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(54) Filter with temperature compensated tuning screw

(57) A temperature compensated filter has a compensating screw (18) mounted in a support (40) in the wall (22) of a cavity. The support is made from a material having a high coefficient of thermal expansion compared to the material of the cavity and the material of the compensating screw. As temperature changes, the support moves the compensating screw either further into the cavity or further out of the cavity to compensate for the change in resonant frequency of the cavity that would otherwise occur. The compensating screw can be used with single, dual or triple mode cavities. The compensating screw can be made of metallic material or it can be made of non-metallic material with a metallic outer surface. The compensating screw is locked in the support before the support is inserted into the wall of the cavity. The support is then locked in the wall of the cavity and the screw automatically changes position within the cavity as temperature changes. An RF barrier (50) can be used to prevent RF energy from the cavity from entering the area of the support.

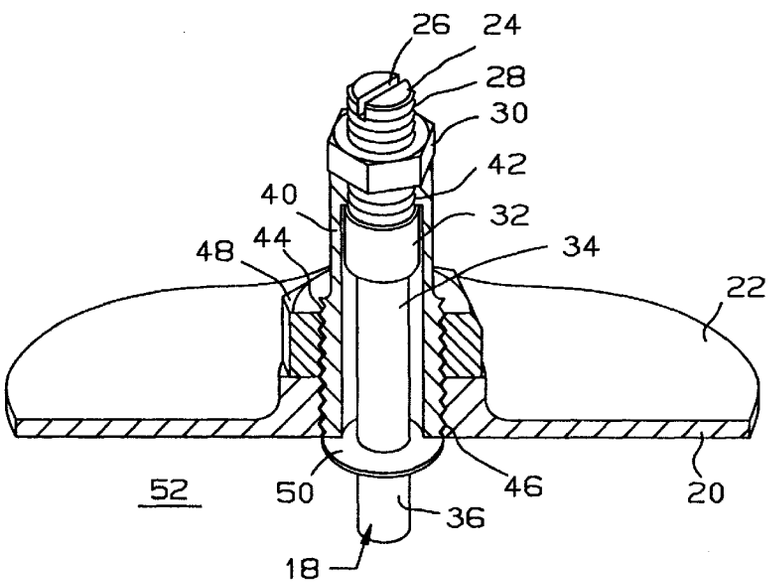


FIGURE 2

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Description

This invention relates to a waveguide filter having a temperature compensating screw mounted on a support made from a material having a higher coefficient of thermal expansion relative to a coefficient of thermal expansion of a material of said screw.

When a higher coefficient of thermal expansion is referred to in this specification, "higher" shall be interpreted to mean more positive (since coefficients of thermal expansion can be negative) . Similarly, lower coefficients of thermal expansion means less positive. Similar terms have corresponding meanings.

It is known that temperature compensated filters can be compensated using irises made from bimetal materials (see Collins, et al., U.S. Patent No. 4,488,132 issued December 11th, 1984; Atia, et al., U.S. Patent No. 4,156,860 issued May 29th, 1979 and Kick U.S. Patent No. 4,677,403 issued June 30th, 1987). Temperature compensated filters that use bimetal end walls can be more complex to design than other temperature compensated filters. Further, in Japanese Patent No. 5-259719 (A) issued on October 8th, 1993, an adjustment screw made from dielectric material is provided with a hollow metallic thread. The dielectric body is fitted into the hollow thread. The dielectric screw penetrates into the cavity to compensate for changes in the cavity resonant frequency with temperature. The dielectric constant of the screw changes with temperature in such a fashion as to oppose changes in cavity resonant frequency that occur with temperature changes. The use of a dielectric screw can degrade the electrical performance of the filter.

It is an object of the present invention to provide a waveguide filter containing a metallic temperature compensating screw mounted in a support in a wall of the cavity where the support has a high coefficient of thermal expansion and moves the screw within the cavity with changes in temperature. As the screw moves further into the cavity, the resonant frequency is reduced. As the screw moves further out of the cavity, the resonant frequency of the cavity is increased. This is opposite to the effect of temperature changes on the resonant frequency where a compensating screw is not utilized.

