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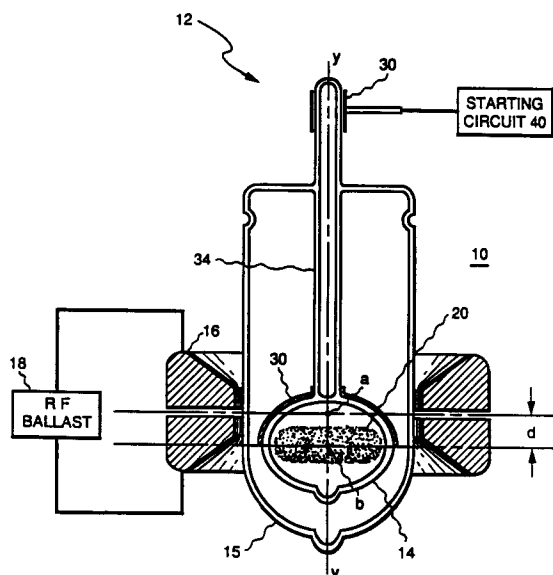
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(54) **High intensity discharge lamp and excitation coil configuration.**

(57) The centroid (a) of the excitation coil of an electrodeless high intensity discharge lamp is offset from the centroid (b) of the arc tube a predetermined distance (d) along a common central axis in order to maximize light output. In a preferred embodiment, i.e., for a lamp configured to direct light downward, the centroid of the excitation coil is situated above the centroid of a spheroidal arc tube; and the upper hemisphere of the arc tube is coated with a reflective coating (30) in order to further maximize light output.



**FIG. 1**

## Field of the Invention

The present invention relates generally to electrodeless high intensity discharge (HID) lamps. More particularly, the present invention relates to an improved HID lamp and excitation coil configuration for maximizing light output.

## Background of the Invention

In a high intensity discharge (HID) lamp, a medium to high pressure ionizable gas, such as mercury or sodium vapor, emits visible radiation upon excitation caused by passage of current through the gas. One class of HID lamps comprises inductively-coupled electrodeless lamps which generate an arc discharge by generating a solenoidal electric field in a high-pressure gaseous lamp fill. In particular, the lamp fill, or discharge plasma, is excited by radio frequency (RF) current in an excitation coil surrounding an arc tube. The arc tube and excitation coil assembly acts essentially as a transformer which couples RF energy to the plasma. That is, the excitation coil acts as a primary coil, and the plasma functions as a single-turn secondary. RF current in the excitation coil produces a time-varying magnetic field, in turn creating an electric field in the plasma which closes completely upon itself, i.e., a solenoidal electric field. Current flows as a result of this electric field, resulting in a toroidal arc discharge in the arc tube.

A practical excitation coil configuration avoids as much light blockage by the coil as possible in order to maximize light output. An exemplary coil configuration is described in commonly assigned U.S. Pat. No. 5,039,903 of G.A. Farrall, issued August 13, 1991 and incorporated by reference herein. However, even though the excitation coil configuration of the Farrall patent is effective in avoiding much light blockage from the lamp, it is desirable to provide a new lamp and coil configuration which increases light output even further.

## Summary of the Invention

The present invention is set forth in Claims 1 and 2.

The centroid of the excitation coil of an electrodeless HID lamp is offset from the centroid of the arc tube a predetermined distance along a common central axis in order to maximize total light output. In a preferred embodiment, i.e., for a lamp configured to direct light downward, the centroid of the excitation coil is situated above the centroid of a spheroidal arc tube; and the upper hemisphere of the arc tube is coated with a reflective coating in order to further maximize light output.

