



(12) **EUROPEAN PATENT APPLICATION**

(21) Application number : **93307233.2**

(51) Int. Cl.⁵ : **H01J 23/065, H01J 25/34,
H01J 1/88, H01J 3/02**

(22) Date of filing : **14.09.93**

(30) Priority : **24.09.92 GB 9220226**

(43) Date of publication of application :
30.03.94 Bulletin 94/13

(84) Designated Contracting States :
DE FR GB SE

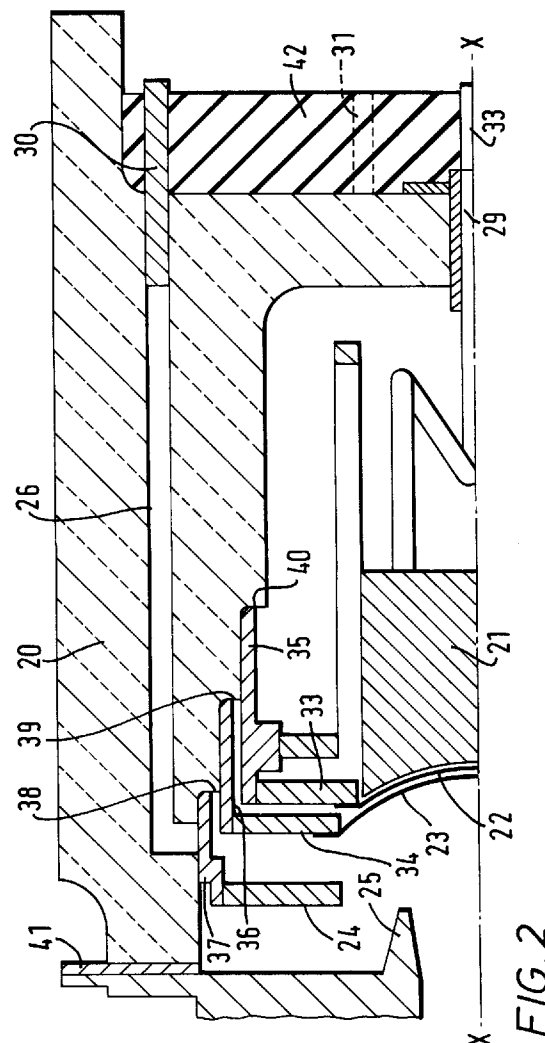
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(54) **Electron gun arrangements.**

(57) An electron gun arrangement which is particularly suitable for use in travelling wave tubes includes a substantially cylindrical ceramic body 20 which partly defines a vacuum envelope. The body 20 surrounds an electrode assembly constituted by cathode 21, grids 22, 23 and 24 and an anode 25. The leads to the grids and cathode are extensive in a generally longitudinal axial direction at the end of the body 20 remote from the anode 25, electrical connection being made via pins and metallised apertures extensive longitudinally through the wall of the body. The internal diameter of the body may be stepped to define ridges to which supports for parts of the electrode assembly are fixed.



This invention relates to electron gun arrangements and more particularly, but not exclusively, to electron gun arrangements suitable for use in travelling wave tubes.

A known electron gun arrangement currently used in travelling wave tubes is schematically illustrated in Figure 1, which is a half-sectional view taken along the longitudinal axis x-x of the arrangement.

The arrangement is substantially cylindrically symmetrical about its longitudinal axis x-x and includes a cathode 1 having a curved front surface 2 from which, in operation, electrons are emitted when the cathode 1 is heated to its operating temperature. Two mesh grids 3 and 4 are located in front of the emitting surface 2 and are followed by a focusing electrode 5 and finally an anode 6.

The electrode assembly is located within a vacuum-tight envelope which consists of a plurality of ceramic cylindrical sections 7, 8, 9, 10 and 11 arranged in a stack with interposed annular metal rings 12, 13, 14, 15, 16 and 17. One of the end rings 12 is electrically connected to the anode 6, permitting a voltage to be externally applied to it. The rings 13 to 16 permit external electrical connection to be made to the cathode 1, its heater and the remaining electrodes 3, 4 and 5. Typically, the anode 6 is maintained at earth potential and the voltages applied to the other electrodes via the rings 13 to 16 are in the region of -15kV, the voltage on the second mesh electrode 4 being variable to produce modulation of the electron beam. The outer surface of the vacuum envelope is coated in a layer 18 of electrically insulating rubber material to prevent arcing between the end ring 12 and the middle rings 13 to 16. The other end ring 17 remote from the anode end of the arrangement is brazed to a metal end plate 19 and is also kept at earth potential, the rubber layer 18 preventing tracking over the outer surface of the envelope between this and the centrally located rings 13 to 16.

