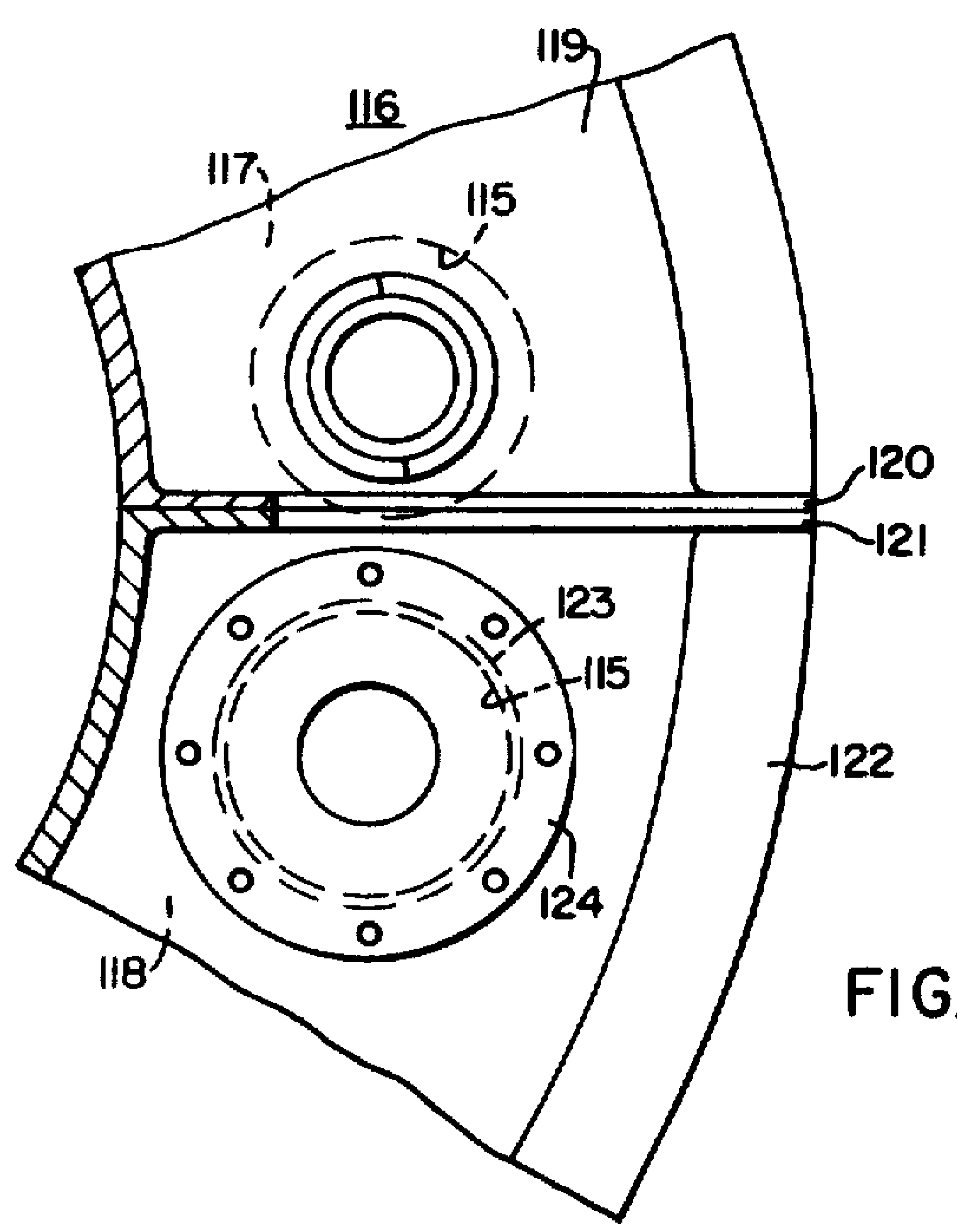
101
104

FIG. 9.


119
116
117
115
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121
123
115
122
124
118

FIG. 10.

COMBUSTION CHAMBER CLUSTERING STRUCTURE

BACKGROUND OF THE INVENTION

The following disclosure relates to gas turbines and more particularly to the combustion chamber clustering structure within the turbine.