## Brief Description of the Drawings

The features and advantages of the present invention will become apparent from the following detailed description of the invention when read with the accompanying drawing figures in which:

Figure 1 illustrates an electrodeless HID lamp and excitation coil configuration according to the present invention;

Figure 2 illustrates an electrodeless HID lamp and excitation coil configuration according to an alternative embodiment of the present invention; and

Figure 3 illustrates an electrodeless HID lamp and excitation coil configuration according to another alternative embodiment of the present invention

## Detailed Description of the Invention

Figure 1 illustrates an electrodeless HID lamp and excitation coil configuration in accordance with the present invention. As shown, HID lamp 10 includes an arc tube 14 preferably formed of a high temperature glass, such as fused quartz, or an optically transparent or translucent ceramic, such as polycrystalline alumina. Typically, as shown, a light-transmissive envelope 15 surrounds arc tube 14. An excitation coil 16 is disposed about arc tube 14, i.e., outside envelope 15, and is coupled to a radio frequency (RF) ballast 18 for exciting a toroidal arc discharge 20 therein. By way of example, arc tube 14 is shown as having a substantially ellipsoid shape. However, arc tubes of other shapes may be desirable, depending upon the application. For example, arc tube 14 may be spherical or may have the shape of a short cylinder, or "pillbox", having rounded edges, if desired.

Arc tube 14 contains a fill in which an arc discharge having a substantially toroidal shape is excited during lamp operation. A suitable fill is described in U.S. Patent No. 4,810,938 of P.D. Johnson, J.T. Dakin and J.M. Anderson, issued on March 7, 1989, and assigned to the instant assignee. The fill of the Johnson et al. patent comprises a sodium halide, a cerium halide and xenon combined in weight proportions to generate visible radiation exhibiting high efficacy and good color rendering capability at white color temperatures. For example; such a fill according to the Johnson et al. patent may comprise sodium iodide and cerium chloride, in equal weight proportions, in combination with xenon at a partial pressure of about 500 torr. Another suitable fill is described in commonly assigned U.S. Pat. No. 4,972,120 of H.L. Witting, issued November 20, 1990, which patent is incorporated by reference herein. The fill of the

Witting patent comprises a combination of a lanthanum halide, a sodium halide, a cerium halide and xenon or krypton as a buffer gas. For example, a fill according to the Witting patent may comprise a combination of lanthanum iodide, sodium iodide, cerium iodide, and 250 torr partial pressure of xenon.

As illustrated in Figure 1, RF power is applied to the HID lamp by RF ballast 18 via excitation coil 16 coupled thereto. Excitation coil 16 is illustrated as comprising a two-turn coil having a configuration such as that described in U.S. Pat. No. 5,039,903 of G.A. Farrall, cited hereinabove. Such a coil configuration results in very high efficiency and causes minimal light blockage from the lamp. The overall shape of the excitation coil of the Farrall patent is generally that of a surface formed by rotating a bilaterally symmetrical trapezoid about a coil center line situated in the same plane as the trapezoid, but which line does not intersect the trapezoid. However, other suitable coil configurations may be used, such as that described in commonly assigned U.S. Patent no. 4,812,702 of J.M. Anderson, issued March 14, 1989, which patent is incorporated by reference herein. In particular, the Anderson patent describes a coil having six turns which are arranged to have a substantially V-shaped cross section on each side of a coil center line. Another suitable excitation coil may be of solenoidal shape, for example. Still another suitable excitation coil may be of a spiral type which conforms to, but is spaced apart from, at least a portion of the arc tube.

In operation, RF current in coil 16 results in a time-varying magnetic field which produces within arc tube 14 an electric field that completely closes upon itself. Current flows through the fill within arc tube 14 as a result of this solenoidal electric field, producing toroidal arc discharge 20 therein. Suitable operating frequencies for RF ballast 18 are in the range from 0.1 to 300 megahertz (MHz), exemplary operating frequencies being 6.78 MHz and 13.56 MHz.

In accordance with the present invention, the centroid *a* of the excitation coil of the electrodeless HID lamp is offset from the centroid *b* of the arc tube a predetermined distance *d* along a common central axis Y-Y. As shown, in a preferred embodiment, the centroid *a* of the excitation coil is situated above the centroid *b* of a spheroidal arc tube. Furthermore, a reflective coating 30 is preferably disposed on the outer surface of the upper hemisphere of arc tube 14 in order to further maximize light output. As described in European patent application, Serial No. 92310081.2 (docket no. LD-10,184), such a reflective coating is disposed on a portion of the arc tube nearest the excitation coil so that light that would otherwise be blocked thereby

is usefully directed out of the arc tube. Such a reflective coating preferably covers between approximately 30% and 70% of the arc tube. Moreover, such a reflective coating is comprised of one or more electrically insulating materials, preferably one or more refractory insulating materials, such as alumina, silica, zirconia, titania, magnesia and tantalum.

