US012020891B2

(12) United States Patent
Urakata

(10) Patent No.: US 12,020,891 B2
(45) Date of Patent: Jun. 25, 2024

(54) **KLYSTRON**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 264 days.

(21) Appl. No.: **17/658,496**

(22) Filed: **Apr. 8, 2022**

(65) **Prior Publication Data**

US 2023/0055124 A1 Feb. 23, 2023

(30) **Foreign Application Priority Data**

Aug. 18, 2021 (JP) 2021-133372

(51) **Int. Cl.**
H01J 25/10 (2006.01)

(52) **U.S. Cl.**
CPC ***H01J 25/10*** (2013.01)

(58) **Field of Classification Search**
CPC H01J 25/10; H03B 9/04
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2019/0057831 A1* 2/2019 Duan H01J 23/20
2020/0118782 A1* 4/2020 Anno H01J 25/10

FOREIGN PATENT DOCUMENTS

JP 2020-113498 A 7/2020

* cited by examiner

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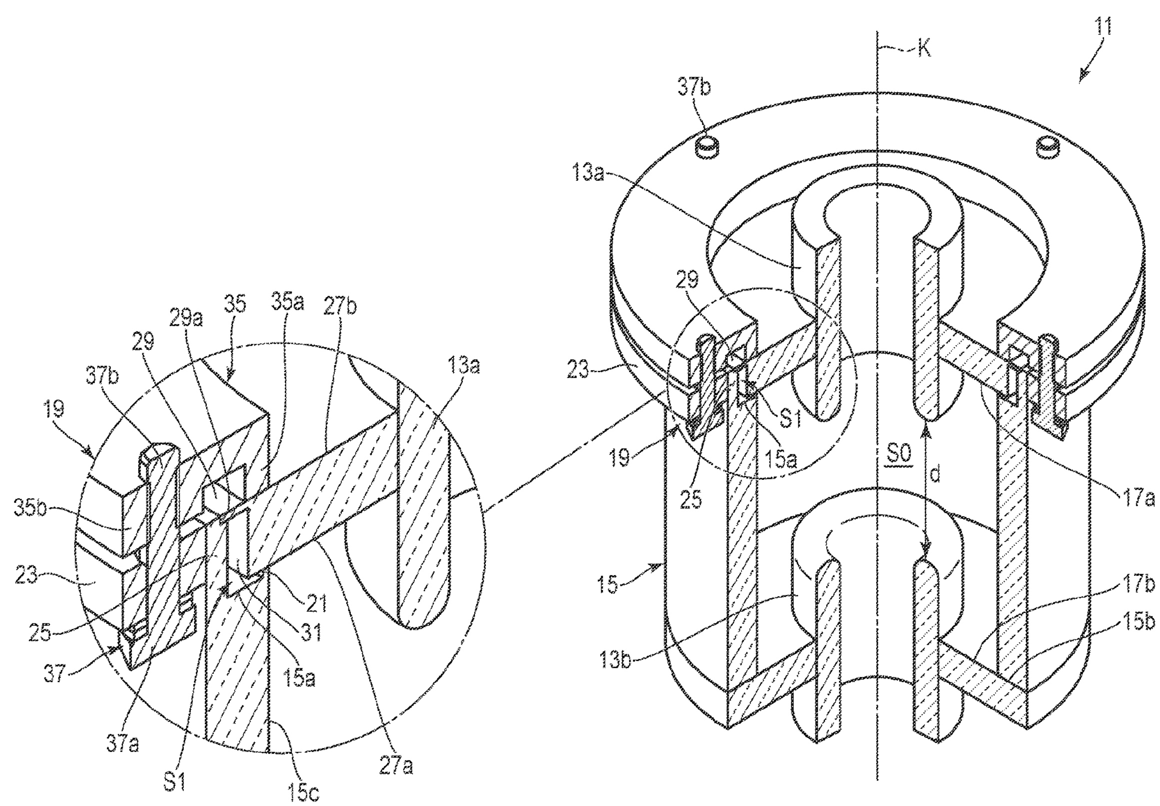
(57) **ABSTRACT**

According to one embodiment, a klystron includes a plurality of cavity resonators arranged next to each other on a coaxial line. The cavity resonators each comprise a cylindrical body, one and another drift tubes provided on respective sides of respective ends of the cylindrical body, one and another support and a space adjustment means which adjusts the space between the one and the other drift tubes. The cylindrical body comprises a projection projecting from one end surface parallel to the axial line, and the one support is provided to abut on the projection, and the space adjustment means presses the one support toward the projection and adjusts the space between the one and the other drift tubes by plastically deforming the projection.

