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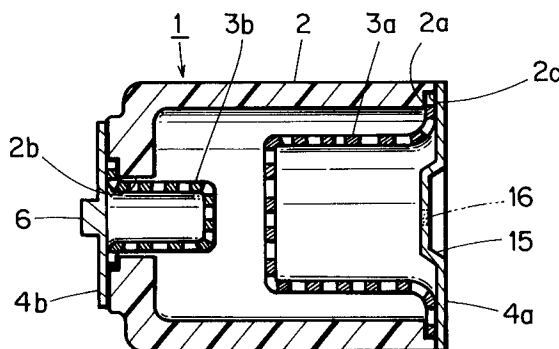
(54) **A gas-filled discharge tube.**

(57) The object of the present invention is to provide a gas-filled discharge tube which is capable of making the discharge tube itself smaller to minimize a plug cap that incorporates the discharge tube therein, thereby to realize a minimization of the size of the whole ignition system having a series gap.

In order to achieve the above object, the gas-filled discharge tube according to the present invention is constructed such that it comprises a tubular body formed of an electrically insulating material and having a notch portion at least one of the opposite open ends thereof, and a notch or projecting portion at the other open end thereof; a pair of electrode bases, at least one of which is formed of an electrically conducting thin metal sheet, airtightly adhered to the respective open ends; and a pair of discharge electrodes having flange portions to be engageably fixed with the notch and/or projecting portions and sandwiched between the tubular body and the respective electrode bases, and with this construction, the electrode base is first formed with a gas filling bore by a laser beam for filling an inert gas, which bore being welded also by the laser beam after the inert gas is filled in the tubular body

so as to enclose the gas therein.

F I G . 1



BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a gas-filled discharge tube, and more particularly to a gas-filled discharge tube for operation as a series gap of an ignition system of an automotive spark-ignition engine or the like.

Description of the Prior Art

There has been proposed a conventional gas-filled discharge tube for operation as a series gap of an ignition system of an automotive spark-ignition engine or the like, a case in point being the one disclosed by the same applicant as the present specification; a Japanese Utility Model Laid-open No.1-82245.

Fig. 6 shows a conventional gas-filled electric discharge tube 1 as disclosed above, wherein at the opposite open ends of a tubular body 2 formed of an electrically insulating material such as ceramic, there are formed a pair of electrode bases 4a and 4b airtightly adhered to the respective open ends for installing electrodes 3a and 3b as discharge electrodes which are formed by pressing a porous metal sheet on the respective electrode bases 4a and 4b, and to this structure, a gas-filled tube 5 is airtightly mounted on one electrode base 4a, and a connecting portion 6 (which is explained later on) is protrudingly formed on the other electrode base 4b. With this construction, a gas-filled discharge tube 1 is formed such that a high-presurized inert gas is injected into the tubular body 2 from the gas-filled tube 5, and after the completion of the gas injection, the tube 5 is sealed by a gas sealing member 7, and thereafter a cylindrical shaped protection terminal 8 is provided to cover the external side of the tube 5, and further, an electrically conducting adhesive member 9 is filled between the protection terminal 8 and the tube 5.

The gas-filled discharge tube 1 as constructed above is, as shown in Fig. 7, incorporated into a plug gap 10 which is to be engaged with a terminal of the spark plug, whereby a pair of intermediate connecting terminals 14, 14, which are formed respectively at one end of the connecting terminal 11 to be connected to the spark plug and at one end of a cable terminal 13 connected to an end portion of a high-voltage cable 12, are engageably fixed respectively with the protection terminal 8 of the electrode base 4a and the connecting portion 6 of the electrode base 4b of the gas-filled discharge tube 1, so that a so-called series gap is connected in series to the spark plug.

However, in the conventional gas-filled discharge tube 1 of the above construction, since the

gas-filled tube 5 for injecting the gas into the tubular body 2 and the protection terminal 8 are largely protruding from the electrode base 4a, the whole length of the discharge tube 1 becomes substantially long, and thereby the plug cap 10 for incorporating the discharge tube 1 therein is forced to become a big size, so that a minimization of the size of the above ignition system with a series gap becomes difficult, and consequently if an automobile has not a large capacity for mounting engine auxiliary devices or the like, it will become difficult to adopt such an ignition system therein.

