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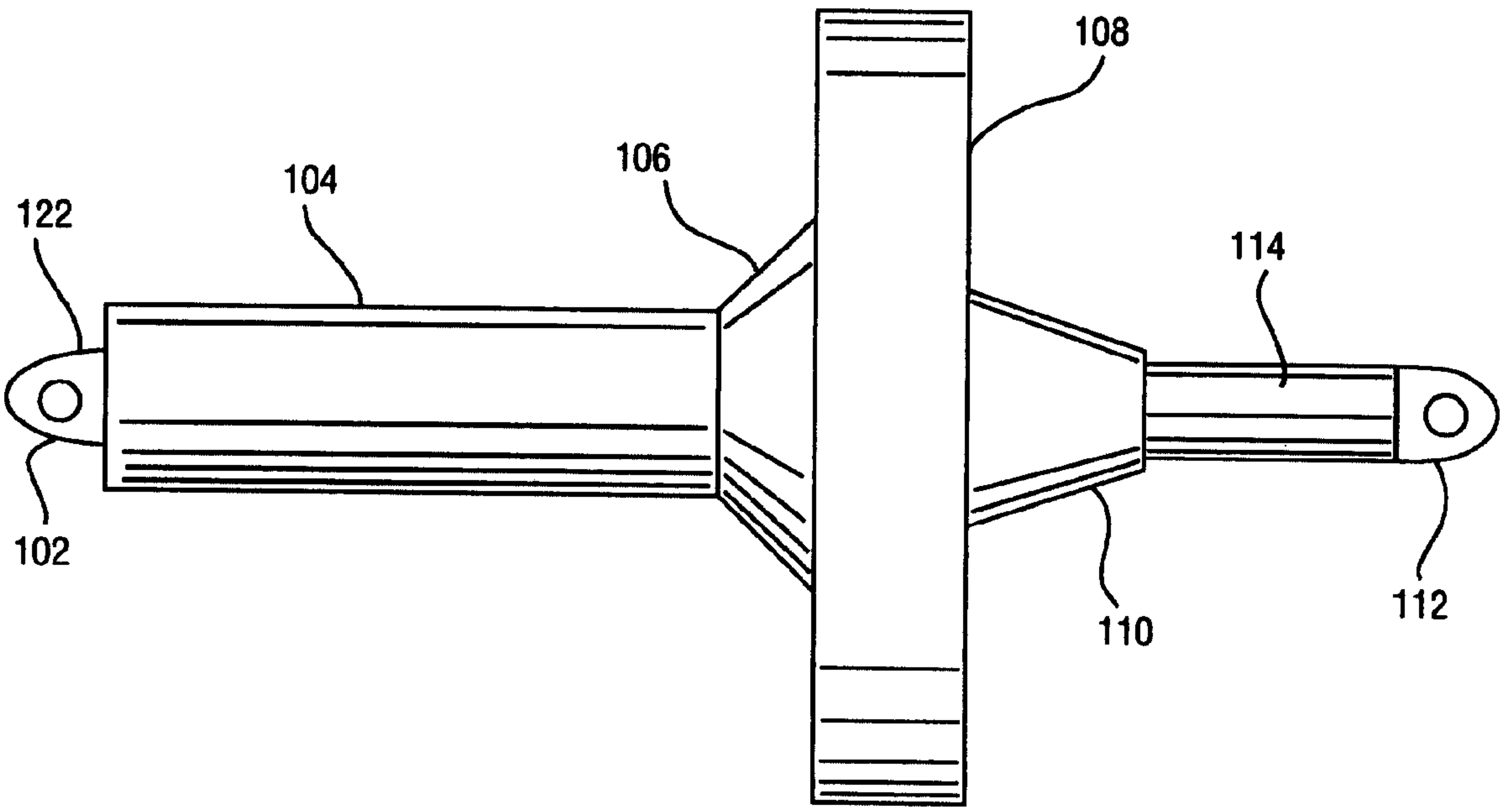
(54) Titre : METHODE ET APPAREIL POUR AUGMENTER LA VALEUR NOMINALE D'UN TRANSFORMATEUR
(54) Title: METHOD AND APPARATUS FOR INCREASING THE RATING OF A TRANSFORMER



(57) Abrégé/Abstract:
The voltage class rating of a transformer is increased by increasing the rating of an off the shelf molded transformer bushing. The rating is increased by increasing the distance from the non-insulated portion of a conductor of a transformer bushing and the transformer wall is increased. A conductive extension is connected to the conductor. Insulating material in the form of mastic and heat shrink tubing is applied to the external portion of the conductor and extension. When the modified transformer bushing is installed into a transformer, an internal end of the conductor extends below the surface of the oil in the transformer. The level of the oil also covers an internal insulating shoulder of the bushing. The insulating values of the mastic and heat shrink tubbing and the insulating value of the conductor immersed in oil, combine to increase the voltage class rating of an off the shelf molded transformer bushing and thereby the transformer.

METHOD AND APPARATUS FOR INCREASING THE RATING OF A TRANSFORMER

ABSTRACT

The voltage class rating of a transformer is increased by increasing the rating of an off the shelf molded transformer bushing. The rating is increased by increasing the distance from the non-insulated portion of a conductor of a transformer bushing and the transformer wall is increased. A conductive extension is connected to the conductor. Insulating material in the form of mastic and heat shrink tubing is applied to the external portion of the conductor and extension. When the modified transformer bushing is installed into a transformer, an internal end of the conductor extends below the surface of the oil in the transformer. The level of the oil also covers an internal insulating shoulder of the bushing. The insulating values of the mastic and heat shrink tubbing and the insulating value of the conductor immersed in oil, combine to increase the voltage class rating of an off the shelf molded transformer bushing and thereby the transformer.

METHOD AND APPARATUS FOR INCREASING THE RATING OF A TRANSFORMER

BACKGROUND OF THE INVENTION

1. Technical Field:

The present invention generally relates to the construction of a transformer and in particular to the electrical connections on the transformer. Still more particularly, the present invention relates to the bushings used for the electrical connections on the transformer.

2. Description of the Related Art:

In the oil-filled transformer industry, transformer capacity is determined based on how much voltage each transformer can safely handle. The amount of voltage a transformer can handle depends on several factors, including the electrical connections. Bushing terminals, the electrical connections on a transformer, are a key component to electrical transformers. Bushing terminals are used to hold the electrical conductors and transfer current from outside of the transformer to windings, or coils, on the inside of the transformer without shorting out to the transformer wall.