A waveguide filter has at least one cavity and said cavity has a cavity wall with at least one metallic temperature compensating screw located therein. The temperature compensating screw is mounted on a support made from a material having a higher coefficient of thermal expansion relative to a coefficient of thermal expansion of a material of said screw. The higher coefficient of thermal expansion material moves the compensating screw further into or further out of said cavity with changes in temperature, thereby at least reducing a change in resonant frequency of the cavity that would otherwise occur as a result of said change in temperature.

A method of at least reducing the effect of temperature changes on the resonant frequency of a waveguide filter, said filter having at least one screw, said cavity having a temperature compensating screw mounted within a support made from a material having a higher coefficient of thermal expansion relative to a coefficient of thermal expansion of a material of said cavity, said method comprising adjusting said compensating screw longitudinally in said support so that said support moves said compensating screw further out of said cavity as temperature increases and further into said cavity as temperature decreases to at least reduce a change in frequency of the cavity that would otherwise occur as a result of said change in temperature.

In Figure 1, there is shown a sectional side view of a three cavity filter where each cavity has a temperature compensating screw;

Figure 2 is a partial perspective view, partially in section, of a temperature compensating screw in a wall of a cavity;

Figure 3 is a partial perspective view, partially in section, of the temperature compensating screw in the wall of a cavity; and

Figure 4 is a partial perspective view of the temperature compensating screw in the wall of a cavity.

Referring to the drawings in greater detail, in Figure 1, a filter 2 has three waveguide cavities 4, 6, 8 with end caps 10, 12, irises 14, 16. Each cavity 4, 6, 8 contains two temperature compensating screw 18. Since Figure 1 is a sectional view, only one compensating screw is shown in the cavity 6. The compensating srews of each cavity are located 90° apart from one another. One compensating screw is located at the top of each cavity. The cavities 4, 8 each have a second compensating screw extending out a far side of the cavity. In the cavity 6, the second compensating screw is located 180° apart from the second compensating screws of the cavities 4, 8 and extends out a rear side (not shown) of the cavity 6. The temperature compensating screws are additional to a conventional tuning screw(s) that are used within each cavity to tune or adjust the frequency of each mode or modes resonating within that cavity. The conventional tuning screws have been deleted from Figure 1 so as not to be confusing with the temperature compensating screws shown. The temperature compensating screws can be located in a side wall of a cavity or in an end wall of a cavity. Preferably, the temperature compensating screws are located in position dictated by the particular cavity resonant mode utilized. There can be more than one temperature compensating screw and corresponding support per cavity.

The filter can have one cavity or any reasonable number of cavities. Each cavity can resonate in a single mode, dual mode or triple mode or in a multi-cavity filter, any combination of single, dual or triple mode cavities can be used. The cross-section of the cavity can be circular, square, rectangular or elliptical. When the filter has a single or dual mode cavity, the modes can be se-

lected from the group of TE_{11n} and TE_{10n}, when n is a positive integer. When the filter has a triple mode cavity, the modes can be selected from the group of TE_{11n}, TE_{10n} and TM_{01m}, when n is a positive integer and m is a positive integer, equal to or greater than zero.

In Figures 2, 3 and 4, it can be seen that a temperature compensating screw 18 is inserted into a wall 20 of a cavity 22. The temperature compensating screw 18 has an outer end 24 containing a slot 26 for receiving a screwdriver (not shown). The slot 26 could be any reasonable shape that corresponds to a shape of a screwdriver. That section of the temperature compensating screw 18 near the outer end 24 has a screw thread 28 thereon, the screw thread 28 being sized to receive a locking nut 30. The screw thread 28 extends to one side of a collar 32. At an opposite side of the collar 32, there is located a middle section 34 of the temperature compensating screw 18. An inner end portion 36 of the screw 18 has a threaded bolt section 38 (as best shown in Figure 3) to allow the inner portion 36 to be attached to the middle section 34.