As gas turbines continue to increase in power output, there is a corresponding increase in the size of the gas turbines. In present turbine design, the largest overall casing diameter is the combustion section. As the combustion casing increases in diameter, the wall thickness also increases and more material is required to withstand the added stress in the casing walls. Larger machines are required to work the casing and there is an increased shipping cost. Finally, the buildings to house the turbines are larger and more expensive.

The outside diameter of the combustion casing is determined by the size of the combustion chambers, the spacing between the combustion chambers, and the number of combustion chambers necessary to supply the hot turbine fluid to drive the turbine rotor. Once the desired force is determined to drive the turbine rotor, the size, the spacing, and the number of combustion chambers are selected to provide this motive force.

Presently, the spacing between the adjacent combustion chambers is set once the size and number of combustion chambers are selected because each combustion chamber is removable through an annular opening in an end wall of the combustion casing for maintenance purposes. The diameter of each end wall opening is slightly larger than the maximum diameter of the combustion chamber and each closure plate, which is bolted to the end wall, has an even larger diameter than the end wall opening so the plate can be bolted to the end wall. Furthermore, the spacing between the adjacent closure plates is determined by the distance the closure plates adjacent the horizontal flanges can be positioned thereto. Therefore, because each combustion chamber has its own end wall opening with a corresponding large diameter closure plate in spaced relation with the horizontal flange, only a very limited reduction in diameter of the combustion casing is possible. An example of this type of clustering structure is shown in C. E. Hussey U.S. Pat. No. 3,169,367 issued Feb. 16, 1965 and assigned to the present assignee.

What is desired then is a combustion chamber structure which can be easily installed, inspected and removed for servicing, while substantially reducing the overall diameter of the combustion casing.

SUMMARY OF THE INVENTION

The following disclosure relates to a combustion chamber structure for a gas turbine and more particularly to an improved clustering arrangement of combustion chambers.

The combustion portion of a gas turbine power plant comprises a cylindrical casing structure having an annular end wall and being divided into upper and lower semi-cylindrical halves along a central horizontal plane. An annular spaced array of combustion chambers is disposed within the casing structure equidistantly from the central axis of the turbine. An annular array of equally spaced openings are disposed in the end wall, one opening corresponding to one combustion chamber.

At least one end wall opening has a diameter which is less than the maximum diameter of the combustion chamber. This enables the diameter of the combustion casing to be reduced for the same number and size of combustion chamber, because of the tighter clustering of the combustion chambers. Alternately, the number or size of combustion chambers can be increased for the same combustion casing diameter. The combustion chamber cannot be removed through that smaller end wall opening but must be removed through some other end wall opening or through the upper semi-cylindrical half of the casing.

In the preferred embodiment, all of the end wall openings are less than the maximum diameter of the associated combustion chambers enabling the most compact clustering arrangement of the combustion chambers.

In subsequent embodiment, the diameters of alternate end wall openings are less than the maximum diameter of the associated combustion chambers, and the other alternate openings have diameters greater than that of the combustion chambers. This results, in some instances, in a larger casing diameter than the first embodiment while allowing for easier insertion and removal of the combustion chambers.

What is shown then is a denser clustering structure of combustion chambers resulting in a smaller diameter turbine casing then is attainable in the prior art.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial longitudinal view of a gas turbine with a portion of the combustion casing removed and exposing combustion chambers disposed in accordance with the principles of the present invention;

FIG. 2 is a view taken along line II—II in FIG. 1;

FIG. 3 is a view taken along line III—III in FIg. 1 and on a somewhat larger scale;

FIG. 4 is a view looking from the right of FIG. 3;

FIG. 5 is a view similar to FIG. 3 but showing a further embodiment of the invention;

FIG. 6 is a view similar to FIG. 3 but showing another embodiment of the invention;

FIG. 7 is a view similar to FIG. 2 but showing still another modification of the invention;

FIG. 8 is an enlarged view of a portion of the combustion chambers, shown in FIG. 7, disposed adjacent the horizontal flange;

FIG. 9 is a view similar to FIG. 8 but showing another embodiment of the invention;