Bushing terminals commonly comprise an insulating bracket, a conductor, and provision for mounting the bracket to the transformer to insulate the conductor from the transformer wall. The insulating bracket includes an insulator material molded around the conductor. Bushings are rated on how well they insulate the transformer wall from current flowing through the conductor. One factor that must be considered in the rating of bushing terminals is based on the contaminants on the bushing. Contaminants on the bushing provide a conductive path which can cause electricity to leak out onto the transformer wall and cause electrical arcing, or striking. Arcing occurs when the potential difference between the transformer wall and the conductor becomes sufficiently large. The air ionizes between the two and this creates a path of relatively low resistance through which current can flow. This blast of electricity can cause a short circuit to occur and severely damage the transformer.

Another factor used to rate bushings is based on electrical "creepage" across the insulating bracket. Creepage is the electrical leakage on a solid dielectric surface. Creepage distance is the shortest distance on a dielectric surface between two conductive elements. The current will essentially track or crawl across the insulating bracket onto the transformer wall. This creepage can produce similar effects to contamination in that the electricity can short to the transformer wall and cause damage to the transformer itself.

One solution to minimize these problems has been to use a material with a high insulating property such as porcelain. One such porcelain bushing is manufactured by Normandy Machine Co. Inc. of Troy, Missouri and is rated to 5 kV (5000 volts). However, porcelain is not durable and is easily broken. A broken or damaged bushing requires costly replacement and down time of the transformer. To make the insulating material more durable, plastic is often used. Unfortunately, plastic has a lower electrical insulator rating than porcelain. One such plastic bushing is manufactured by Central Moloney Inc of Pine Bluff, Arkansas under the trademark of Tuf Ex-Mount™. **Figure 4A** is a line drawing of a Central Moloney Inc. Tuf Ex-Mount™ molded transformer bushing as cited. Bushing 400 contains a threaded portion 402 of a conductor 404 adjacent to second shoulder 406 of insulating mounting bracket 408. Conductor 404 is surrounded by insulating mounting bracket 408 having a first shoulder 410 and second shoulder 406. Front end 412, for connecting to transformer windings, of conductor 404 is adjacent to first shoulder 410 of insulating mounting bracket 408. **Figure 4B** represents bushing 400 installed in an oil-filled transformer. Frequently, bushing 400 is not immersed in oil 414 causing a reduction in voltage capacity.

When mounted, the Tuf Ex-Mount™ inside and outside surfaces are rated at 1.2kV. In addition, the creepage and strike distances are also designed for use at 1.2kV. Notably, the molded 1.2kV bushing is designed and used such that the external hardware may be installed or exchanged in the field. However, as shown from the relatively low voltage rating of the plastic bushing, the insulating properties of plastic are poor when compared to the insulating properties of porcelain. This low rating results in high incidents of arcing, striking or creepage across the insulating bracket.

Therefore, a need exists for a durable, cost effective method for reducing the external creepage and incidents of arcing when using transformer bushings.

SUMMARY OF THE INVENTION

It is therefore one object of the present invention to increase the voltage class of a transformer by increasing the rating of a transformer bushing with a nominal increase in costs.

It is another object of the present invention to decrease the external creepage on bushings.

It is yet another object of the present invention to provide an increased strike distance from the conductor of the bushing to a transformer wall.

The foregoing objects are achieved as is now described. The voltage class rating of a transformer is increased by increasing the rating of an off the shelf molded transformer bushing. The rating is increased by increasing the distance from the non-insulated portion of a conductor of a transformer bushing and the transformer wall. A conductive extension is connected to the conductor. Insulating material in the form of mastic and heat shrink tubing is applied to the external portion of the conductor and extension. When the modified transformer bushing is installed into a transformer, an internal end of the conductor extends below the surface of the oil in the transformer. The level of the oil also covers an internal insulating shoulder of the bushing. The insulating values of the mastic and heat shrink tubbing and the insulating value of the conductor immersed in oil combine to increase the voltage class rating of the off the shelf molded transformer bushing and thereby the transformer.

The above as well as additional objectives, features, and advantages of the present invention will become apparent in the following detailed written description.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself however, as well as a preferred mode of use, further objects and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

Figure 1 is a block diagram of a transformer with a converted transformer bushing in accordance with a preferred embodiment of the present invention may be implemented;

Figure 2A is a converted transformer bushing in accordance with a preferred embodiment of the present invention may be implemented;

Figure 2B is a cross section of a converted transformer bushing in accordance with a preferred embodiment of the present invention;

Figure 2C is a detailed cross section of an extension attached to a bushing in accordance with a preferred embodiment of the present invention;

Figure 2D is a detailed cross section of mastic and insulating material applied to a second shoulder of an insulating mounting bracket in accordance with a preferred embodiment of the present invention;

Figure 3 is a high-level block diagram exemplifying a method for improving a transformer rating in accordance with a preferred embodiment of the present invention;

Figure 4A is a molded bushing that is commonly used in the manufacture of oil-filled transformers; and

Figure 4B is a molded bushings installed in a transformer as is commonly used in the art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference now to the figures, and in particular with reference to **Figure 1**, a transformer in which a preferred embodiment of the present invention may be implemented is depicted. High voltage conductor 121 is connected to transformer 100 by external hardware 120. External hardware 120 is attached to back end 102 of conductor 114. Insulated material 104 covers conductor 114 from the back end 102 of conductor 114 to second shoulder 106 of insulating mounting bracket 108. Insulating mounting bracket 108 is attached to transformer wall 116. Conductor 114 runs through transformer wall 116 and conductor 114 is surrounded by insulating mounting bracket 108. First shoulder 110 of insulating mounting bracket 108 and front end 112, of conductor 114 are immersed in oil 118. Front end 112 of conductor 114 is for connecting to transformer windings.

Referring to **Figures 2A - 2D**, a converted transformer bushing in accordance with a preferred embodiment of the present invention is illustrated. In the exemplary embodiment, by way of illustration and not of limitation, extension 200 is attached, using in this case nut 204, to the threaded portion 206 of an off the shelf molded transformer bushing similar to the one shown in **Figure 4A**. Anyone skilled in the art will recognize that there are other ways to attach an extension. Extension 200 increases the distance from the back end 102 of conductor 114 and transformer wall 116.

After extension 200 is attached, a mastic 202 is applied. The mastic 202 is applied to extension 200 so as to cover back end 102 of conductor 114 up to a mounting point for external hardware 122. Also, the mastic 202 is applied to attachment 204 and the threaded portion 206 of the molded transformer bushing so as to completely cover the conductor 114 from the second shoulder 106 of the insulating mounting bracket 108 to the back end 102 of the conductor 114. Finally, mastic 202 is applied to the second shoulder 106 of insulating mounting bracket 108. Mastic 202 is applied to this area because the insulating material 104 will cover the conductor 114 and a portion of the second shoulder 106 of the insulating mounting bracket 108. The insulating material 104 covers conductor 114 and a portion of the second shoulder 106 of the insulating mounting bracket 108 to reduce creepage as well as protect against arcing from conductor 114 to the transformer wall 116. Proper application of the mastic 202 to conductor 114 and a portion of the second shoulder 106 of the insulating mounting bracket 108 is important to ensure there are no voids between the conductor 114 and the second shoulder 106 of the insulating mounting bracket 108. This prevents creepage from the second shoulder 106 of the insulating mounting bracket 108 to the transformer wall 116.