5 Claims, 3 Drawing Sheets



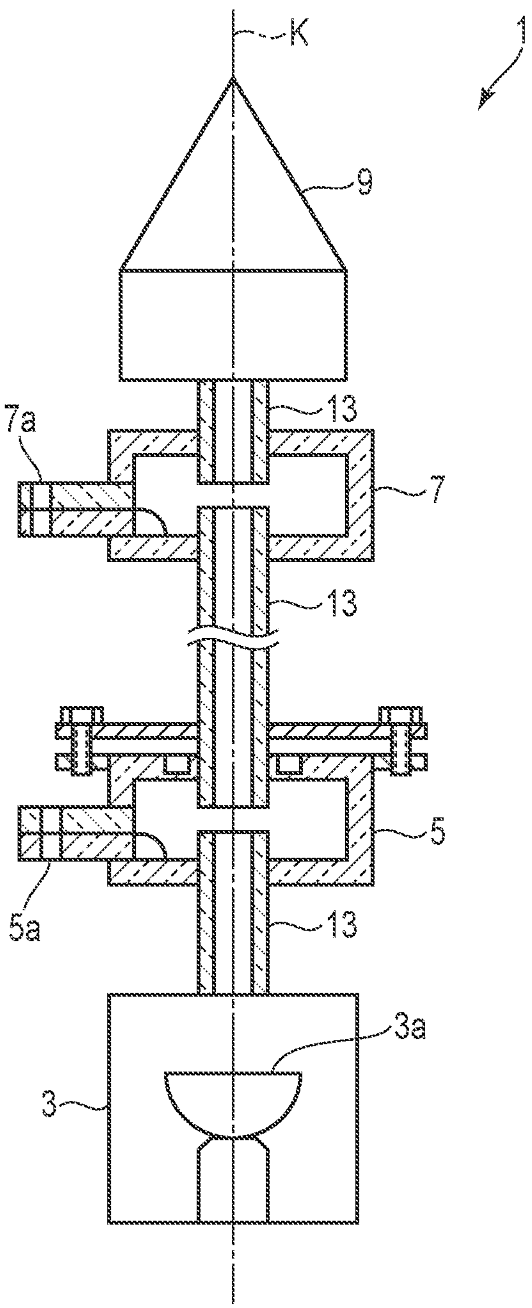
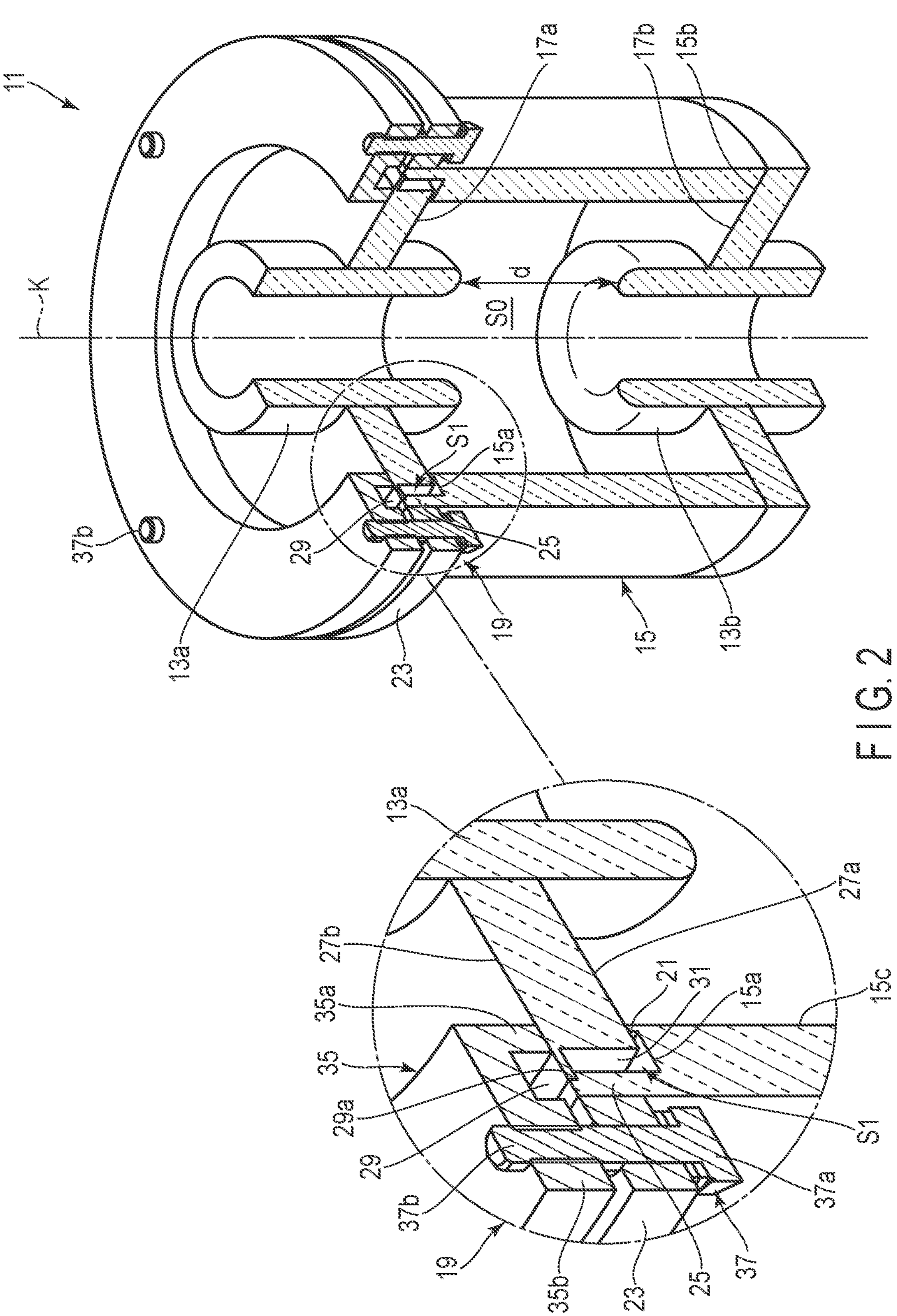