The lamp and excitation coil configuration of the present invention results in an increased total light output as well as a higher forward lumen ratio, i.e., ratio of forward light output by the lower hemisphere of the arc tube to total light output from the lamp. By way of example, for an HID lamp and excitation coil configured as shown in Figure 1 with an arc tube having an outer diameter of approximately 26 mm and a height of approximately 19 mm, the total light output and the forward lumen ratio increased for a displacement *d* in the range from approximately 3 to 6 millimeters, resulting from a reduction in the direct light incident on the surface of the excitation coil. However, further displacement of the coil resulted in a decrease in light output due to the reduced coupling efficiency between the arc tube and the excitation coil. Hence, for the lamp shown in the Figure 1, there is an optimum range of displacement of the coil with respect to the arc tube.

In one alternative embodiment, as illustrated in Figure 2, excitation coil 16 is offset from the arc tube by a distance *d'* such that the excitation coil does not cover any of the uncoated portion of the arc tube. In this way, substantially no light is absorbed by the excitation coil.

In still other alternative embodiments, a coated or uncoated arc tube may be employed in conjunction with suitable reflectors and/or refractors. For example, as illustrated in Figure 3, an electrodeless HID lamp and excitation coil configured according to the present invention are employed as the light source for a luminaire 40. As shown, luminaire 40 includes a cup-shaped enclosure 42 having an open end 44 through which light is transmitted. A bowl-shaped refractor 46 is mounted over open end 44. As described in European patent application no. 92310081.2 (docket no. LD-10,184), cited hereinabove, such a refractor may have a prismatic outer surface for directing light from the lamp to desired locations beneath the luminaire. In Figure 3, luminaire 40 is also illustrated as including a reflective partition 48 for reflecting spill light.

Although the centroid of the excitation coil has been illustrated as being situated above the centroid of the arc tube, it is to be understood that the centroid of the excitation coil may be situated below the centroid of the arc tube, depending upon the particular application and the particular reflector/refractor configurations employed. Further-

more, other arc tube shapes may be used, if desired, with the centroid of the excitation coil being offset from the centroid of the arc tube in order to maximize light output in accordance with the present invention.

While the preferred embodiments of the present invention have been shown and described herein, it will be obvious that such embodiments are provided by way of example only. Numerous variations, changes and substitutions will occur to those of skill in the art without departing from the invention herein. Accordingly, it is intended that the invention be limited only by the scope of the appended claims.

### Claims

1. An improved electrodeless high intensity discharge lamp of the type comprising an excitation coil situated about an arc tube for exciting an arc discharge in an ionizable fill contained in said arc tube, wherein the improvement comprises:
  - offsetting the centroid of said excitation coil from the centroid of said arc tube a predetermined distance along a common central axis in order to maximize light output from said lamp.
2. An electrodeless high intensity discharge lamp, comprising:
  - an arc tube for containing an ionizable fill; and
  - an excitation coil disposed about said arc tube for coupling to a radio frequency power supply for exciting an arc discharge in said fill, the centroid of said excitation coil being offset a predetermined distance along a common central axis from the centroid of said arc tube in order to maximize light output from said lamp.
3. The lamp of claim 2, further comprising an outer envelope surrounding said arc tube, said outer envelope being disposed between said arc tube and said excitation coil.
4. The lamp of claim 1 or 2, further comprising a reflective coating disposed on a portion of said arc tube.
5. The lamp of claim 4 wherein said distance is determined such that said excitation coil is situated about the coated portion of said arc tube.
6. The lamp of claim 4 wherein the centroid of said excitation coil is situated above the centroid of said arc tube, said reflective coating being disposed on the upper portion of said arc tube.
7. The lamp of claim 6 wherein said excitation coil is situated about the upper, coated portion of said arc tube.
8. The lamp of claim 4 wherein said reflective coating covers approximately 30% to 70% of said arc tube.
9. The lamp of claim 4 wherein said reflective coating is comprised of a material selected from the group consisting of alumina, silica, zirconia, titania, magnesia, tantalum, and combinations thereof.
10. The lamp of claim 4, further comprising light redirecting means for receiving light reflected from said reflective coating and redirecting said light to control the distribution of light output from said lamp.