Next, an insulating material 104, such as heat shrink tubing, is installed from the second shoulder 106 of the insulating mounting bracket 108, to the back end 102 of the conductor 114. As stated earlier, the insulating material 104 is applied to the second shoulder 106 of the insulating mounting bracket 108 so that the insulating material 104 covers the conductor 114 and a portion of the second shoulder 106 of the insulating mounting bracket 108. This aids in reducing creepage and leakage onto the insulating mounting bracket 108 as well as protecting against arcing from the conductor 114 to the transformer wall 116. Insulating material 104 and mastic 202 can also be applied so as to cover a portion of the external hardware 120 attached to back end 102 of conductor 114. This further increases strike distance and reduces creepage. However, by covering external hardware 120 with insulating material 104 the flexibility to change external hardware 120 is then limited due to the need to compromise the integrity of the insulator if the attaching hardware were removed or replaced.

Any length of extension 200, or no extension, can be used to increase the standard bushing rating by a measurable amount, so long as the distance from a non-insulated portion of the conductor 114 to transformer wall 116 is increased. The increase in distance means more air must ionize before the potential difference between the transformer wall 116 and the conductor 114 becomes sufficiently large enough to create a path through which current can flow. Therefore, the longer an extension, the greater the strike distance. In addition, external creepage is minimized because the current has a significantly further distance to travel. By choosing the proper hardware and length of heat shrink tubing, the external creepage and strike distance of the bushing assembly can be increased to the extreme.

The bushing has an external portion located outside the transformer and an internal portion located inside the transformer. Once the rating on the external portion of the bushing is increased, the internal surface of the bushing becomes the lowest rated portion of the bushing. The rating on the internal surface of the bushing, can be increased by mounting the bushing with the internal surface under oil 118. By immersing front end conductor 112 and first shoulder 110 of insulating mounting bracket 108 in oil 118, the rating of the internal surface of the bushing can be significantly increased and thereby increasing the voltage class of a transformer.

Now referring to **Figure 3**, a high-level block diagram exemplifying a method for improving a transformer rating in accordance with a preferred embodiment of the present invention is illustrated. In order to further clarify this method, reference to **Figures 1, 2A - 2D and 4A** is encouraged and will be referred to throughout the following process steps. The process begins with step 300, which depicts preparing a plastic bushing to receive a threaded extension 200 and mastic 202. The bushing is similar to a 1.2kV Tuf Ex-Mount™ illustrated in **Figure 4A**. The process next passes to step 302, which illustrates extension 200 being attached, using nut 204, to the threaded portion 206 of the Tuf Ex-Mount™ plastic bushing similar to the one shown in **Figure 4A**. Anyone skilled in the art will recognize that there are other ways to attach an extension. The extension 200 increases the distance from the back end of conductor 102 and transformer wall 116. Any length of extension 200, can be used to increase the standard bushing rating by a measurable amount so long as the distance from a non-insulated portion of the conductor 114 to transformer wall 116 is increased.

The process then proceeds to step 304 which depicts applying mastic 202. The mastic 202 is applied to help the heat shrink insulating material 104 adhere to the conductor 114 and the insulated mounting bracket 108. The mastic 202 is applied to extension 200 so as to completely enclose back end 102 of conductor 114 as shown in **Figure 2A**. Also, the mastic 202 is applied to nut 204 and threaded portion 206 of the bushing so as to completely cover the conductor 114 from the second shoulder 106 of the insulating mounting bracket 108 to the back end 102 of the conductor 114. Finally, the mastic 202 is applied to the second shoulder 106 of the insulating mounting bracket 108. The mastic 202 is applied to this area because the insulating material 104 will cover the conductor 114 and a portion of the second shoulder 106 of the insulating mounting bracket 108. The insulating material 104 will cover conductor 114 and a portion of the second shoulder 106 of the insulating mounting bracket 108 to reduce creepage as well as protect against arcing from the conductor 114 to the transformer wall 116. Proper application of the mastic 202 to conductor 114 and a portion of the second shoulder 106 of the insulating mounting bracket 108 is important to ensure there are no voids between the conductor 114 and the second shoulder 106 of the insulating mounting bracket 108. This prevents creepage from the second shoulder 106 of the insulating mounting bracket 108 to the transformer wall 116.

The process proceeds to step 306 which illustrates applying heat shrink tubing or insulating material 104 to the conductor 114 and other connecting surfaces. An insulating material 104, such as Raysulate BPTM and BBIT high-voltage insulating tubing, a product of Raychem, Menlo Park, CA is installed from the second shoulder 106 of the insulating mounting bracket 108, to the back end 102 of the conductor 114. The heat shrink tubing, which has a high voltage insulating property is installed over the complete area covered by the mastic 202. If the heat shrink tubing is factory installed, a wide variety of hot air ovens or infrared heaters can be used to shrink the tubing. If the heat shrink tubing is installed on a transformer bushing in the field, a clean-burning propane torch with a "bushy" flame can be used to shrink the tubing. The heat is evenly applied until the heat shrink tubing shrinks onto and tightly conforms to conductor 114 and insulating mounting bracket 108, and any other surface being insulated. As stated earlier, the insulating material 104 is applied to the second shoulder 106 of the insulating mounting bracket 108 so that the insulating material 104 covers the conductor 114 and a portion of the second shoulder 106 of the insulating mounting bracket 108. This helps prevent creepage and leakage onto the insulating mounting bracket as well as protect against arcing or sparking from the conductor 114 to the transformer wall 116. Insulating material 104 and mastic 202 can also be applied to cover a portion of the external hardware 120 attached to back end 102 of conductor 114. This further increases strike distance and reduce creepage.

The process continues to step 308 which depicts completing the installation of the bushing. The bushing has an external portion located outside the transformer and an internal portion located inside the transformer. By immersing front end conductor 112 and first shoulder 110 of insulating mounting bracket 108 in oil 118, the rating of the internal surface of the bushing can be significantly increased and thereby increasing the voltage class of a transformer.

CLAIMS:

What is claimed is:

1. A method for improving a transformer voltage rating comprising the steps of:

utilizing a bushing having a conductor, with a front end and a back end and an insulating mounting bracket having a first and second shoulder; and

enclosing a portion of said back end of said conductor and said second shoulder of said insulating mounting bracket with insulating material.

2. An apparatus for improving a transformer voltage rating, comprising:

a bushing having a conductor, with a front end for connecting to transformer windings and a back end for connecting to a power source and an insulating mounting bracket having a first and second shoulder; and

means for enclosing a portion of said back end of said conductor and said second shoulder of said insulating mounting bracket with insulating material.