FIg. 10 is a view similar to FIG. 8 but showing another embodiment thereof; and

FIG. 11 is a partial end view of the combustion section of a gas turbine indicating the state of the prior art.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings, in detail and particularly to FIG. 1, there is shown combustion apparatus, generally designated 10, associated with an axial flow gas turbine power plant. Since the combustion apparatus 10 may be employed with any suitable type of gas turbine power plant, only a portion of the power plant sufficient for comprehension of the invention has been shown. However, it will be understood, that the power plant includes an axial flow air compressor 12 for directing gas to the combustion apparatus 10 and a gas turbine 14 in fluid communication with the combustion apparatus 10 and receiving hot products of combustion therefrom for motivating the power plant.

The air compressor 12 includes, as well known in the art, a multi-stage rotor structure (FIGS. 1 and 2) having rotating blades 16, cooperatively associated with stationary blades 17 (FIGS. 1 and 2) for compressing the air directed therethrough to the combustion apparatus 10. The outlet of the compressor 12 is directed to a plenum chamber 18 defined by a casing structure 19.

The casing structure 19 is divided into upper and lower semi-cylindrical casing halves 20 and 21, respectively, along a central horizontal plane, which halves are coaxial with the central axis of the power plant. A forward dome-shaped end wall member 22 is secured at its downstream and to the outer casing of the compressor 12 and is secured at its upstream end to the casing halves 20 and 21 along vertically extending annular flanges 22*a* and 22*b* by fastening means 22*c*. A downstream annular-shaped wall member 23 is connected to the outer casing of the turbine 14 on its downstream end and is connected to the casing halves 20 and 21 on its upstream end along vertically extending flanges 22*a* and 22*b* by fastening means 22*c*.

The turbine 14 is of the axial flow type and includes a plurality of expansion stages formed by a plurality of rows of stationary blades 34 cooperatively associated with an equal plurality of rotating blades 25 mounted on a turbine rotor 26. The turbine rotor 26 is drivingly connected to the compressor rotor 15 by a means well known in the art (not shown).

Within the casing 19, there are provided a plurality of tubular combustion chambers or baskets 30 of the canister type disposed in an annular, mutually spaced array equidistant from the centerline of the power plant, as best illustrated in FIG. 2. The combustion chambers 30 are equally spaced from each other in the housing 19 are arranged in such a manner that their axes are substantially parallel to the longitudinal centerline of the power plant and the casing structure 19.

Since the combustion chambers 30 may be substantially identical, only one will be described. The combustion chamber 30 is of the step-liner type and includes an upstream end portion 31 which may be formed of a plurality of cylindrical liner members 32 of graduated size disposed in slightly overlapping relation with each other and forming a primary combustion zone 33. The liner members 32 have an annular array of apertures 34 admitting primary air into the combustion zone 33 to support the combustion of fuel injected thereinto by suitable fuel means (not shown) at the upstream end.

Each combustion chamber 30 further includes an intermediate cylindrical portion 41 provided with plurality of annular rows of apertures 42 for admitting secondary air into the combustion chamber during operation. Furthermore, the chamber 30 includes a downstream end portion or transition member 44 having a forward portion 45 of cylindrical shape disposed in encompassing and slightly overlapping relation with the intermediate portion 41, and a rearward tubular portion 46 that progressively changes in contour from circular cross section at the jointure with the cylindrical portion 41 to arcuate cross section at its outlet end portion 48. The arcuate extent of the outlet 48 is such that jointly with the outlets of the other combustion chambers 30, a complete annulus is provided for guiding the hot products of combustion from the combustion chambers 30 to the blades 24 and 25 of the turbine 14, thereby to provide full peripheral admission of motivating gases to the turbine 14, as well known in the art, and best seen in FIGS. 1 and 2. The diameter of each end wall opening 35 is less than the maximum diameter of the associated combustion chamber 30 which occurs at the cylindrical portion 41 of the chamber.