FIG. 1


11
K
17a
17b
15b
d
S0
S1
15a
37b
29
25
19
15
13b
13a
23
13a
27a
27b
21
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23
25
37

FIG. 2

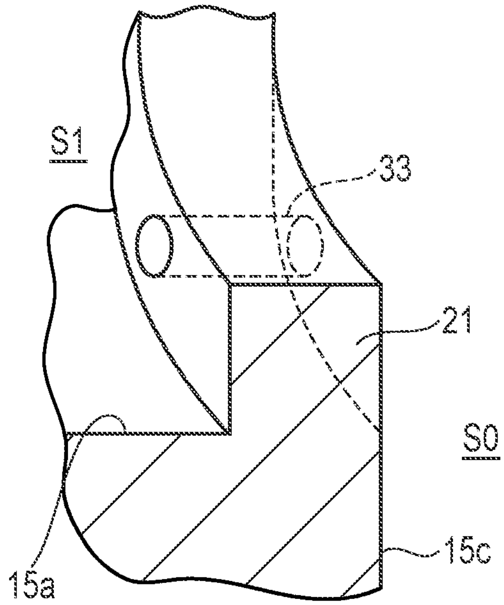

FIG. 3

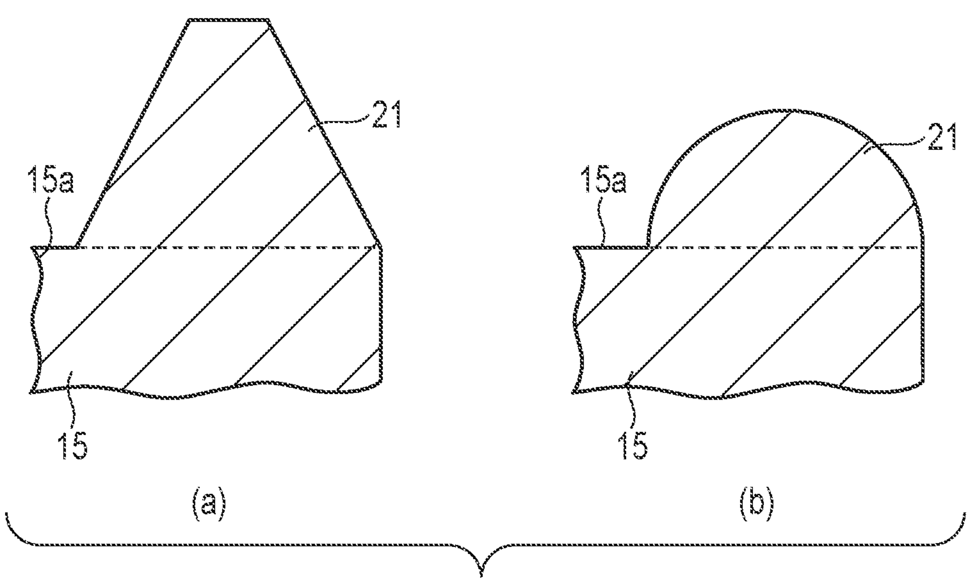

FIG. 4

KLYSTRON

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2021-133372, filed Aug. 18, 2021, the entire contents of which are incorporated herein by reference.