3. A kit for improving a transformer voltage rating comprising:

a bushing having a conductor, with a front end for connecting to transformer windings and a back end for connecting to a power source and an insulating mounting bracket having a first and second shoulder;

an extension for said back end of said conductor; and

insulating material for enclosing a portion of said back end of said conductor and said second shoulder of said insulating mounting bracket.

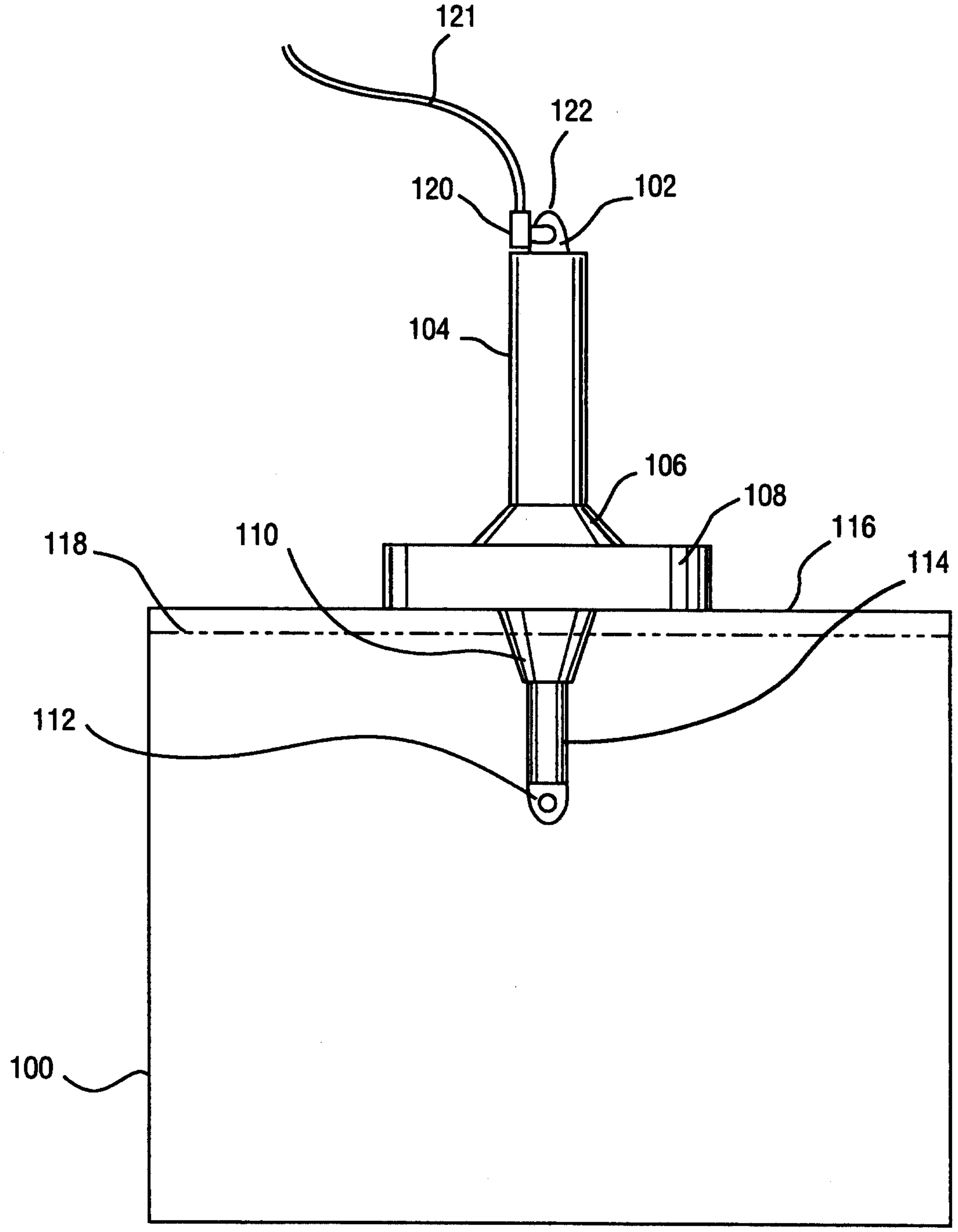


FIG. 1

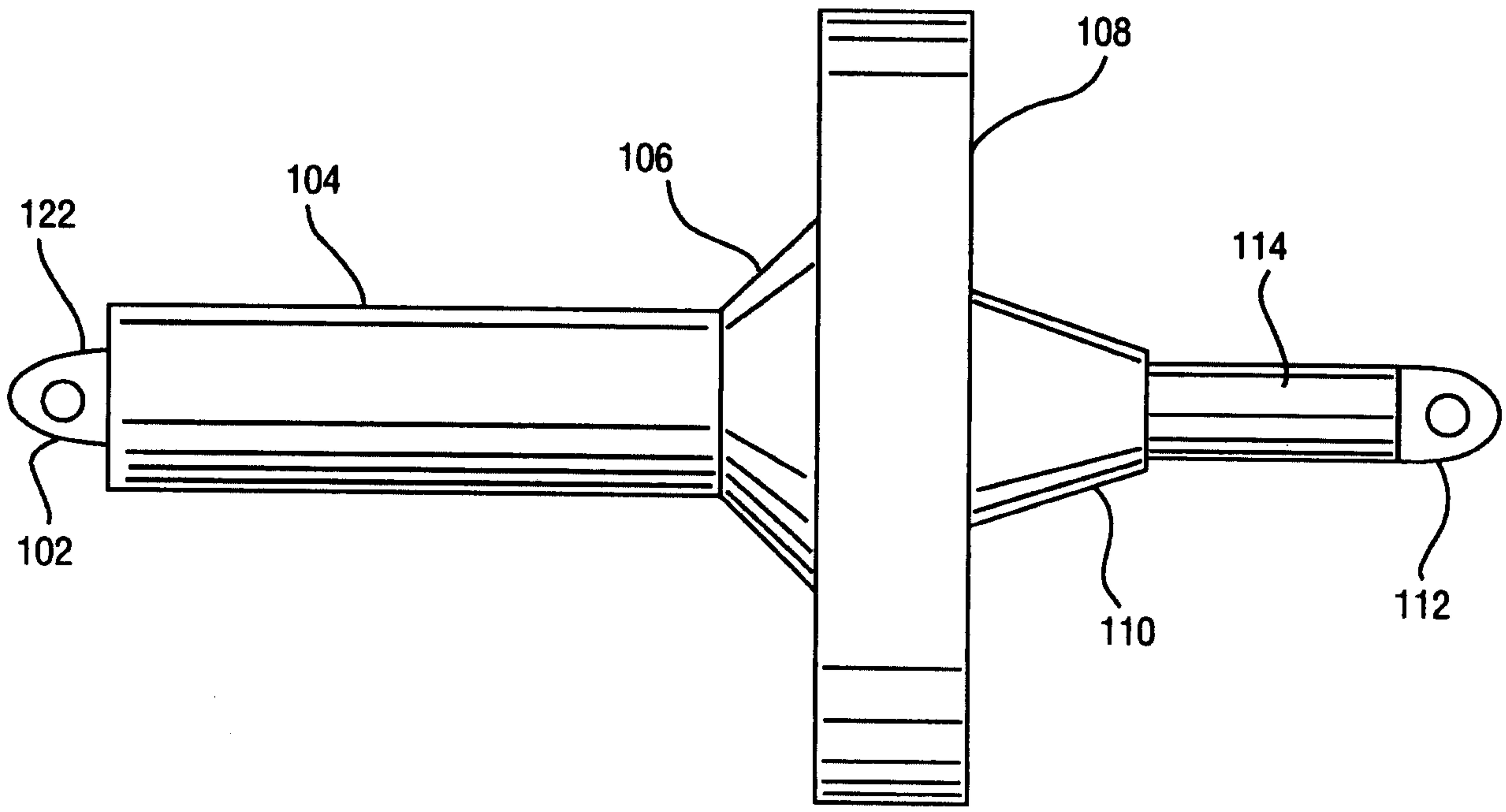


FIG. 2A

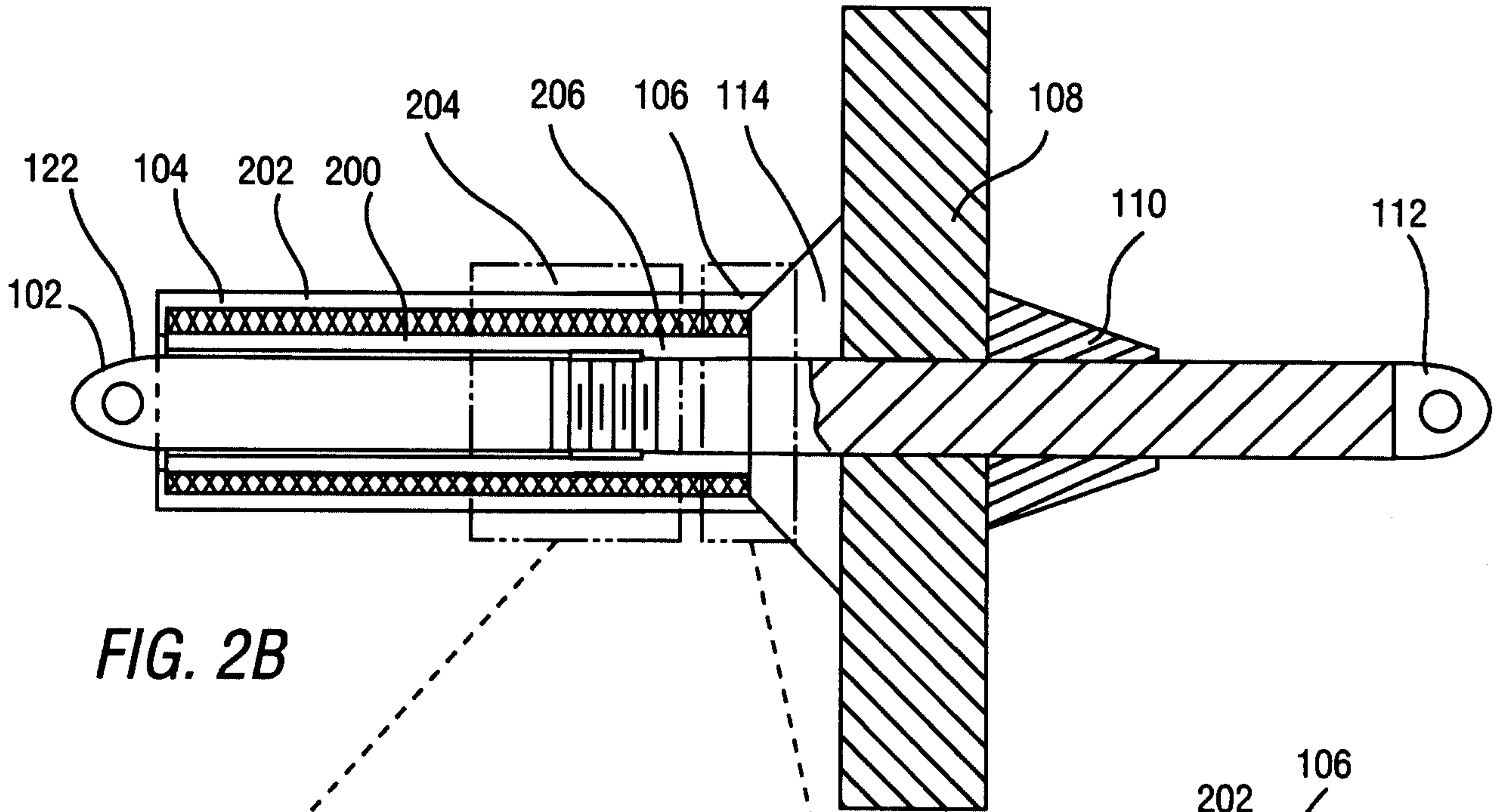
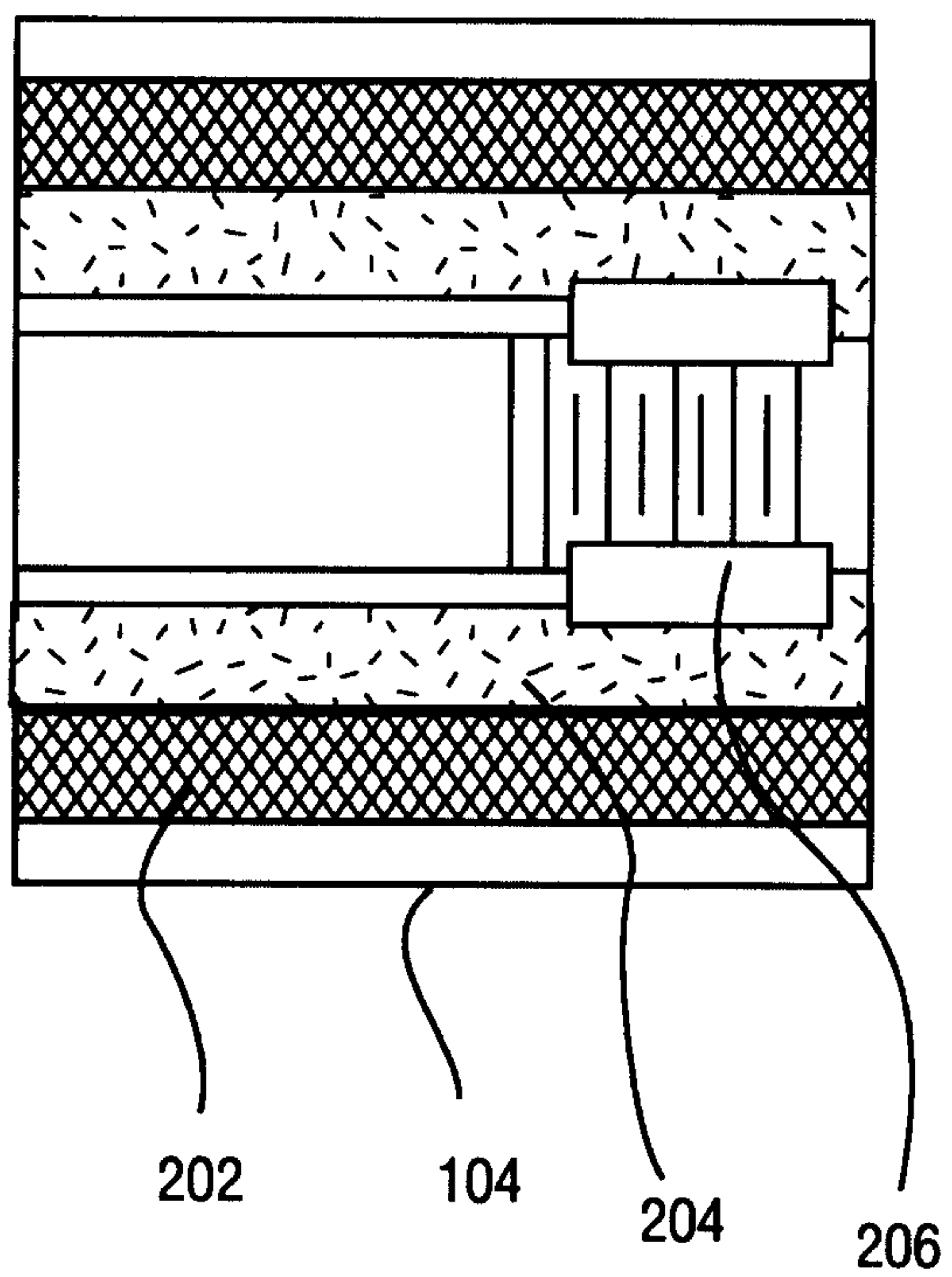