In the preferred embodiment, as shown in FIGS. 1 and 2, the upstream end wall 22 of the combustion apparatus 10 is provided with an array of circular openings or end wall apertures 35. The apertures 35 are mutually spaced or are equally spaced from each other in an annular direction and are equidistant from the centerline of the power plant, one corresponding to each combustion chamber. Each end wall aperture 35 accepts fuel supplying means (not shown) which is well known in the art, to supply a suitable fuel for each combustion chamber 30 and which closes the apertures 35 as shown in the Hussey patent. A frustoconical dome member 39 serves to close the extreme forward end of the combustion chamber 30 and accommodates the fuel supplying means (not shown). The dome member 39 cooperatively associates with the nozzle in such a manner that substantially no air flow is admitted therethrough into the combustion zone 33. Also, suitable igniting means is provided (not shown) for igniting the fuel and air mixture in the combustion zone 33.

An example of the prior art is partially shown in FIG. 11 and is more clearly shown and described in the previously cited Hussey patent. The forward wall 21a of the combustion apparatus 10a is provided with a circular opening 38a of sufficiently large diameter for removal of a combustion chamber 30a for service purposes and is enclosed by a circular closure member 36a attached to the end wall 21a in any suitable manner, as indicated by the bolts 37a.

Each combustion chamber 30a is removed through the opening 38a in the end wall 21a and the closure plate 36a is secured to the end wall to block the opening. The overall diameter of the combustion apparatus 10a is limited by the spacing between adjacent closure plates. This spacing S_A between the adjacent closure plates 36a is determined by the spacing between the two adjacent closure plates, on either side of the horizontal flanges 50a and 51a, where 50a is the upper horizontal flange and 51a is the lower horizontal flange. A clearance must be maintained between the closure plate 36a adjacent the top portion of the upper horizontal flange 50a and the plate adjacent the bottom portion of the lower flange 51a, because stress relief in the form of fillets 52a are provided. Additionally, working space must be allowed to enable bolts 54a and nuts 55a to be fastened to secure the flanges 50a and 51a.

Therefore, since it is the current practice for each combustion chamber 30a to have its own end wall opening 38a for insertion and removal and a corresponding larger diameter closure plate 36a the spacing S_A between adjacent closure plates is limited by the spaced relation between the plates and the horizontal flanges 50a and 51a. This in turn determines the total outside diameter D_A of the combustion apparatus 10a once the power requirement, the combustion chamber diameter, and the number of combustion chambers are selected. As a typical example for illustrative purposes of the prior art (FIG. 11), a gas turbine having sixteen combustion chambers 30a with corresponding closure plates 36a, the combustion chambers having a diameter of twelve inches and the closure plates having a diameter of 18 inches, would require an overall combustion casing diameter D_A of 172 inches.

The distance S_A between the adjacent closure plates 36a is considerably larger than the distance between the adjacent combustion chambers 30a. Furthermore, each closure plate 36a is concentrically disposed with the corresponding combustion chamber 30a, and the largest diameter portion of the combustion chamber 30a adjacent the horizontal flanges 50a and 51a is in a spaced horizontal relation with the flanges.

Referring to FIG. 3, each end wall aperture 35 is machined in an annular boss or protuberance 57, which can also be seen in FIG. 1. The protuberance 57 adjacent the upper horizontal flange 50 and the protuberance adjacent the lower horizontal flange 51 is in spaced relation therewith for the same reasons that the closure plates 36a in the prior art are in spaced relation as previously mentioned. Through each end wall aperture 35 fuel supplying means (not shown) is inserted therethrough to supply fuel to the combustion chamber 30. Because the closure plates 36a are eliminated, the limiting spacing distance S_C , which is the distance between adjacent combustion chamber 30 can be appropriately selected and the clustering of the combustion chambers 35 can be more compact. The protuberance 57 can be positioned sufficiently close to the upper surface of the horizontal flange 50, so that the maximum diameter of the combustion chamber 30, which is the cylindrical portion 41, (FIGS. 3 and 4) extends in the horizontal region defined by the upper surface of the upper horizontal flange 50 and the lower surface of the horizontal flange 50. For appropriately selected spacing S_C between combustion chambers 30, the maximum diameter of the combustion chamber, adjacent the upper horizontal flange 50, extends into a region defined by the upper and lower surfaces of the upper flange 50; the maximum diameter of the combustion chamber adjacent the lower horizontal flange 51 extends into a horizontal region defined by the bottom surface of the lower horizontal flange 51 and the upper surface of the lower horizontal flange.