FIELD

Embodiments described herein relate generally to a klystron.

BACKGROUND

The klystron comprises multiple cavity resonators arranged on a coaxial line, and when an electron beam output from the electron gun are allowed to pass through the cavity resonators, the interaction between the electron beam and the cavity resonators converts the DC power to high-frequency power, resulting in stable microwave amplification. The cavity resonators are tuned to a resonance frequency suitable for the interaction with the electron beams.

On the other hand, some cavity resonators comprise a cylindrical body, drift tubes at respective ends of the cylindrical body and discs (supports) each supporting the drift tubes at each end of the cylindrical body.

In such a cavity resonator, the drift tubes are disposed to face each other at a predetermined interval therebetween. Here, in order to adjust the interval between the drift tubes, the disc (support) is provided with a thin part to surround the drift tubes, and thus the position of the drift tubes can be adjusted by plastically deforming the thin part surrounding the drift tubes.

In the cavity resonators, the electron beams passing through are subjected to velocity modulation to be density modulated by the cavity resonator. Thus, as the electron beams with crude density pass through the drift tube, the induced current flows on the inner surface wall of the drift tube.

As described above, when the klystron is operated, the loss occurs on the inner wall of the drift tube due to the induced current, which is converted into heat and diffused to the surroundings.

However, when a thin wall is provided for the support, the heat diffusion from the inner wall of the drift tube is blocked by the thin wall, and the heat conduction to the surrounding direction of the disk cannot occur sufficiently, which may increase the temperature of the drift tube to high. When the temperature of the drift tube changes significantly, the dimensions change due to thermal expansion, and the resonance frequency changes. As a result, the interaction between the cavity resonator and the electron beam is affected, and the operation of the klystron becomes unstable, which is not desired.

An object of the embodiments is to provide a klystron that can operate stably.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional view showing a schematic structure of a klystron according to an embodiment.

FIG. **2** is a partially decomposed perspective diagram showing a cavity resonator used in the klystron of the embodiment.

FIG. **3** is a partially decomposed perspective diagram showing a projection portion shown in FIG. **2**.

FIG. **4** is a cross-sectional view showing a modified example of the projection.

DETAILED DESCRIPTION

In general, according to one embodiment, a klystron comprises a plurality of cavity resonators arranged next to each other on a coaxial line. The cavity resonators each comprising a cylindrical body, one and another drift tubes provided on respective sides of respective ends of the cylindrical body, one and another support supporting the drift tubes respectively at the respective ends of the cylindrical body, and a space adjustment means which adjusts the space between the one and the other drift tubes. The cylindrical body comprises a projection projecting from one end surface parallel to the axial line, and the one support being provided to abut on the projection, and the space adjustment means presses the one support toward the projection and adjusts the space between the one and the other drift tubes by plastically deforming the projection.

Embodiments will be described hereinafter with reference to the accompanying drawings. The disclosure is merely an example, and proper changes within the spirit of the invention, which are easily conceivable by a skilled person, are included in the scope of the invention as a matter of course. In addition, in some cases, in order to make the description clearer, the widths, thicknesses, shapes, etc., of the respective parts are schematically illustrated in the drawings, compared to the actual modes. However, the schematic illustration is merely an example, and adds no restrictions to the interpretation of the invention. Besides, in the specification and drawings, the same or similar elements as or to those described in connection with preceding drawings or those exhibiting similar functions are denoted by like reference numerals, and a detailed description thereof is omitted unless otherwise necessary.

First, an embodiment will be described with reference to FIGS. **1** to **3**.

As shown in FIG. **1**, a klystron **1** of the embodiment comprises an electron gun **3**, an input cavity **5**, an output cavity **7**, and a collector **9** on a coaxial line with respect to an axial like K, and between the input cavity **5** and the output cavity **7**, a plurality of cavity resonators **11** (see FIG. **2**) are installed next to each other on the axial line K.

The electron gun **3** comprises a cathode **3***a*.