FIG. 2B



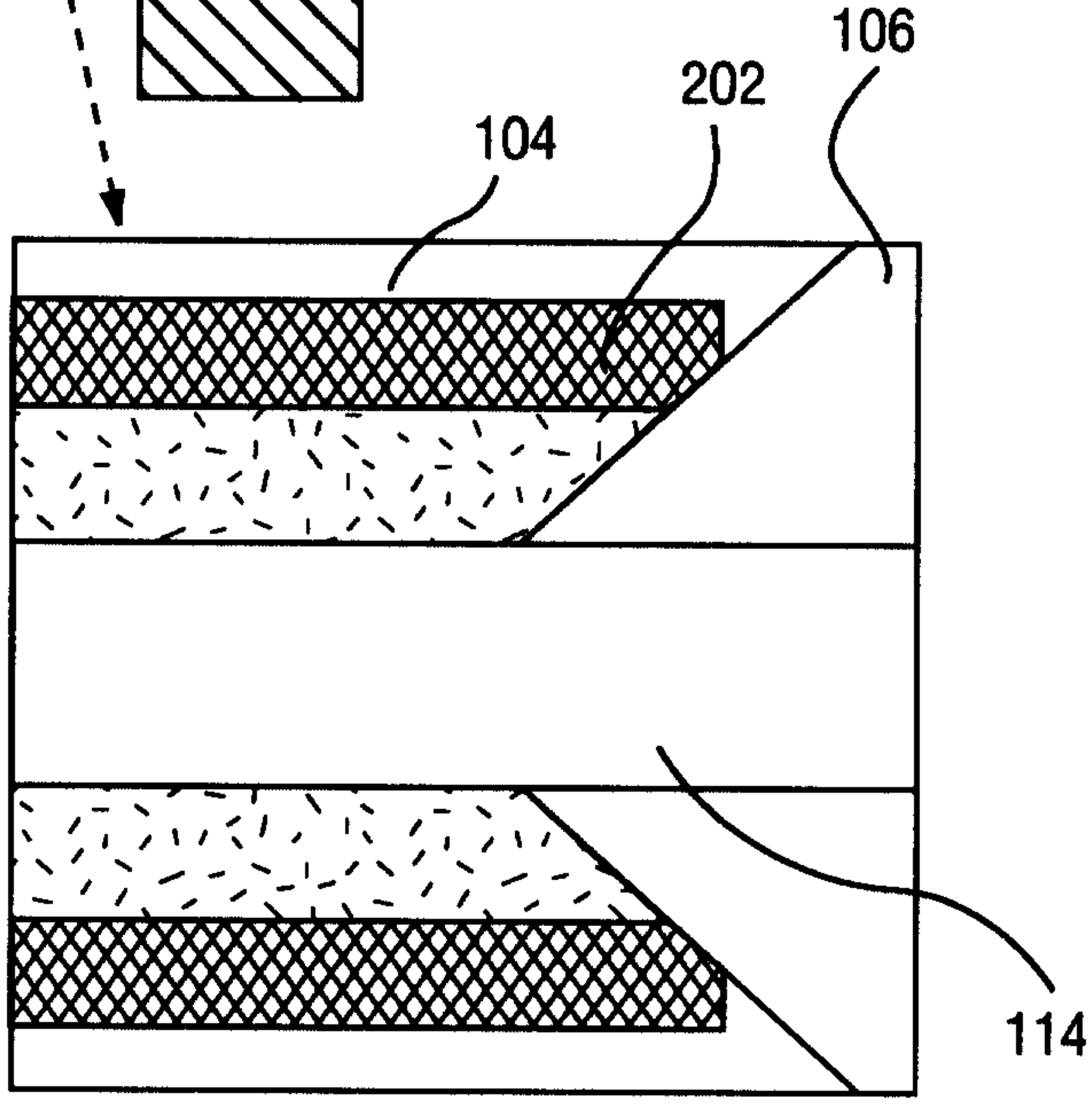


FIG. 2D

FIG. 2C

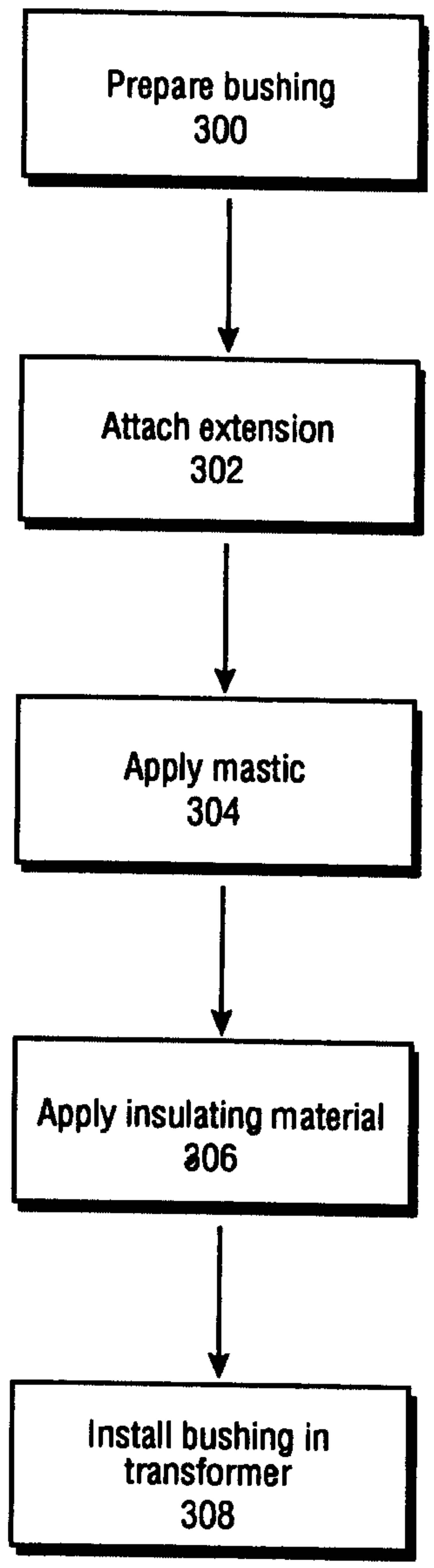

Prepare bushing
300
Attach extension
302
Apply mastic
304
Apply insulating material
306
Install bushing in
transformer
308