The temperature compensating screw 18 is mounted within a bushing 40, the bushing being made of a material having a higher coefficient of thermal expansion than a material of the temperature compensating screw 18. The bushing 40 constitutes a support for the screw 18 and contains an inner screw thread 42 to receive the screw thread 28 and an outer screw thread 44 to mesh with an inner screw thread 46 in the cavity wall 20. A nut 48 also intermeshes with the screw thread 46 to lock the bushing 40 in position vis-a-vis the cavity wall 20. Between the inner end 36 and the bushing 40, there is located a circular disc 50 made of conductive material. The disc 50 provides an RF energy barrier so that energy from an interior 52 of the cavity 22 will not pass into the bushing 40. The energy barrier is not always required. In certain instances, the glometry of the internal bushing structure, the electrical properties of the materials used and the electrical requirements of the filter assembly being compensated may result in the RF barrier being eliminated. The bushing 40 provides a support for the metallic compensating screw 18. Preferably, the outer end 24, the section making up the screw thread 28, the collar 32 and the middle section 34 are machined as one piece of material (hereinafter called the "outer portion"). Virtually any material can be used for the outer portion as this material is located entirely behind the RF barrier 50. This outer portion of the screw 18 is threaded into the bushing 40 so that the screw thread 28 intermeshes with the screw thread 42 until an outer edge of the collar abuts against the bushing 40. The nut 30 is then tightened to lock the screw assembly in position within the bushing 40. A screwdriver (not shown) can be inserted into the slot 26 to turn the middle section 34 relative to the bushing 40. The inner portion of the compensating screw 18 has a cylindrical section 36 and a threaded section 38. Preferably, the inner end is machined as well. The threaded section 38 is sized so that it will thread within a hollow inner end of the middle section 34, which contains a corresponding screw thread. The RF barrier 50 is placed over the threaded section 38 and the inner end is then turned into the central section 34 so that the threaded section 38 is located within the central section 34 as shown in Figure 3 with the RF barrier 50 located between the cylindrical section 36 and the bushing 40. After the RF barrier 50 is in place, it is bonded to the inner end of the bushing 40.

The bushing 40 is made of a material having a higher coefficient of thermal expansion than the cylindrical section 36, which is made of a material having a low coefficient of thermal expansion. The bushing 40 is then turned into a suitable opening in the wall 20 of the cavity 22 so that the screw thread 44 intermeshes with the screw thread 46. The nut 48 is then turned onto the screw thread 44 to lock the bushing in position within the cavity wall 20.

When in place, the compensating screw 18 is not adjustable within the bushing 40. However, adjustments can be made through the choice of material for the bushing and also through the choice of material and the length of the inner portion 36 of the compensating screw.

Various materials can be used for the various components. For example, the cavity can be made of Invar and the inner portion of the compensating screw can be made of Invar or the cavity and inner portion of the compensating screw can both be made of silver plated Invar. Both the cavity and the inner portion would then have a low coefficient of thermal expansion. As another example, the cavity can be made of a light weight material (e. g. aluminum). An aluminum cavity would have advantageous properties over an Invar cavity. Invar is presently the most common cavity material. This invention permits a wider range of cavity materials to be chosen, with advantageous results, over Invar. The disc 50 can be made of any metal, for example silver. Preferably, the disc 50 is made of a highly conductive metal. The bushing can be made of any material having a relatively high coefficient of thermal expansion compared to the material of the cavity and the inner end of the compensating screw. For example, the bushing 40 could be made of aluminum or silver plated aluminum. The compensating screw can be made of a metallic material; or it can be made of a non-metallic material or a metallic material coated or plated with a metallic material. For example, the compensating screw could be made of a composite material that is silver plated. The composite material could have a low coefficient of thermal expansion relative to a metallic screw. The silver plating provides a good electrical conductor. An exterior surface of the screw must be metallic.