This results in a substantial reduction in the total diameter of the casing structure 19 of the combustion apparatus 10 which is designated as D_T and which can be calculated as follows:

$$D_T = D_{CL} + {}_{DC} + 2(S_1 + S_2 + S_3)$$

$$C_{CL} = \pi D_{CL} = N_C(D_C + S_C)$$

$$D_{CL} = N_C(D_C + S_C)\,\pi$$

where:

D_T = the total diameter of the casing;

D_{CL} = the diameter of the center of the combustion chamber cluster;

D_C = the maximum diameter of the combustion chamber;

S_1 = the distance between the combustion chamber and the casing;

S_2 = the thickness of the casing;
S_3 = The width of the horizontal flange;
C_{CL} = the circumference of the center of the combustion chamber cluster;
N_C = the number of combustion chambers; and
S_C = the spacing between adjacent combustion chambers.

The reduction obtained in diameter between the diameter of the old casing D_A and the new casing D_T, will vary depending on what distance S_C between adjacent combustion chambers is selected. A chart prepared in accordance with the preceding equations with various spacing between adjacent combustion chambers S_C is tabulated in Table I and compared with the prior diameter D_A of the combustion casing to determine the actual reduction in diameter.

TABLE I

S_C (in.)	D_T (in.)	D_A (in.)	D_A–D_T (in.)
2 in.	110 in.	172	62 in.
3 in.	115 in.	172	57 in.
4 in.	120 in.	172	52 in.
5 in.	125 in.	172	47 in.
6 in.	130 in.	172	42 in.
8 in.	140 in.	172	32 in.

As an example of a typical calculation in Table I, where the distance S_C between combustion chambers equals eight inches, the number of combustion chambers N_C equals sixteen, the maximum diameter of each combustion chamber D_C is twelve inches, the distance between the combustion chamber and the vertical flange S_1 is 6 inches, the thickness of the casing S_2 is 2 inches and the thickness of the vertical flange S_3 is 5½ inches, then the total diameter D_T according to the above equation equals approximately 140 inches. When D_T is subtracted from the total diameter D_A of 172 inches, this gives a reduction in diameter of the combustion casing of 32 inches.

To remove the combustion chambers **30** from the casing structure **19** the upper cylindrical half **20** must be removed. The combustors may be inspected without removal of the upper cylindrical half **20** through the end wall apertures **35** after the fuel assembly has been removed.

Another embodiment similar to the combustion chamber clustering structure shown in FIGS. **1**, **2**, **3** and **4** is shown in FIG. **5** and is similar thereto but differs in the following manner. A mutually spaced array of combustion chambers **65** is disposed around the central axis of the turbine and is equidistant from the axis. The casing structure of the combustion section is divided into upper and lower semi-cylindrical casing halves **66** and **67** respectively along a central horizontal plane. Casing halves **66** and **67** have horizontally extending flanges **68** and **69** which are joined together by any suitable means (not shown). An upstream end wall member **71**, which is a portion of the casing structure, has an annular array of equally spaced openings **72**, one opening corresponding to each combustion chamber **65**. Each opening **72** is bored through a circular protuberance **73**. The combustion chambers **65** adjacent the horizontal flanges **68** and **69** are disposed so that neither of the combustion chambers extend into the horizontal region defined by the flanges. This embodiment is not as compact as the previous embodiment but gives the added advantage of allowing more space between the protuberance and the flanges **68** and **69**.

Another modification of the invention is shown in FIG. **6** and is similar thereto except for the following. A plurality of combustion chambers **76** are mutually disposed from each other and from the central axis of the turbine, and are enclosed in turbine casing structure. The casing structure is divided into upper and lower semi-cylindrical halves and are joined together at their horizontal flanges **78** and **79**, respectively, by any suitable means (not shown). A plurality of circular protuberances **81** are mutually disposed from each other and the central axis of the turbine, one protuberance corresponding to each combustion chamber **76**. One of the combustion chambers **76** adjacent a horizontal flange, which as shown in FIG. **6** is the combustion chamber adjacent the upper horizontal flange **78**, is disposed so that the maximum diameter portion of the combustion chamber **76** extends into both the upper and lower casing halves. This clustering allows a disposition of the combustion chambers **76** so that the chambers adjacent the horizontal flange **78** and **79** are unequally spaced relative to the horizontal flanges. This gives added design flexibility and can allow an asymmetrical clustering arrangement.