SUMMARY OF THE INVENTION

The present invention has been made to eliminate such problems as described above, and it is an object of the present invention to provide a discharge tube which is capable of making the discharge tube itself smaller to minimize a plug cap that incorporates the discharge tube therein, thereby to realize a minimization of the size of the whole ignition system having a series gap.

In order to achieve the above object, the gas-filled discharge tube according to the present invention is constructed such that it comprises a tubular body formed of an electrically insulating material and having a notch portion at least one of the opposite open ends thereof, and a notch or projecting portion at the other open end thereof; a pair of electrode bases, at least one of which is formed of an electrically conducting thin metal sheet, airtightly adhered to the respective open ends; and a pair of discharge electrodes having flange portions to be engageably fixed with the notch and/or projecting portions and sandwiched between the tubular body and the respective electrode bases, and with this construction, the electrode base is first formed with a gas filling bore by a laser beam for filling an inert gas, which bore being welded also by the laser beam after the inert gas is filled in the tubular body so as to enclose the gas therein.

By the present invention, since it is constructed such that at least one of the electrode bases which are supporting discharge electrodes and airtightly adhered to the electrically insulating tubular body is formed of an electrically conducting thin sheet, and this electrode base is formed with a bore which is made by a laser beam for filling an inert gas and welded also by the laser beam after the inert gas filling operation is completed to enclose the filled gas, it is no longer necessary to use a gas-enclosed tube to inject a gas to the tubular body because of the above gas filling bore, so that the above conventionally adopted gas-enclosed tube that largely protrudes from the electrode base can be obviated, thereby a reduction of the whole

length of the gas-filled discharge tube can be made possible.

Other objects and features of the invention will be more fully understood from the following detailed description and appended claims when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view of the gas-filled discharge tube according to one embodiment of the present invention;

Fig. 2 is a sectional view showing the state that the gas-filled discharge tube of Fig. 1 is incorporated into a plug cap;

Fig. 3 is an illustration showing one embodiment of a welding device to be used for assembling the gas-filled discharge tube of Fig. 1;

Figs. 4A and 4B are illustrations respectively showing the state that a bore is formed and that the bore is welded to be sealed both by a laser beam;

Fig. 5 is a sectional view of the gas-filled discharge tube according to another embodiment of the present invention;

Fig. 6 is a sectional view of a conventional gas-filled discharge tube; and,

Fig. 7 is a sectional view showing the state that the conventional gas-filled discharge tube is incorporated into a plug cap.

In the drawings, reference numeral 1 denotes a gas-filled discharge tube, numeral 2 denotes a tubular body, 3a and 3b respectively denote electrodes, 4a and 4b respectively denote electrode bases, 5 a gas-enclosed tube 6 a connecting portion, 8 a protection terminal, 10 a plug cap, 14 an intermediate connecting terminal, 16 a gas filling bore, 17 an electrically conducting spring, 18 a carrier belt, 19 a welding device, 20 a laser beam and reference numeral 21 denotes an installing projection.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following, one embodiment of the present invention is described with reference to the Figs. 1 to 5.

Fig. 1 is an illustration showing one embodiment of a gas-filled discharge tube 1 according to the present invention, in which the discharge tube comprises a tubular body 2 formed of an electrically insulating material such as ceramic, one end of which is formed with an aperture 2a of a large diameter, while the other end thereof is formed with the other aperture 2b of a small diameter, and further, notch portions 2c, 2c are provided at the respective apertures 2a and 2b. With this

construction, discharge electrodes 3a and 3b, which are respectively formed by pressing a porous metal sheet so as to fit with each of these apertures, are engageably fixed with these notch portions 2c, 2c of the respective apertures 2a and 2b of the tubular body 2, and these electrodes 3a and 3b are supported by electrode bases 4a and 4b respectively, which are airtightly adhered to the end surfaces of the respective apertures of the tubular body 2 through soldering or the like.

Here, the electrode base 4a of a large diameter for supporting the electrode 3a of a large diameter is formed of a thin metal sheet whose thickness is below 1.00 mm, and this electrode base 4a is further formed with a dented portion 15 at the center portion thereof to be contacted with an electrically conducting spring 17 (explained later) and the dented portion 15 is further formed with a tiny gas filling bore 16 which is, as explained later on, welded to close after the gas filling operation is completed so as to enclose the gas in the tubular body. On the other hand, the other electrode base 4b of a small diameter for supporting the electrode 3b of a small diameter is formed of a lid-like metal sheet, at the center portion of which a connecting portion 6 is protrudingly formed just like the above-explained conventional device.