Claims

1. A waveguide filter (2) comprising at least one cavity (4), said cavity having a cavity wall (22) with at least

one metallic temperature compensating screw (18) located therein, said compensating screw being mounted on a support (40) made from a material having a higher coefficient of thermal expansion relative to a coefficient of thermal expansion of a material of said screw, said higher coefficient of thermal expansion material being shaped to move the compensating screw further into or further out of said cavity with changes in temperature, thereby at least reducing a change in resonant frequency of the cavity that would otherwise occur as a result of said change in temperature.

2. A waveguide filter as claimed in Claim 1 wherein the material of said support has a substantially higher coefficient of thermal expansion than the coefficient of thermal expansion of the material of said screw.

3. A waveguide filter as claimed in Claim 1 wherein support is adjustable longitudinally relative to the cavity.

4. A waveguide filter as claimed in Claim 3 wherein an RF energy barrier surrounds said compensating screw.

5. A waveguide filter as claimed in Claim 4 wherein said energy barrier (50) is located on said screw near said support to block RF energy from said cavity from travelling into said support.

6. A waveguide filter as claimed in any one of Claims 1, 2 or 3 wherein the filter has a plurality of cavities, with at least two cavities (4, 6) having compensating screws mounted in a support made from a material having a high coefficient of thermal expansion.

7. A waveguide filter as claimed in any one of Claims 1, 2 or 3 wherein the at least one compensating screw is mounted in a side wall (22) of said at least one cavity.

8. A waveguide filter as claimed in any one of Claims 1, 2 or 3 wherein the at least one compensating screw is mounted in an end wall (10) of said at least one cavity.

9. A waveguide filter as claimed in Claim wherein the support (40) is a bushing containing an inner screw thread (42) for receiving said screw and an outer screw thread (44) to affix the bushing to the cavity.

10. A waveguide filter as claimed in any one of Claims 1, 2 or 3 wherein said filter has two modes selected from the group of TE_{11n} and TE_{10n}, where n is a positive integer.

11. A waveguide filter as claimed in any one of Claims 1, 2 or 3 wherein said filter is a triple mode filter having modes selected from the group of TE_{11n}, TE_{10n} and TM_{01m}' where n is a positive integer and m is a positive integer equal to or greater than zero.

12. A method of at least reducing the effect of temperature changes on the resonant frequency of a waveguide filter (2), said filter having at least one cavity (4), said cavity having a temperature compensating screw (18) mounted within a support (40) made from a material having a higher coefficient of thermal expansion relative to a coefficient of thermal expansion of a material of said said, said method comprising adjusting said compensating screw longitudinally in said support, locking said compensating screw in position within said support, installing said compensating screw and support in a wall (22) of said cavity so that said support moves said compensating screw further out of said cavity as temperature increases and further into said cavity as temperature decreases to at least reduce a change in resonant frequency of the cavity that would otherwise occur as a result of said change in temperature.