The electron gun arrangement illustrated in Figure 1 is combined with a slow wave structure and a collector to form a travelling wave tube device, the three elements being fixed to a base plate to give a rigid construction. Typically, the electron gun arrangement is clamped to the base plate by a bracket bolted around it.

The present invention seeks to provide an improved electron gun arrangement and more particularly one which is suitable for travelling wave tube applications, although it is envisaged that it could be advantageously used in other devices.

According to the invention there is provided an electron gun arrangement comprising a substantially cylindrical ceramic body surrounding an electrode assembly and forming at least part of a gas-tight envelope, electrical connection to at least one electrode of the assembly being made via a conductive path extending through the ceramic body substantially paral-

lel to its longitudinal axis.

The electrode assembly may consist simply of a cathode and an anode but typically there are also intervening grids and electrodes for controlling the shape and/or density of the resultant electron beam. The term "cylindrical" should be taken to include bodies having a square annular cross section, and other shapes in addition to those which are circularly annular. However, electrical and mechanical characteristics tend to be optimized in circularly symmetrical devices.

By employing the invention, connections may be made to electrodes of the assembly which are physically robust and remain in their correct alignment. The surrounding ceramic material offers good electrical insulation and allows the conventionally provided encasing rubber to be dispensed with, enabling the outer dimensions of the electron gun to be reduced. This is advantageous for those applications where accommodation space for the arrangement is limited. In addition, the inventors have realised that this reduction in diameter may be made without increasing the overall length of the arrangement, and indeed it may permit the length of the gun to be reduced compared to that of previously used designs working under similar operating conditions and voltages.

In one embodiment of the invention, the conductive path is defined by an aperture. The walls of the aperture may be metallised and /or the aperture may be filled with conductive material. The aperture may also include a radially extensive portion, for example to make a connection to the electrode or to a support for an electrode.

In one embodiment of the invention, electrical connection to the assembly is made at an end of the ceramic body via a plane transverse to its longitudinal axis. It is thus possible to separate the connections external to the envelope to parts of the electrode assembly between which there is a large voltage difference by a sufficiently great distance that arcing between them does not occur. For example, the anode may be maintained at earth potential and its external connection taken from the arrangement in a radial direction, in a similar fashion to that of previous designs, whereas connections to the remaining electrodes, including the cathode, can each be made externally in a substantially longitudinal direction, these electrodes being typically at a voltage of -15kV.

Furthermore, by using the invention, the gun arrangement may be more easily, securely and less bulkily fixed in position when it is incorporated into a device utilizing an electron beam. For example, in a travelling wave tube, the electron gun arrangement is typically mounted on a base plate to which a slow wave structure and collector are also mounted. This gives a rigid coupling between them and enables the whole device to be more easily handled and positioned in a larger item of equipment. In previous elec-

tron gun arrangements, the arrangement has been fixed to the base plate by a bracket clamped over it and secured by bolts to the base plate. By employing the invention, however, it is no longer necessary to coat the outer surface of the ceramic envelope with an insulator, even though large voltage differences may exist between the external connections to electrodes of the electrode assembly. It is therefore possible to fix the ceramic body itself directly to a base plate or other surface on which it is to be mounted. One way in which this may be done is to metallise part or all of the outer surface of the ceramic body and then braze it in position to the base plate. The base plate may be of a curved configuration to conform to the outer surface of the ceramic body.

The envelope may include a gaseous filling but typically, is a vacuum envelope.

Preferably, the electrical connection made at the end of the body is to the cathode and one or more grids.

Advantageously, the ceramic body is of a symmetrical configuration, having a transverse section which is circularly annular. However, irregular, non-symmetrical configurations could be used.

Preferably, the ceramic body includes an end portion which is substantially transverse to its longitudinal axis. The body may then surround the electrode assembly in a circumferential direction and also form an end wall on the side of the cathode opposite to the face from which electrons are emitted. Connections to electrodes are then made in a longitudinal direction via apertures in the transverse end wall of the ceramic body. However, an end wall defining the volume in which the electrode assembly is contained may be constituted by a separate ceramic disc fixed to the elongate ceramic body or by a wall of a different material. However, it is preferred that the end wall is integral with the longitudinally extending body as this reduces the number of items to be assembled during manufacture.