Thereafter, a gas-filled discharge tube 1 enclosing an inert gas is, as shown in Fig. 2, incorporated into a plug cap 10 which is to be engageably fixed to a terminal of the spark plug, wherein a spring 17 is suppressedly provided between a connecting terminal 11 to be connected to the spark plug and the electrode base 4a of the discharge tube 1, and a connecting portion 6 of the other electrode base 4b is engageably fixed to an intermediate connecting terminal 14 provided to a cable terminal 13 which is connected to one end of the high-voltage cable 12, thereby forming a so-called series gap connected in series to the spark plug.

In the following, an assembling process for the above gas-filled discharge tube 1 is explained.

First, the electrodes 3a and 3b are engageably fixed to the notch portions 2c, 2c of the respective apertures 2a and 2b of the above tubular body 2, and the electrode bases 4a and 4b are airtightly adhered through soldering or the like to the respective end surfaces of the tubular body 2, whereby the discharge tube 1 without inert gas enclosed therein is first assembled. Then, as shown in Fig. 3, put the discharge tube 1 with the electrode base 4a side facing upward using a jig or the like on a carrier belt 18. Here, the carrier belt 18 is extended to the inner side of a chamber (not shown) having a pressure-proof character, and above the carrier belt 18 within the chamber a welding device 19 such as a YAG laser is movably mounted in respective

vertical directions.

In the above state, the carrier belt 18 is moved in a step-by-step form, and when the discharge tube 1 comes just below the welding device 19, the welding device 19 is activated to irradiate a laser beam 20 onto the center portion of the electrode base 4a of the discharge tube 1 for 1 to 10 shots to form a gas filling bore 16 having a diameter 0.3 to 1.00 mm on the electrode base 4a. Thereafter, the chamber in which the discharge tube 1 is located is put in a vacuum state, and high-pressurized Argon or Xenon gas and a mixed gas with a rare gas N₂ are injected into the chamber so as to fill the chamber with the inert gas. By this operation, the high-pressurized inert gas is filled into the discharge tube 1 by way of the above gas filling bore 16.

After the above operation, the welding device 19 held at the location where the gas filling bore 16 is formed is slightly moved upward and downward so as to shift the focal point of the laser beam 20 and irradiate the laser beam 20 again onto the center portion of the electrode base 4a of the discharge tube 1. By this operation, as shown in Fig. 4B, the gas filling bore 16 formed on the above discharge tube 1 is welded and sealed, and a gas-filled discharge tube having a high-pressurized inert gas enclosed therein is thereby formed.

Subsequently, since in the present embodiment an electrode base 4a of a large diameter airtightly adhered to the tubular body 2 for supporting the electrode 3a of a large diameter is formed of a thin metal sheet, and is also formed with a gas filling bore 16 by a laser beam 20 which bore is welded to be closed also by the laser beam 20 after the inert gas filling operation is completed, the gas can be filled into the tubular body 2 by way of the gas filling bore 16 obviating the use of a conventionally adopted gas-enclosed tube, and the gas-enclosed tube largely protruding from the electrode base 4 can also be unneeded, thereby enabling to shorten the whole length of the gas-filled discharge tube 1. Further, by minimizing the size of the gas-filled discharge tube 1 as above, the plug cap 10 of an ignition system having a so-called series gap for incorporating this discharge tube 1 therein can also be minimized, so that the whole ignition system having a series gap can be minimized, and due to this fact, an engine room adopting such ignition system can have more space for other functions.

Furthermore, since its assembling procedure is such that a discharge tube 1 without any inert gas enclosed therein is first formed, and carried into a chamber where the laser beam 20 is irradiated onto an electrode base 4a thereof formed of a thin metal sheet to form a gas filling bore 16, and also after the completion of the gas filling operation by

way of this gas filling bore 16, the laser beam 20 is again irradiated to the focal point slightly shifted from the above made bore so as to weld and seal this gas filling bore 16, a mechanical assembling procedure of the discharge tube 1 which should conventionally be done in a chamber with full of high-pressurized gas can be avoided, the device for manufacturing the gas-filled discharge tube 1 can be prevented from becoming large and complicated, so that its manufacturing cost can be greatly reduced in due course.