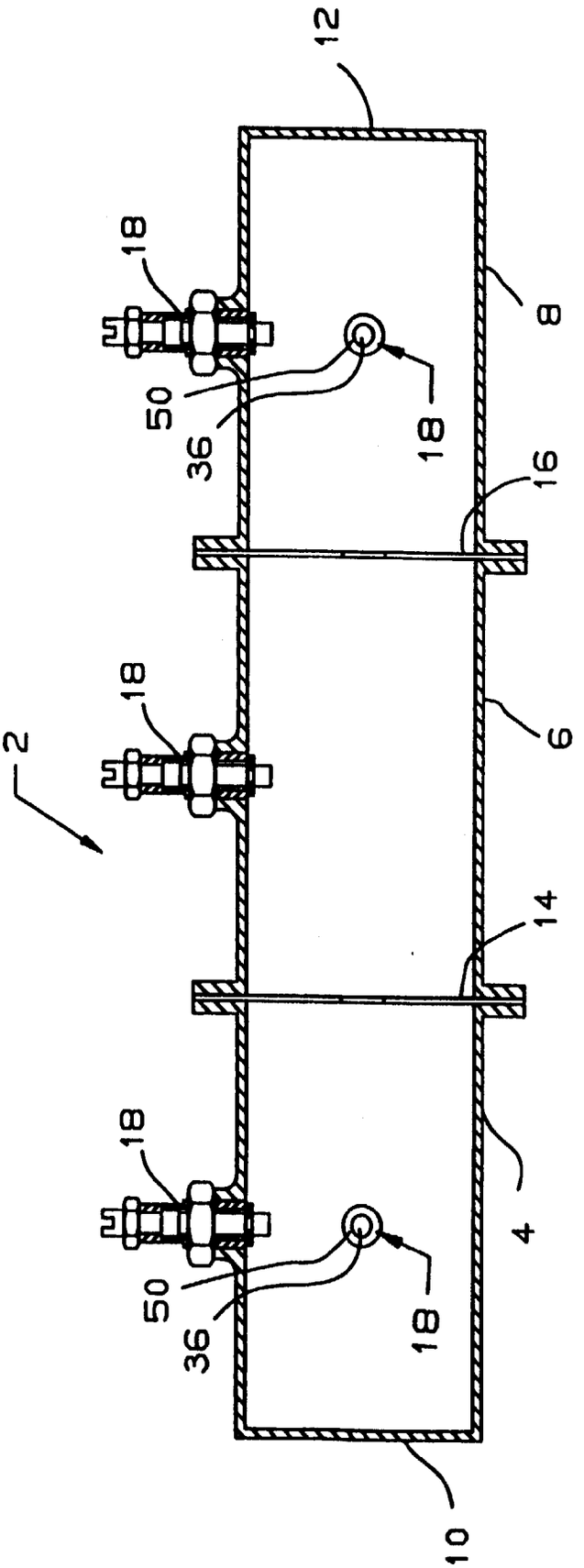


FIGURE 1