The input cavity **5** comprises an input window **5***a* for high radio frequency (RF) power, and the output cavity **7** comprises an output window **7***a* for the radio frequency (RF) power.

The cavities **5**, **7** and **11** are arranged so that drift tubes **13** thereof are aligned with the axial line K.

An electron beam output from the electron gun **3** is allowed to pass through the input cavity **5** and the cavity resonators **11** (to be described later), where an interaction between the electron beam and the cavity resonators **11** occurs to convert DC power to RF power, and then the amplified RF power is extracted from the output window **7***a* of the output cavity **7**.

As shown in FIG. **2**, the cavity resonators **11** each comprise a cylindrical body **15**, a drift tube **13***a* provided on one end side of the cylindrical body **15**, another drift tube **13***b* provided on the other end side of the cylindrical body **13**, a support **17***a* which supports the drift tube **13***a*, another support **17***a* which supports the other drift tube **13***b* and a space adjustment means **19**.

The cylindrical body **15** comprises a projection **21** projecting outward from one end surface **15***a* parallel to the axial line K. The projection **21** continuously projects on an inner circumferential surface **15***c* side of the cylindrical body **15** and is continuous throughout the entire circumference of the cylindrical body **15**.

As shown in FIG. **3**, the projection **21** has a substantially rectangular shape in its longitudinal section.

As shown in FIG. **2**, the outer circumference on the one end surface **15***a* side of the cylindrical body **15** comprises a flange **23** provided all along the circumferential direction.

The drift tube **13***a* and the other drift tube **13***b* are each cylindrical in shape and comprise respective end portions facing each other, and they are arranged to be spaced apart from each other with a gap d between the drift tubes. By adjusting the drift tube gap d, the resonance frequency is adjusted.

The support **17***a*, which supports the drift tube **13***a*, and the other support **17***b*, which supports the other drift tube **13***b* are each formed into a disk shape with a hole in the center, and the disks are formed to have a uniform thickness.

Into the holes in the center of the support **17***a* and the other support **17***b*, the drift tube **13***a* and the other drift tube **13***b* are respectively made to penetrate and fixed thereon.

The support **17***a* is provided on an end surface **15***a* side of the cylindrical body **15**, and the outer circumferential portion thereof is disposed to abut to the projection **21**.

The other support **17***b* is provided on the other end surface **15***b* side of the cylindrical body **15**, and the outer circumferential portion thereof is tightly attached to the other end surface **15***b* and fixed by brazing or the like.

Here, the end surface **15***a* of the cylindrical body **15** and the outer circumferential portion of the support **17***a* will now be described in more detail.

A step portion **25** is form to rise continuously on the outer circumferential portion of the end surface **15***a* of the cylindrical body, as a step to the end surface **15***a*.

On the outer circumferential portion of the support **17***a*, an abutting piece **29** is formed on a surface **27***b* on an opposite side to an abutting surface **27***a* to the projection **21**, which continuously protrudes therefrom in the outer circumferential direction so as to abut on the step portion **25**. The abutting piece **29** is formed over the entire circumferential direction of the support **17***a*.

An outer circumferential edge **29***a* of the abutting piece **29** is engaged and fixed to the inner circumferential surface of the step portion **25** by brazing or the like.

Them, between the outer circumferential surface **31** of the support **17***a* and the end surface **15***a* of the cylindrical body **15**, an airtight space S**1** surrounded by the projection **21**, the step portion **25** and the above-mentioned abutting piece **29** is formed.

As shown in FIG. **3**, the projection **21** comprises communicating holes which communicate to the airtight space S**1** and an inner space S**0** of the cylindrical body **15**, arranged in the circumferential direction thereof at predetermined intervals therebetween.

The space adjustment means **19** presses the supports **17***a* toward the projection **21** to plastically deform the projection **21**, and thus the drift tube gap d is adjusted.

The spacing adjustment means **19** comprises a support abutting member **35** that abut on a surface **27** on the opposite side to the projection **21** on the support **17***a*, and a screw member **37** that screws into the support abutting member **35**.

The support abutting member **35** comprises a pressing portion **35***a* that presses the supports **17***a* and a screwing portion **37** to which the support abutting member **35** is screwed, formed thereon, and the pressing portion **35***a* and the screwed portion **35***b* form an L-shape in cross section. The pressing portion **35***a* is provided at a position corresponding to the projection **21**, and presses only the outer circumferential portion of the support **17***a*.

The screw member **37** is a bolt with a head **37***a* engaged with the flange **23** and a shaft **37***b* inserted to the flange **23**, thus screwed into the support abutting member **35**.