FIGS. **7** and **8** show another embodiment of the clustering structure. The combustion apparatus of a gas turbine has a casing structure **83** comprising an upper cylindrical casing half **84** and a lower cylindrical casing half **85** joined at the horizontal flanges **87** and **88** by any suitable means not shown. The upstream end wall member **90**, which is disc-shaped, is joined to the upper and lower casing halves along vertically extending flanges **91** by means not shown. A plurality of combustion chambers **92** are annularly disposed within the combustion casing structure equally spaced from each other in an annular direction and equally spaced from the central axis of the turbine. A corresponding plurality of apertures **94** are disposed within annular bosses or protuberances **95** which correspond to the combustion chambers **92**.

There are two different size diameter protuberances **95** alternately disposed on the end wall **90**. The first or smaller protuberance **95*a*** defines the apertures **94** to accommodate the fuel structure (not shown) through which fuel is admitted to the combustion chambers **92**. The protuberance **95*a*** is smaller in diameter than the largest diameter portion of the combustion chamber **92** (FIG. **8**). The second or larger diameter protuberance **95*b*** accommodates an annular end wall closure plate **97** which seals a circular opening **98** in the end wall **90** which is slightly greater in diameter than the combustion chamber **92**. An aperture **94** is concentrically disposed in the closure plate **97** to accommodate the fuel structure to supply fuel to the combustion chamber **92**. This portion of the combustion structure is substantially similar to the structure described in the Hussey patent previously cited.

Referring to FIG. **8**, the closure plate **97** is disposed in the upper casing half **84** adjacent the upper horizontal flanges **87** and in spaced relation therewith. The combustion chamber **92** associated with the closure plate **97** is inserted and removed through the larger diameter aperture **98**. The combustion chamber **92** adjacent the lower horizontal flange **88** has no larger diameter aperture in the end wall **90** for removal. For this reason, the combustion chamber **92** can be disposed within the casing structure closer to the horizontal flange **88** because the protuberance **95a** is of much smaller diameter than that for the closure plate structure. The combustion chamber **92** adjacent the lower horizontal flange **88** projects into a horizontal region defined by the lower horizontal flange **88**.

This embodiment provides for removal of the combustion chamber **92** without a cover plate, through an adjacent larger diameter aperture **98** in the end wall **90** in the adjacent combustion chamber, after removal of the adjacent combustion chamber. This alternate removal clustering structure is somewhat easier than removing the upper casing half, as previously described, although a somewhat larger overall diameter for the casing structure **83** will result under certain spacing values when compared with the previously described embodiment.

It will be noted however there can be fewer closure plates **97** than shown in FIG. **7** or more closure plates, and the closure plates can be on either side of the horizontal flange. Furthermore, there can be many combinations of large and small apertures **98** and **94**, respectively, and still be within the spirit of the invention.

Another modification of the alternate removal clustering structure shown in FIGS. **7** and **8** is shown in FIG. **9**. A plurality of combustion chambers 101 are annularly disposed within combustion casing structure 102. The casing structure 102 is comprised of upper and lower semi-cylindrical halves 103, 104 respectively having an upstream end closure portion 105 secured to the casing halves 103 and 104 at vertically extending flange 106 by any suitable means not shown. The upper and lower semi-cylindrical halves 103 and 104, respectively, are secured together by any suitable means along horizontally extending flanges 108 and 109 by any suitable means not shown. The combustion chamber 101 disposed adjacent the upper horizontal extending flange 108 can be inserted and removed through a slightly larger diameter aperture 110 in the end wall 105 which is sealed by an end wall closure plate 111. The combustion chamber 101 adjacent the lower horizontal flange 109 has no corresponding aperture 110 for removal and access and must be removed through an adjacent aperture 110 on either side of it.