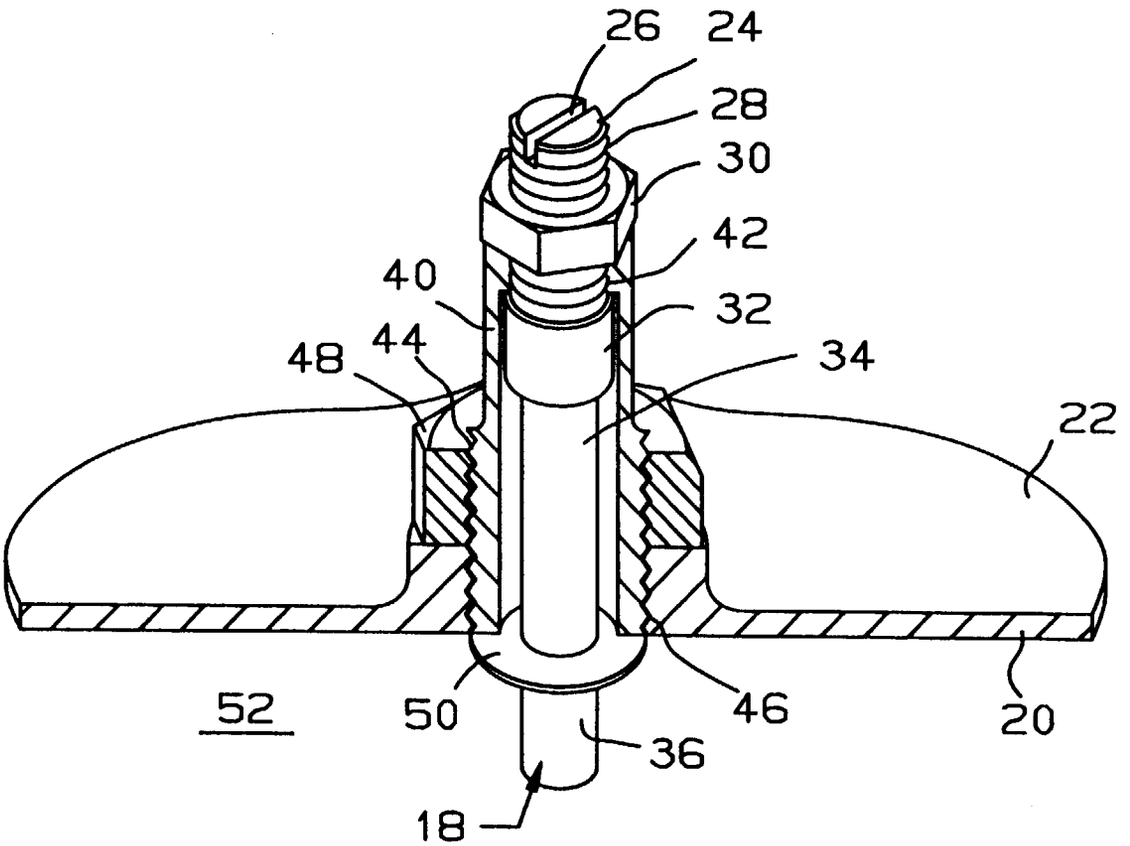


FIGURE 2

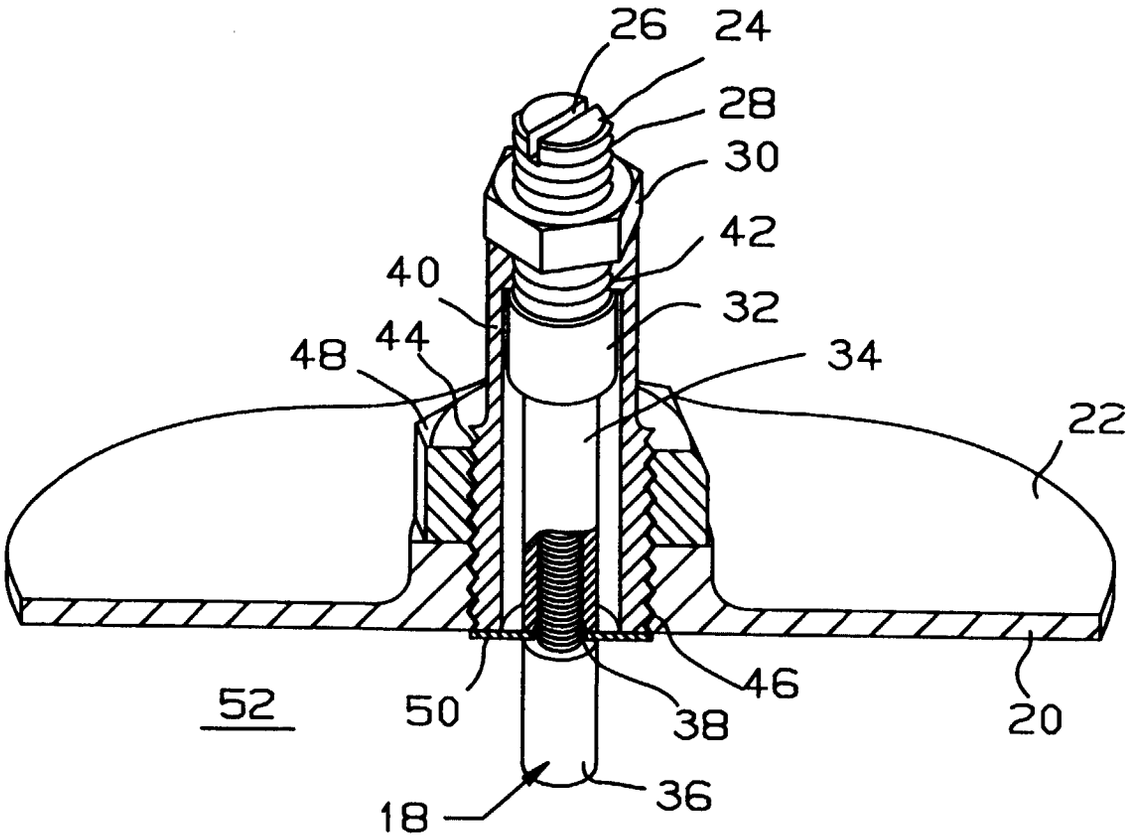