By screwing in the screw member **37**, the pressing portion **35***a* of the support abutting member **35** presses the support **17***a* toward the projection **21**, and as the projection **21** deforms plastically, the support **17***a* moves toward the other support **17***b* to narrow the drift tube gap d.

Next, an operational effect of the klystron **1** of the embodiment will be explained.

In the cavity resonator **11**, to reduce the drift tube gap d, the screw member **37** is tightened. In this manner, the supports **17** is pressed by the pressing portion **35***a* of the support abutting member **35**, and thus the projection **21** of the cylindrical body **15** is plastically deformed and crushed. Thus, the drift tube **13***a*, which is fixed to the support **17***a*, approaches the other drift tube **13***b*, thus reducing the drift tube gap d.

When the klystron is operated, the loss of the current induced by the voltage change is converted to heat, which diffuses to the surroundings on the inner walls of the drift tubes **13***a* and **13***b*.

The support **17***a* and the other support **17***b* each have a uniform thickness and do not include thin portions as in the conventional technology. Therefore, the thermal diffusion of the drift tubes **13***a* and **13***b* is not interfered with and the heat is propagated uniformly in the surrounding direction. Thus, the heat is diffused to the support **17***a* and the other support **17***b* and the cylindrical body **15** entirely. As a result, the temperature of the drift tubes **13***a* and **13***b* can be prevented from becoming excessively high, the change in dimensions due to thermal expansion can be reduced, and the change in resonance frequency can be prevented. Thus, the operation of the klystron can be stabilized.

The space adjustment means **19** is constituted by the support abutting member **35** and the screw member **37** that screws into the support abutting member **35**, thus achieving a simple configuration. Further, the drift pipe gap can be easily adjusted by screwing the screw member **37**.

The support abutting member **35** has substantially an L-shaped cross section formed by the pressing portion **35***a* and the screwed portion **35***b*, which is small and compact shape. Further, the pressing portion **35***a* is located at a position corresponding to the projection **21**, and therefore the force to crush the projection **21** (force to plastically deform it) is easily transmitted.

Between the outer circumference **31** of the support **17***a* and the end surface **15***a* of the cylindrical body **15**, the airtight space S**1** surrounded by the projection **21**, the step portion **25** and the abutting piece **29** is formed so as to be communicated to the inner space S**0** in the cylindrical body **15**. With this structure, even if the supports **17***a* is displaced, the abutting piece **29** can follow it by plastically deforming, and thus the vacuum in the airtight space S**1** can be maintained.

The airtight space S**1** and the inner space S**0** can be easily communicated to each other by the communicating holes **33** formed in the projection **21**.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

For example, the shape of the projection **21** is not limited to a rectangular cross-section, but may be a wedge shape in cross-section as shown in FIG. **4**, part (a) or a semicircular shape in cross-section as shown in FIG. **4**, part (b).

Further, the pressing portion **35***a* on the support abutting member **35** is not limited to the continuous structure along the circumferential direction, but can also be provided with intervals.

What is claimed is:

1. A klystron comprising;

a plurality of cavity resonators arranged next to each other on a coaxial line,

the cavity resonators each comprising a cylindrical body, one and another drift tubes provided on respective sides of respective ends of the cylindrical body, one and another support supporting the drift tubes respectively at the respective ends of the cylindrical body, and a space adjustment means which adjusts the space between the one and the other drift tubes,

the cylindrical body comprising a projection projecting from one end surface parallel to the axial line, and the one support being provided to abut on the projection, and

the space adjustment means pressing the one support toward the projection and adjusts the space between the one and the other drift tubes by plastically deforming the projection.

2. The klystron of claim **1**, wherein

the spacing adjustment means comprises a support abutting member which abuts on the one support and a screw member that screws into the support abutting member, and

the support abutting member presses, as the screw member screws, the one support toward the projection.

3. The klystron of claim **2**, wherein

the support abutting member comprises a pressing portion protruding toward the one support at a position corresponding to the projection.

4. The klystron of claim **1**, wherein

the one end surface of the cylindrical body comprises a step portion provided on an outer circumferential portion of the projection, which faces an outer circumferential surface of the one support, and the outer circumferential surface of the one support comprises an abutting piece that abuts on the step portion, and the projection, the step portion, and the abutting piece surround and form an airtight space between the outer circumferential surface of the one support and the one end surface of the cylindrical body.

5. The klystron of claim **4**, wherein

the projection comprises a communicating hole formed therein, which communicates to an inner space of the cylindrical body.

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