Preferably, the ceramic body is unitary and forms a single component. However, it could be constituted by two or more sections fitted together. By using a unitary body, assembly is facilitated, being both quicker because of fewer parts need to be handled and furthermore enabling jiggling of the electrode assembly within the body and other parts to be more precisely carried out. The outer diameter of the ceramic body, for example, may be used as a reference in the assembly process and, as such ceramic tubes may be manufactured with great accuracy, it enables correct positioning of the remaining components to be achieved.

In one preferred embodiment of the invention, the internal diameter of the ceramic body varies along its length so as to define steps or ridges. Such ridges enable electrodes and their supports to be nested one within another whilst maintaining the desired

longitudinal and radial spatial separations. Supports for the electrodes may be precisely located relative to one another by accurately machining the ceramic body to the required internal configuration. Furthermore, such an internal configuration affords the supports a large surface area onto which they are mounted, giving a rigid robust structure. The transverse areas of the steps may be normal to the longitudinal axis but alternatively they may be oblique to the axis.

Preferably, one or more electrodes of the electrode assembly are supported by substantially tubular supports to give support around the whole electrode circumference.

Advantageously, where electrical connection is made to the electrode assembly at an end of the ceramic body, it includes a layer of electrically insulating material around the connection or connections. High voltages may then be applied to the connections whilst isolating them from users of the equipment to ensure safety.

In one preferred embodiment of the invention, the ceramic body is configured such that its length in a longitudinal axial direction is greater at its circumference than at a central part of the envelope, where external connections to the electrode assembly are located. By including a region of increased length compared to the central part of the envelope, the path length between the anode and other electrode connections, say, may be increased compared to what would be the case if the body were of uniform length across its entire width. The amount of overlap provided by the extended portion of the body at its circumference is chosen depending on the amount of voltage it is required to hold off. The ceramic may be convoluted or grooved so as to improve voltage hold off characteristics if necessary.

According to a feature of the invention, a travelling wave tube device includes an electron gun arrangement in accordance with the invention, a slow wave structure and a collector, the electron gun arrangement being fixed to a base plate to which the slow wave structure and collector are fixed. Preferably, the electron gun arrangement is mounted in position by brazing, the outer surface of the ceramic body being metallised.

In one advantageous embodiment of the feature, means for producing a magnetic field is located around the ceramic body to produce a magnetic field in the region of the electrode assembly. In previously known electron gun arrangements, because of the diameter of the envelope and the necessary insulation around it, it has not been practical to employ a magnet in this location. Hence, the end magnet of the slow wave structure tends to produce a non-uniform field in the electron gun region, affecting the operating efficiency of the device. By employing the invention, the diameter of the electron gun arrangement may be smaller than that of previous devices and hence a

magnet may be employed without the arrangement occupying an unacceptably large volume. This enables the magnetic characteristics of the device to be controlled over a larger part of the electron beam path.

One way in which the invention may be performed is now described by way of example with reference to the accompanying drawings in which:

Figure 2 is a schematic, half-sectional view taken along the longitudinal axis of an electron gun arrangement in accordance with the invention;

Figure 3 is an end view of the arrangement shown in Figure 2; and

Figure 4 schematically shows a travelling wave tube incorporating the arrangement of Figures 2 and 3.

With reference to Figures 2 and 3, an electron gun arrangement includes a generally circularly cylindrical ceramic body 20 which partly defines a vacuum envelope and encloses a volume within which is located an electron gun assembly consisting of a thermionic cathode 21, mesh grids 22 and 23, a focusing electrode 24 and an anode 25. The ceramic body 20 has four longitudinally extending apertures therethrough, the first three of which 26, 27 and 28 are located around the periphery of the body 20, as shown in Figure 3, and the fourth aperture 29 being located along the longitudinal axis X-X of the electron gun arrangement. Connections are made to parts of the electrode assembly via the apertures. The surfaces of the three apertures 26, 27 and 28 at the periphery of the body 20 are metallised to form conductive tracks along them and aperture 29 is filled with conductive material. Each of the apertures 26 to 29 includes a pin 30, 31, 32 and 33 respectively which is extensive of the aperture and via which external connection is made to the electrode assembly.