Still further, since the gas filling bore 16 which has been formed by a laser beam 20 can be easily welded only by shifting the focal point of the laser beam 20, a laser beam treating operation itself can be largely facilitated, and thereby the productivity thereof can be enormously improved.

By the way, both of the electrode bases 4a and 4b airtightly adhered to the opposite end portions of the tubular body 2 can be respectively formed of thin metal sheets, and the electrodes 3a and 3b to be engageably fixed to the tubular body 2 can be formed of a same diameter.

Fig. 5 is an illustration showing a gas-filled discharge tube according to another embodiment of the present invention. In this embodiment, the inner peripheral wall 2d of the tubular body 2 is formed as thin as possible to the extent that it can endure the high-pressure of the inert gas filled into the tubular body 2, and in addition, an installing projection 21 is formed at the aperture 2a of a large diameter of the tubular body 2, whereby a flange portion 3a' of a the large diameter electrode 3a is engageably fixed to the aperture 2a. In the state that the electrode 3a is engageably fixed to the installing projection 21 of the tubular body 2, an electrode base 4a of a large diameter is further airtightly adhered to the end surface 21a of the installing projection 21.

This above construction is same as that of the first embodiment in that the electrode base 4a is formed of a thin metal sheet, and that the gas filling bore 16 formed in the electrode base 4a is welded to seal the bore after the inert gas is filled therein.

In this embodiment also, the gas can be filled into the tubular body 2 by way of the gas filling bore 16 without using a conventionally adopted gas-enclosed tube, so that the gas-enclosed tube largely protruding from the electrode base 4 can also be unneeded, thereby the whole length of the gas-filled discharge tube 1 can be shortened. Further, by minimizing the size of the gas-filled discharge tube 1 as above, the whole ignition system having a series gap can be minimized.

Furthermore, with the above construction, by forming the inner peripheral wall 2d of the tubular body 2 as thin as possible, the weight of the whole

gas-filled electric discharge tube 1 can be reduced, and by minimizing the quantity of an electrically insulating material such as ceramic forming the tubular body 2, the manufacturing cost for the whole discharge tube 1 can be also reduced, so that the total weight of the whole ignition system having a series gap to incorporate this discharge tube 1 therein, and the total cost for its production can also be greatly reduced.

[Effect of the Invention]

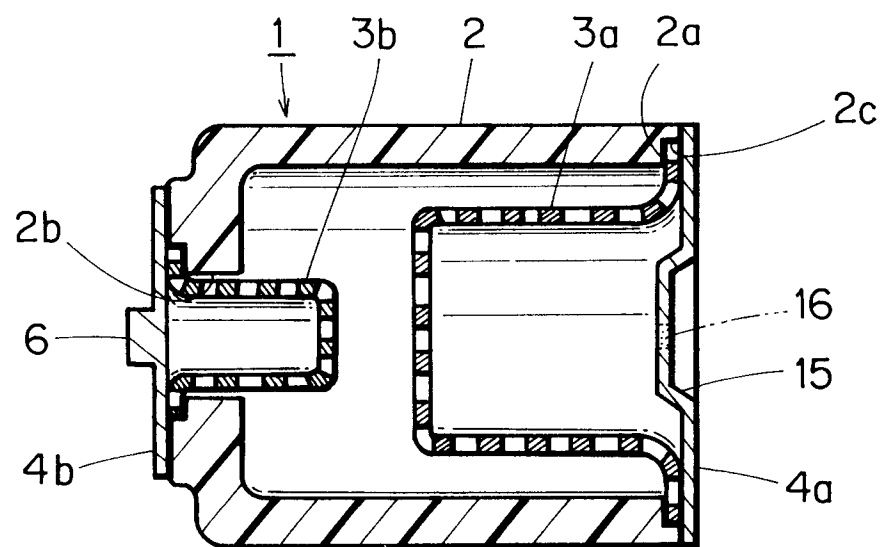
As mentioned heretofore, a gas-filled discharge tube according to the present invention is constructed such that it comprises a tubular body formed of an electrically insulating material, and electrode bases to be airtightly adhered thereto, at least one of which electrode bases being formed of an electrically conducting thin sheet, wherein the electrode base is formed with a gas filling bore 16 by a laser beam so as to first fill the gas, and then welded to close the bore by the laser beam after the inert gas filling operation is completed, whereby the inert gas can be filled into the tubular body 2 by way of the gas filling bore without using a conventionally adopted gas-enclosed tube, so that the conventional gas-enclosed tube largely protruding from the electrode base 4 can also be unneeded, and thereby the whole length of the gas-filled electric discharge tube 1 can be shortened, and consequently, the size of the whole ignition system having a series gap for incorporating the discharge tube therein can be minimized.