FIG. 3

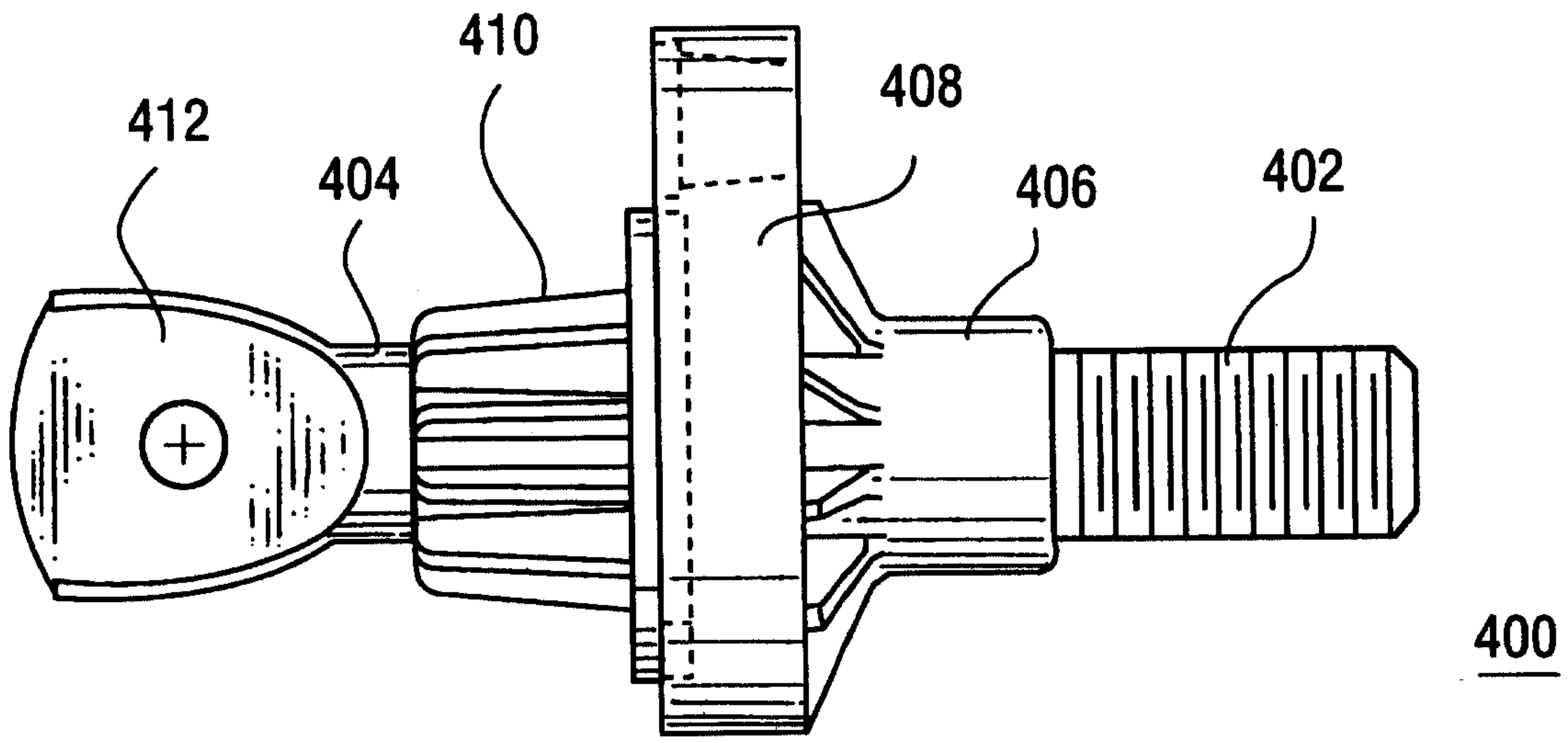


FIG. 4A

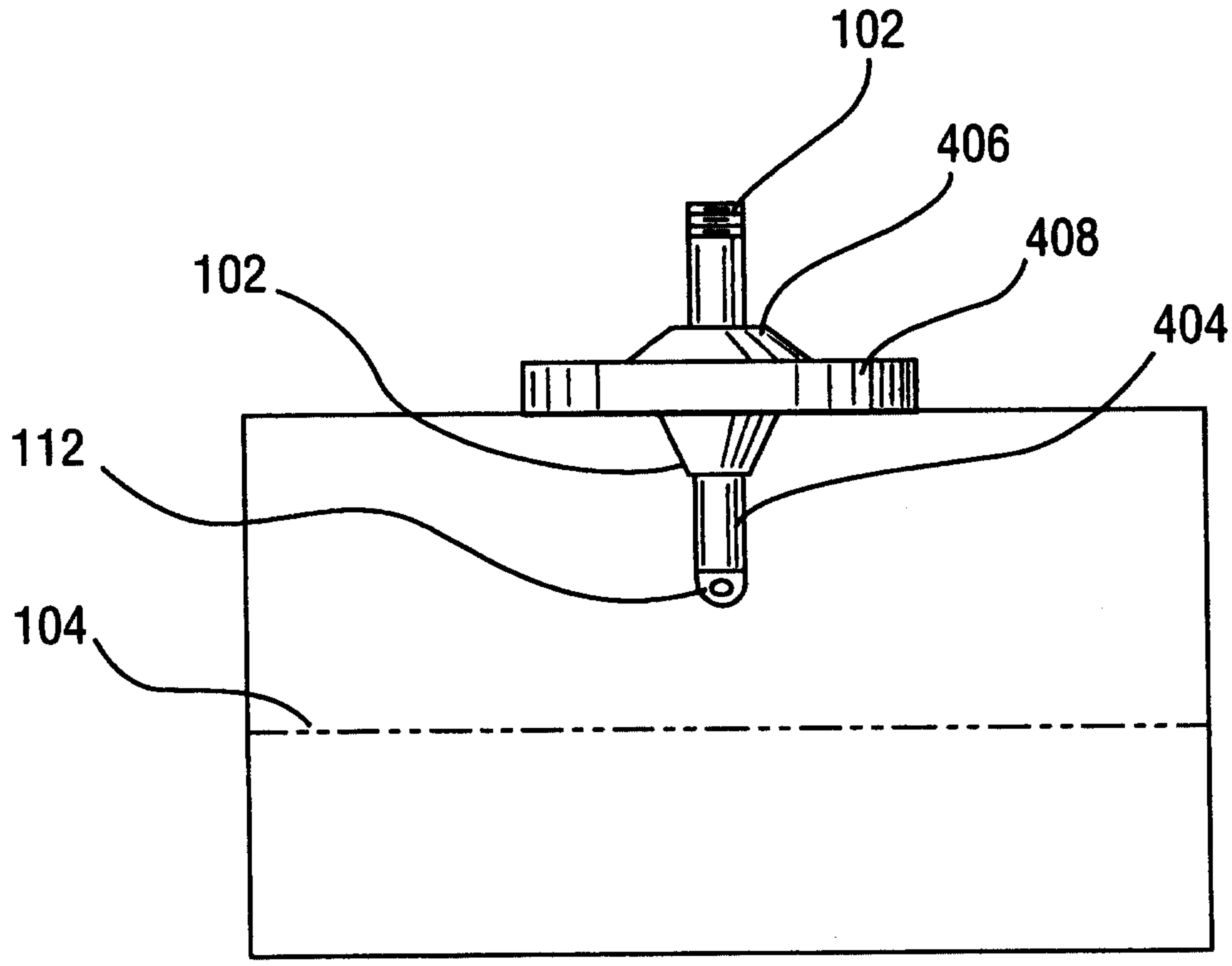