The mesh electrodes 22 and 23 are mounted on annular metallic rings 33 and 34 which are supported by cylindrical metal segments 35 and 36 respectively. The electrode 24 is constituted by an annular ring which is also mounted on a generally cylindrical conductive member 37. The three cylindrical members 35, 36 and 37 are fixed to inner surfaces of the ceramic body 20. The interior of the body 20 is configured to define three circumferential ridges 38, 39 and 40 and the exterior surfaces of the cylindrical segments 35 to 37 are attached to the longitudinal surfaces between the circumferential ridges.

The anode 25 is brazed to an end ring 41 at the left hand end of the ceramic body 20 as shown.

The right hand end of the ceramic body 20 is extensive over a longer axial direction at its outer circumference than its inner portion. This increases the path length along the body 20 between the anode connection 25 and the pins 30 to 33 extensive from the apertures 26 to 29. A layer 42 of electrically insulating rubber material surrounds the pins 30 to 33 to

provide electrical insulation.

Figure 4 schematically illustrates a travelling wave tube device in accordance with the invention. The outer surface of the ceramic body 20 is metallised and brazed to a base plate 43 to fix it into position. The electron gun arrangement is located at the right hand side as shown and is connected to a slow wave structure 44 which in turn is connected to a collector 45. The other two components making up the device are also mounted on the base plate 43, which has a curved upper surface to receive the outer surfaces of the various sections.

A magnet 46, which in this case is formed by permanent magnetic material but which could be an electromagnet, is located at the left hand side of the electron gun arrangement as shown. The magnet surrounds the outer circumference of the ceramic body 20 and is arranged to produce a magnetic field in the region of the gun between the cathode 21 and the anode 25. The slow wave structure also includes a plurality of magnets 47 stacked along its length. As the gun arrangement is compact, having a relatively small diameter compared to previous arrangements, the addition of the magnet 46 does not appreciably add to the overall diameter occupied by the travelling wave tube.

Claims

1. An electron gun arrangement comprising a substantially cylindrical ceramic body (20) surrounding an electrode assembly (21 to 25) and forming at least part of a gas-tight envelope, electrical connection to at least one electrode of the assembly being made via a conductive path (26, 27, 28) extending through the ceramic body (20) substantially parallel to its longitudinal axis (X-X).
2. An arrangement as claimed in claim 1 wherein the conductive path is defined by an aperture (26, 27, 28).
3. An arrangement as claimed in claim 2 wherein the aperture has a metallised surface (26, 27, 28).
4. An arrangement as claimed in claim 2 wherein the aperture (29) is substantially filled with electrically conductive material.
5. An arrangement as claimed in any preceding claim wherein electrical connection to the assembly is made at an end of the ceramic body via a plane transverse to its longitudinal axis (X-X).
6. An arrangement as claimed in any preceding claim wherein the internal diameter of the ceramic

ic body (20) varies along its length so as to define steps (38, 39, 40), supports (35, 36, 37) for the electrode assembly being located adjacent the longitudinal surfaces of the body (20) between the steps (38, 39, 40).

7. An arrangement as claimed in any preceding claim wherein the ceramic body (20) is of unitary construction.

8. An arrangement as claimed in any preceding claim and wherein the ceramic body (20) is extensive over at least substantially the entire length of the assembly between an anode (25) and a cathode (21) .

9. An arrangement as claimed in any preceding claim wherein the ceramic body (20) is substantially symmetrical about its longitudinal axis (X-X).

10. An arrangement as claimed in any preceding claim wherein the ceramic body (20) includes an end portion which is substantially transverse to its longitudinal axis (X-X).

11. An arrangement as claimed in any preceding claim wherein a connection to an anode (25) included in the electrode assembly is extensive in a radial direction relative to the ceramic body (20) and connections to the cathode (21) and at least one grid (22, 23) of the electrode assembly are extensive in a direction substantially parallel to the longitudinal axis (X-X) of the body (20).

12. An arrangement as claimed in any preceding claim wherein external connections to the electrode assembly are made at an end of the body (20) and including a layer of electrically insulating material (42) around a connection or connections at said end.

13. An arrangement as claimed in any preceding claim wherein the ceramic body (20) is configured such that its length in a longitudinal axial direction is greater at its circumference than at a central part of the envelope where external connections (30 to 33) to the electrode assembly are located.

14. An arrangement as claimed in any preceding claim and including means (46) for producing a magnetic field located circumferentially around the outside of the ceramic body (20) to produce a magnetic field in the region between a cathode (21) and anode (25) of the electrode assembly.

15. A travelling wave tube device including an elec-

tron gun arrangement as claimed in any preceding claim, a slow wave structure (44) and a collector (45), the electron gun arrangement being fixed to a base plate (43).