FIGURE 3

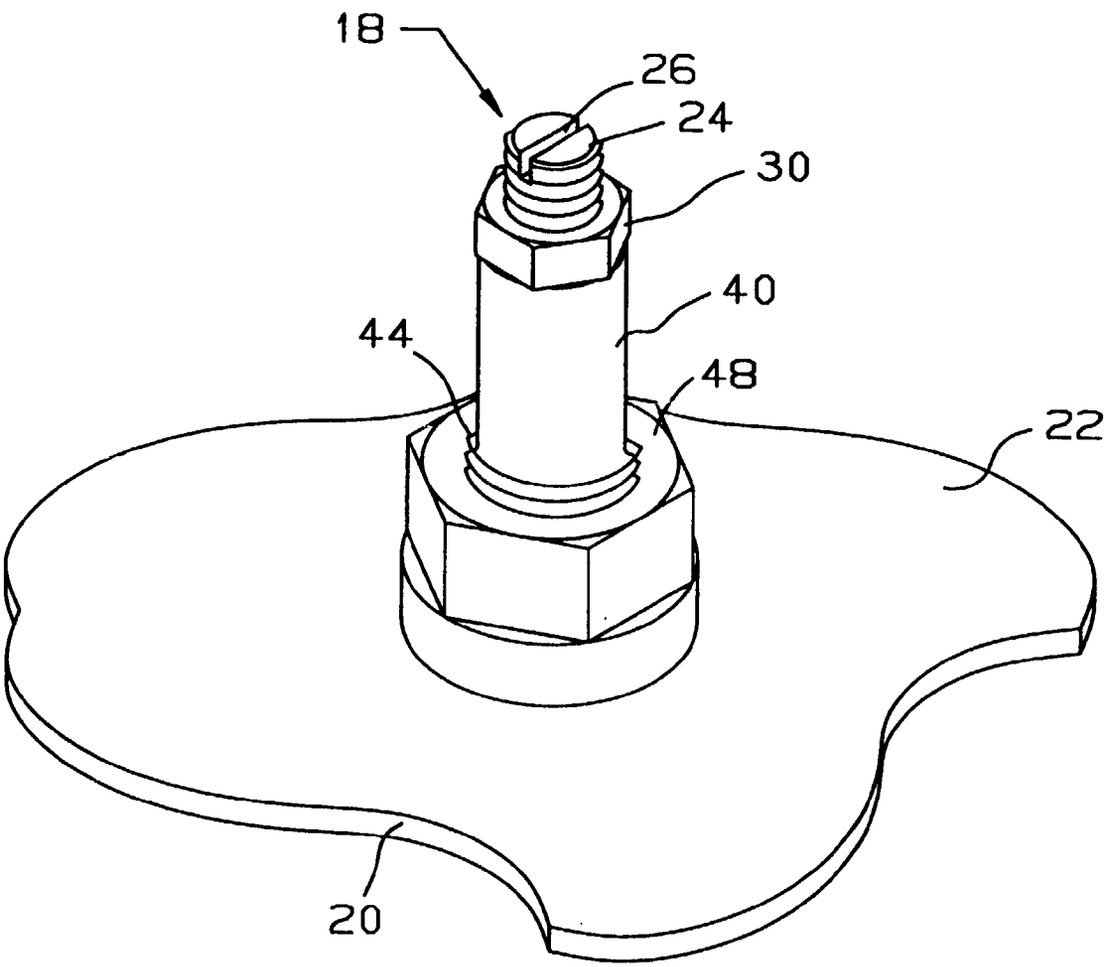


FIGURE 4