Although the invention has been described with a certain degree of particularity, obviously many changes and variations are possible therein. It is therefore to be understood that the invention may be practiced otherwise than specifically described herein without departing from the scope and spirit thereof.

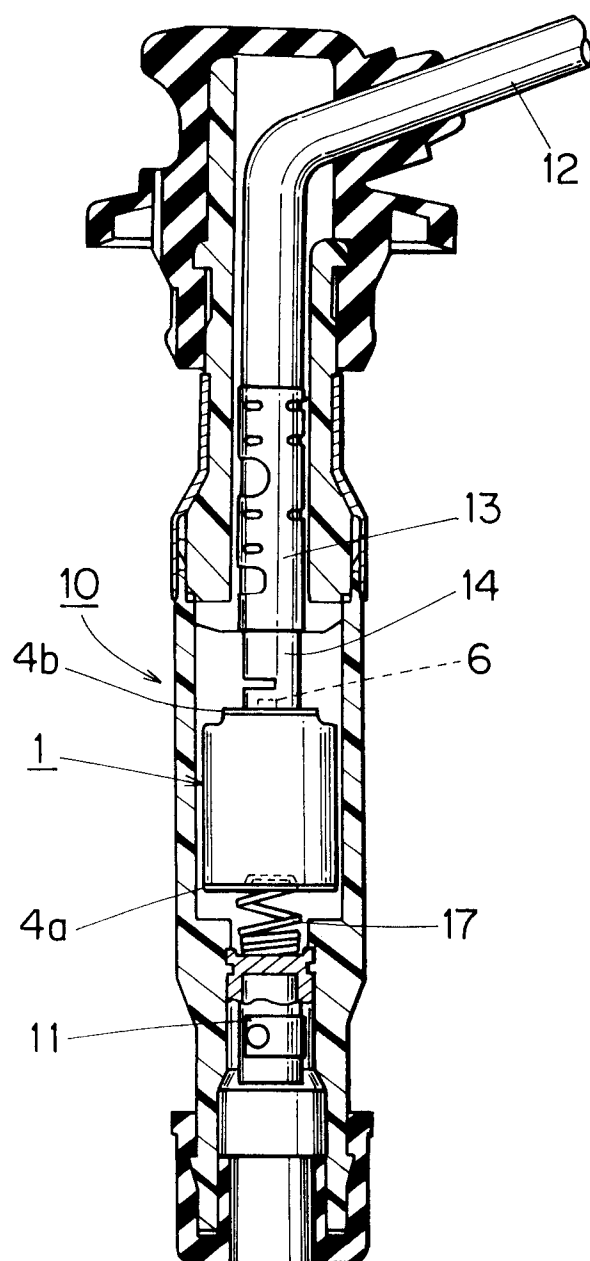
Claims

1. A gas-filled discharge tube comprising:
 - a tubular body formed of an electrically insulating material and having engaging portions respectively at opposite open ends thereof;
 - a pair of electrode bases, at least one of which is formed of an electrically conducting thin metal sheet, airtightly adhered to said respective open ends; and
 - a pair of discharge electrodes having flange portions to be engaged with said respective engaging portions and sandwiched between said tubular body and said respective electrode bases;
 wherein one of said electrode bases is first
2. A gas-filled discharge tube as claimed in claim 1, wherein said engaging portions are both notch portions, whereby said flange portions are respectively engaged with said respective notch portions and sandwiched between said tubular body and said respective electrode bases;
3. A gas-filled discharge tube as claimed in claim 1, wherein one of said engaging portions is a projecting portion formed around the periphery of said tubular body, whereby the flange portion of one of said electrodes is engageably fixed in said projecting portion and sandwiched between said tubular body and one of said electrode bases facing to said projecting portion of said tubular body.
4. A gas-filled discharge tube as claimed in any one of claims 1 to 3, wherein one of said electrodes is formed with a dented portion in the center portion thereof for receiving the laser beam to form said gas filling bore.
5. A gas-filled discharge tube as claimed in any one of claims 1 to 3, wherein said respective electrode bases are both formed of an electrically conducting thin metal sheet.
6. A gas-filled discharge tube as claimed in any one of claims 1 to 3, wherein said respective electrodes are formed of a same diameter.
7. A gas-filled discharge tube as claimed in claim 1, wherein a focal point of said laser beam can be readily changed in vertical directions.
8. A gas-filled discharge tube as claimed in claim 3, wherein the inner peripheral wall of said tubular body is formed as thin as possible to the extent that it can endure the high-pressure of said inert gas filled into said tubular body.