16. A travelling wave tube device as claimed in claim 15 wherein the electron gun arrangement is fixed to the base plate (43) by brazing of a metallised outer surface of the ceramic body.

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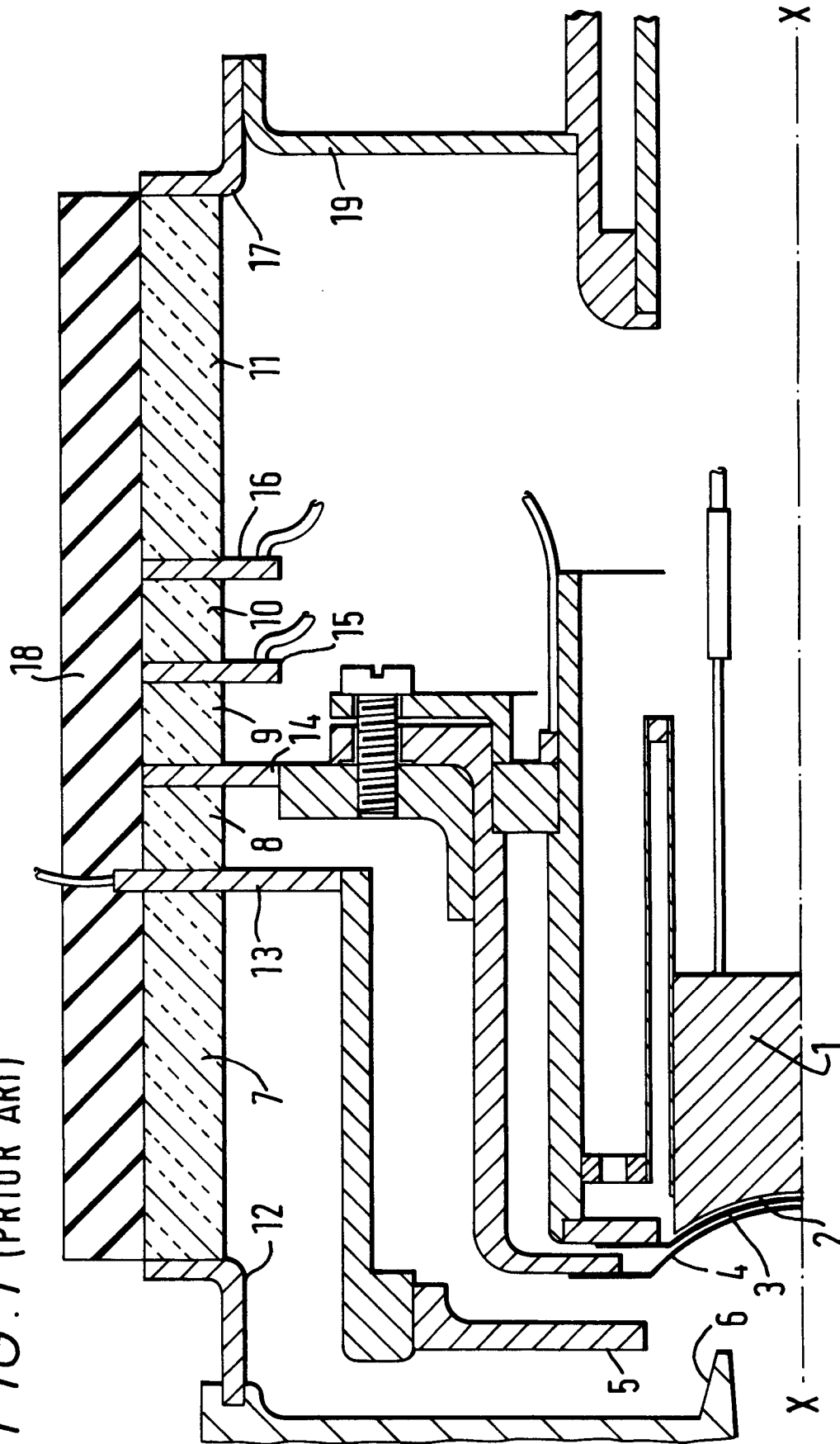
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FIG. 1 (PRIOR ART)