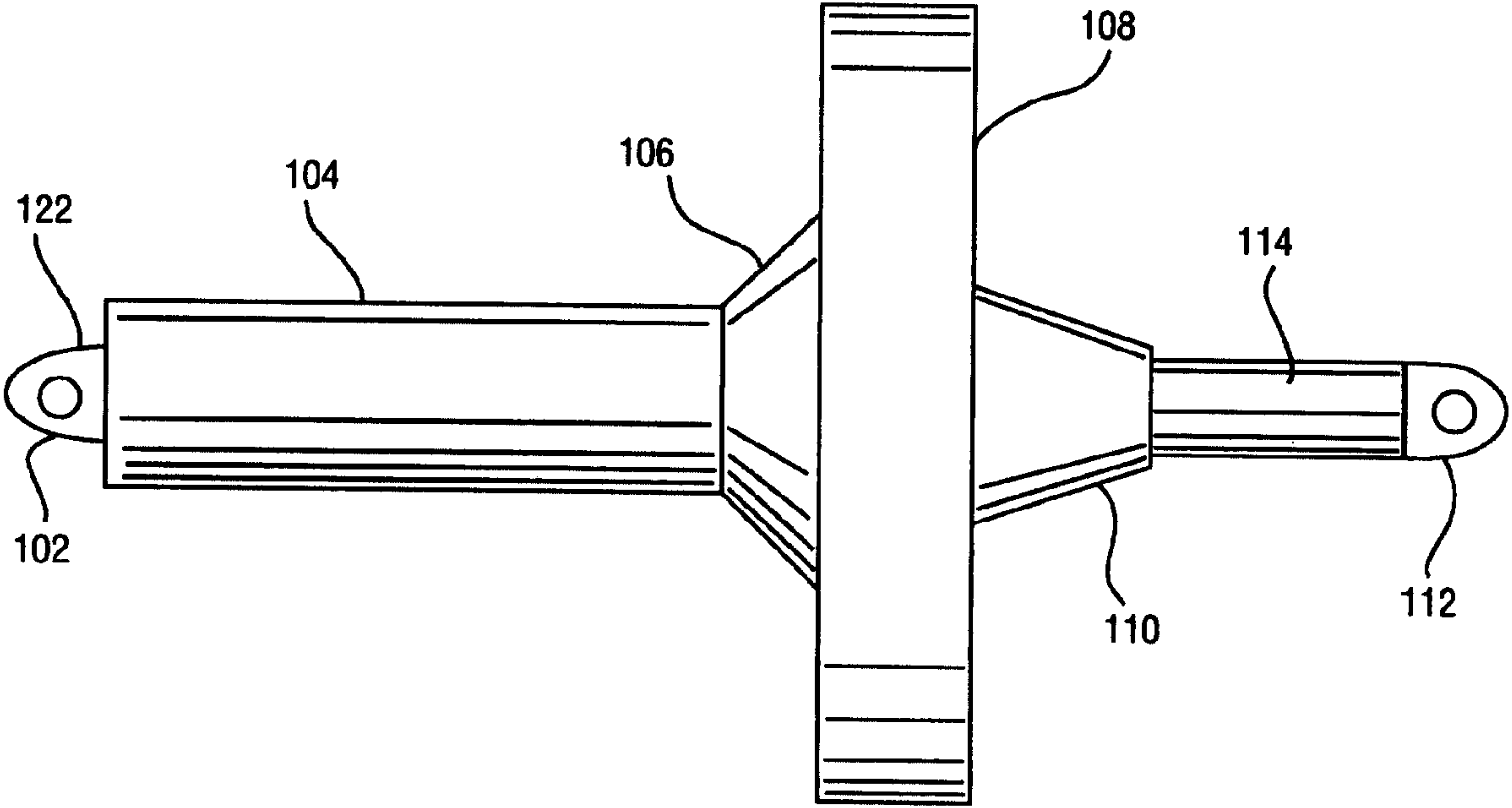


FIG. 4B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