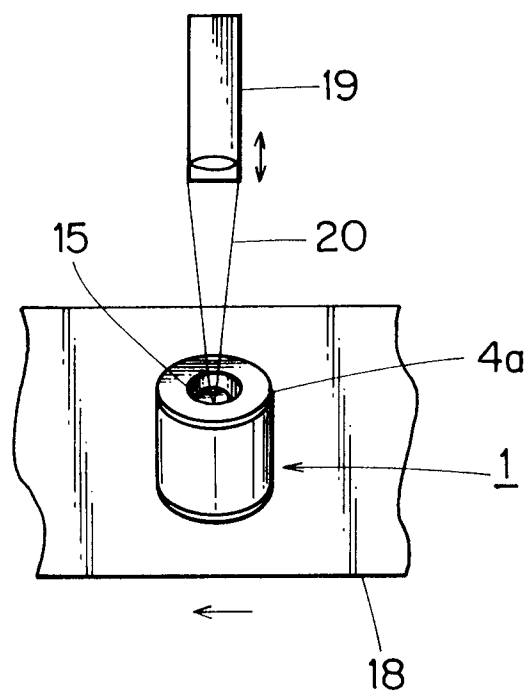
F I G . 1



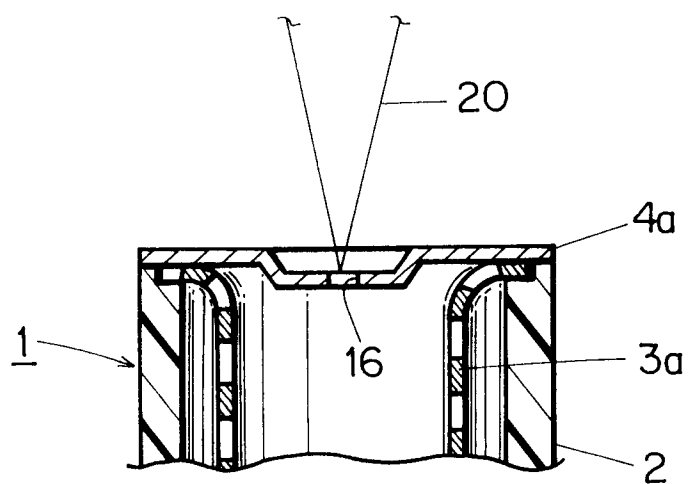
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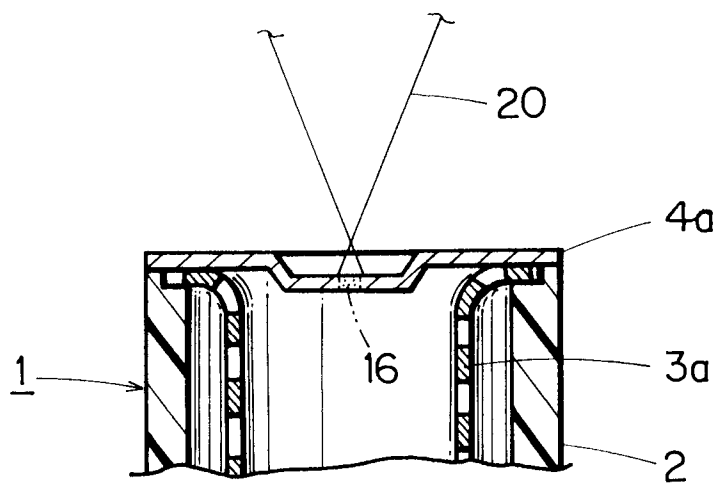