As shown in FIG. 9, the combustion chamber 101 adjacent the lower horizontal flange 109 is in spaced relation therefrom. This provides for a slightly greater spacing flexibility than the embodiment shown in FIG. 7 for the combustion chambers adjacent the horizontal flanges 108 and 109.

Another embodiment of the clustering structure shown in FIG. 7, is shown in FIG. 10. A plurality of combustion chambers 115 are annularly disposed within a combustion casing 116. The casing 116 is divided into upper and lower semi-cylindrical halves 117 and 118 respectively and are joined by any suitable means along horizontal flanges 120 and 121. An upstream end wall 119 is secured to the casing halves 117 and 118 along vertical flanges 122. The combustion chamber 115 disposed in the upper casing half 117 adjacent the upper horizontal flange 120 is disposed so that the maximum diameter of the combustion chamber 115 lies in a region defined by the horizontal flanges 120 and 121 and furthermore is disposed in both the upper casing half 117 and lower casing half 118.

The combustion chamber 115 disposed adjacent the lower horizontal flange 121 is disposed in a spaced relation with the lower horizontal flange. The combustion chamber 115 is inserted and removed through a larger diameter opening 123 disposed in the end wall 119 and the opening 123 is sealed by an end closure plate 124.

The combustion chambers 115 adjacent the combustion chamber with the closure plate 124 is removed through the larger diameter opening 123 therein.

The main advantage of this embodiment is that a more compact clustering arrangement can be provided for than disclosed in FIG. 7 since the combustion chamber can be disposed in both the upper and lower casing halves, lying in a horizontal plane defined by both horizontal flanges.

What is shown then is a combustion chamber structure wherein the clustering structure of the combustion chambers enables a more compact relationship than is available under the prior art and at least one of the end wall openings has a smaller diameter than the associated combustion chamber.

Although more than one embodiment has been shown, it is intended that all the matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative and not in the limiting sense.

What is claimed is:

1. A gas turbine power plant which comprises:

a combustion section having a casing structure;

said casing structure being circular in cross section and being divided into two halves by a plane passing through the central axis of the power plant;

a plurality of combustion chambers annularly disposed within said casing structure and the centers of said chambers being equidistant from the central axis of the power plant;

said casing structure having an upstream annular end wall portion, a removable intermediate portion, and a downstream end wall portion;

said upstream end wall portion having an annular array of openings corresponding to said combustion chambers; and

at least one of said end wall openings having a smaller diameter than the maximum outer diameter of the associated combustion chamber so that said opening obstructs removal of the associated combustion chamber therethrough,

and said combustion chamber being radially removable through said intermediate portion.

2. The structure recited in claim 1 wherein all of the end wall openings corresponding to the combustion chambers have smaller diameters than the diameter of the associated combustion chambers.

3. The structure recited in claim 2 wherein the end wall openings accommodate means to supply combustible fuel to the combustion chambers.

4. The structure recited in claim 1 wherein each casing half has a mating horizontally extending flange disposed adjacent the central horizontal plane,

and where at least one of the combustion chambers extends into a horizontal region defined by the flanges.

5. The structure recited in claim 1 wherein at least one of the combustion chambers is disposed partially in both the upper and lower casing halves.

6. The structure recited in claim 1 wherein at least one of said end wall openings has a diameter at least as great as the diameter of the associated combustion chamber.

7. The structure as recited in claim 6 wherein each casing half has a mating horizontally extending flange adjacent the central horizontal plane;

and where at least one of the combustion chambers extends into a horizontal region defined by said flanges.

8. The structure recited in claim 6 wherein at least one of said combustion chambers is partially disposed in the upper and lower casing halves.

9. The structure recited in claim 1 wherein the casing structure of the combustion section is cylindrical and the end wall is dome-shaped.

10. The structure recited in claim 1 wherein at least one of the smaller diameter end wall openings and the associated combustion chamber is disposed adjacent the central horizontal plane.

11. The structure recited in claim 1 wherein the casing structure defines an annular plenum chamber, and the combustion chambers are disposed therein.

12. The structure recited in claim 1 wherein each combustion chamber is of the step-liner type and has at least one liner having a maximum diameter and one liner having a minimum diameter.

* * * * *