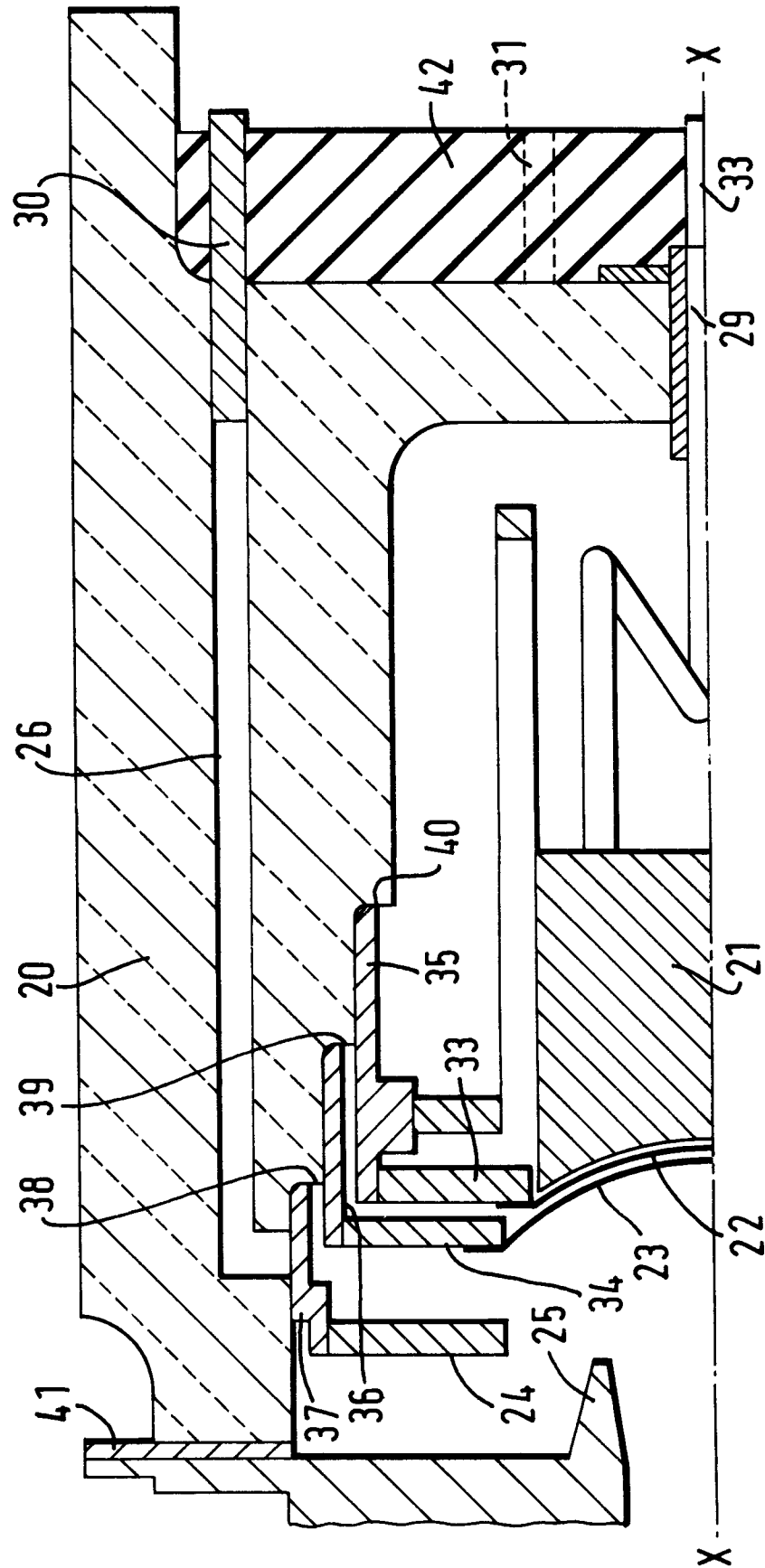


FIG. 2

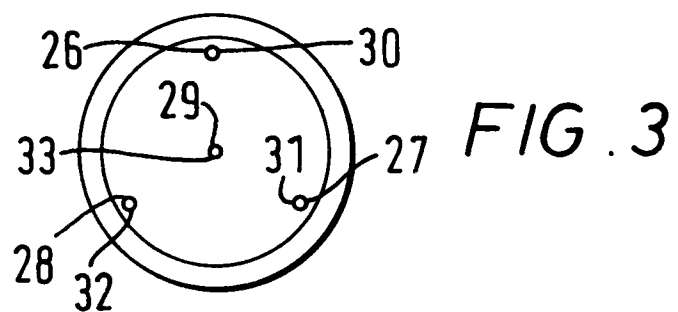


FIG. 4