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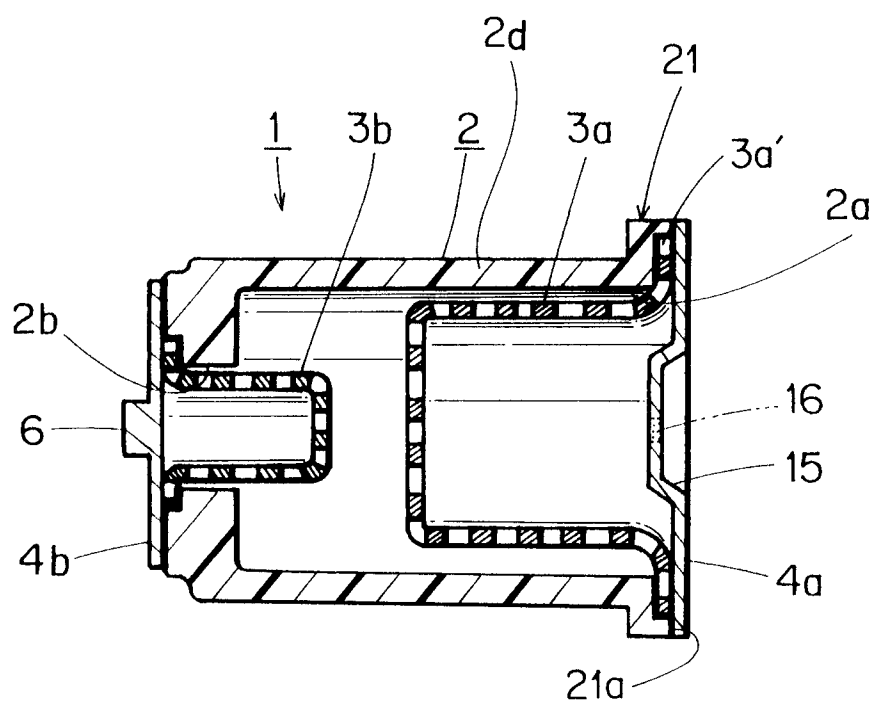
F I G . 4 A



F I G . 4 B



F I G . 5



F I G . 6

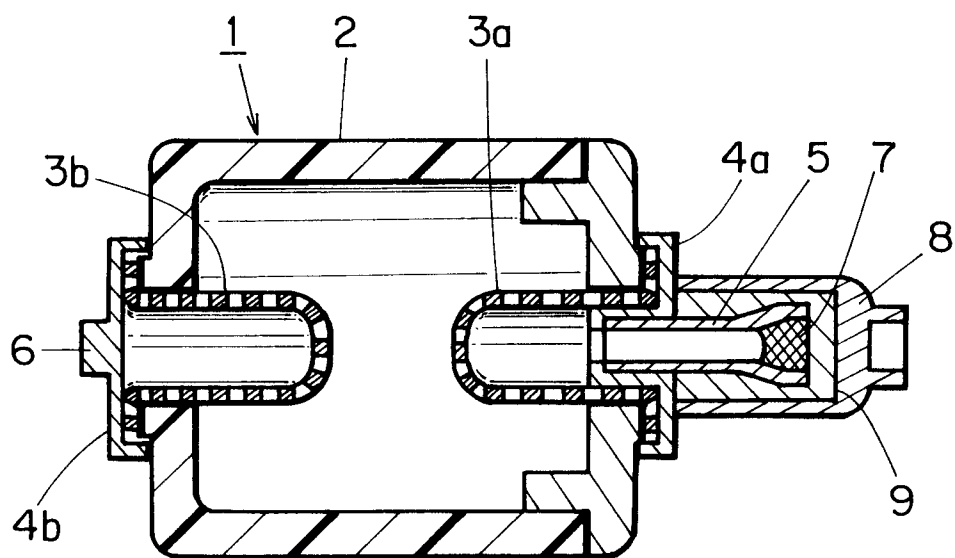


FIG. 7