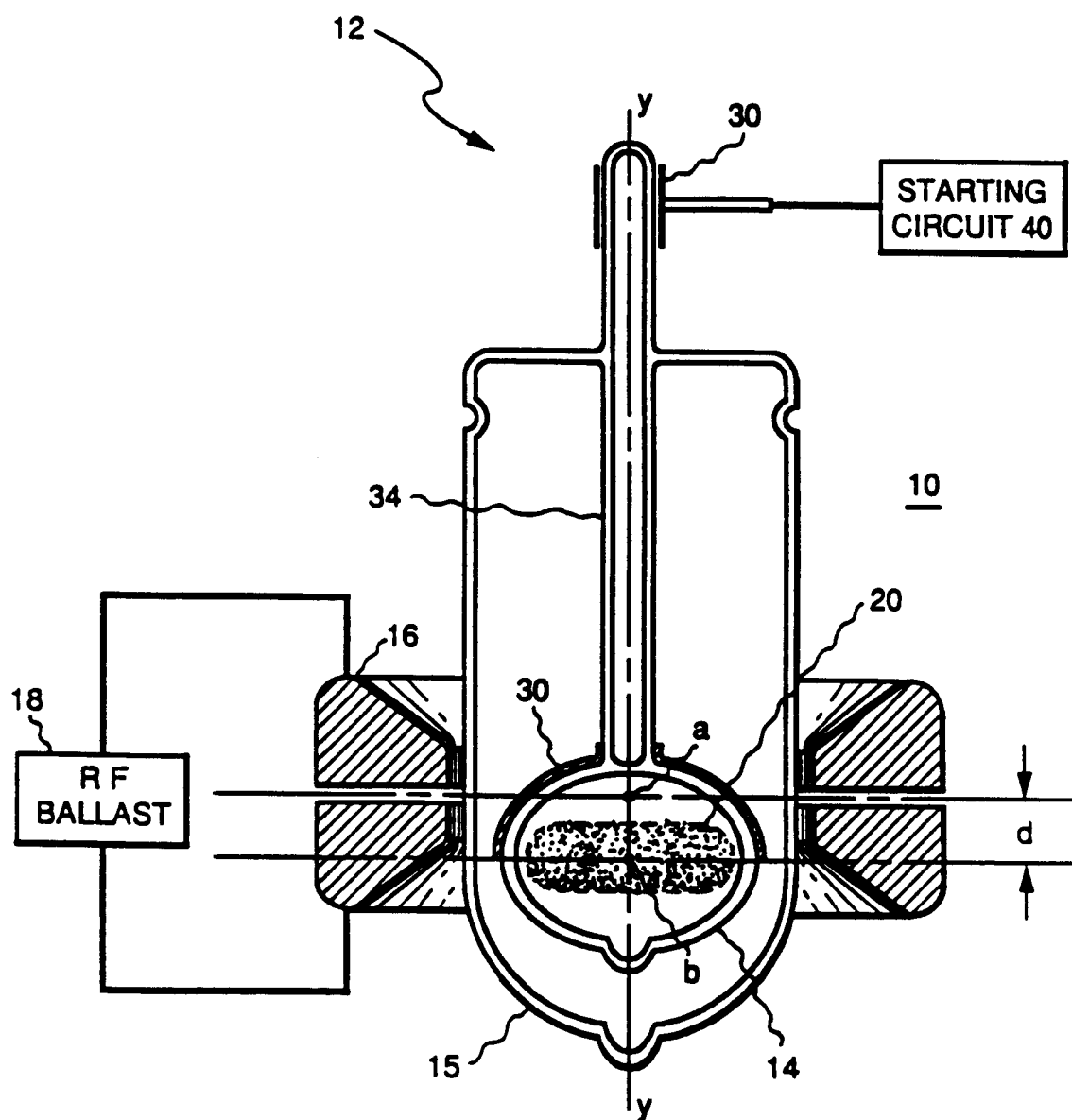


FIG. 1

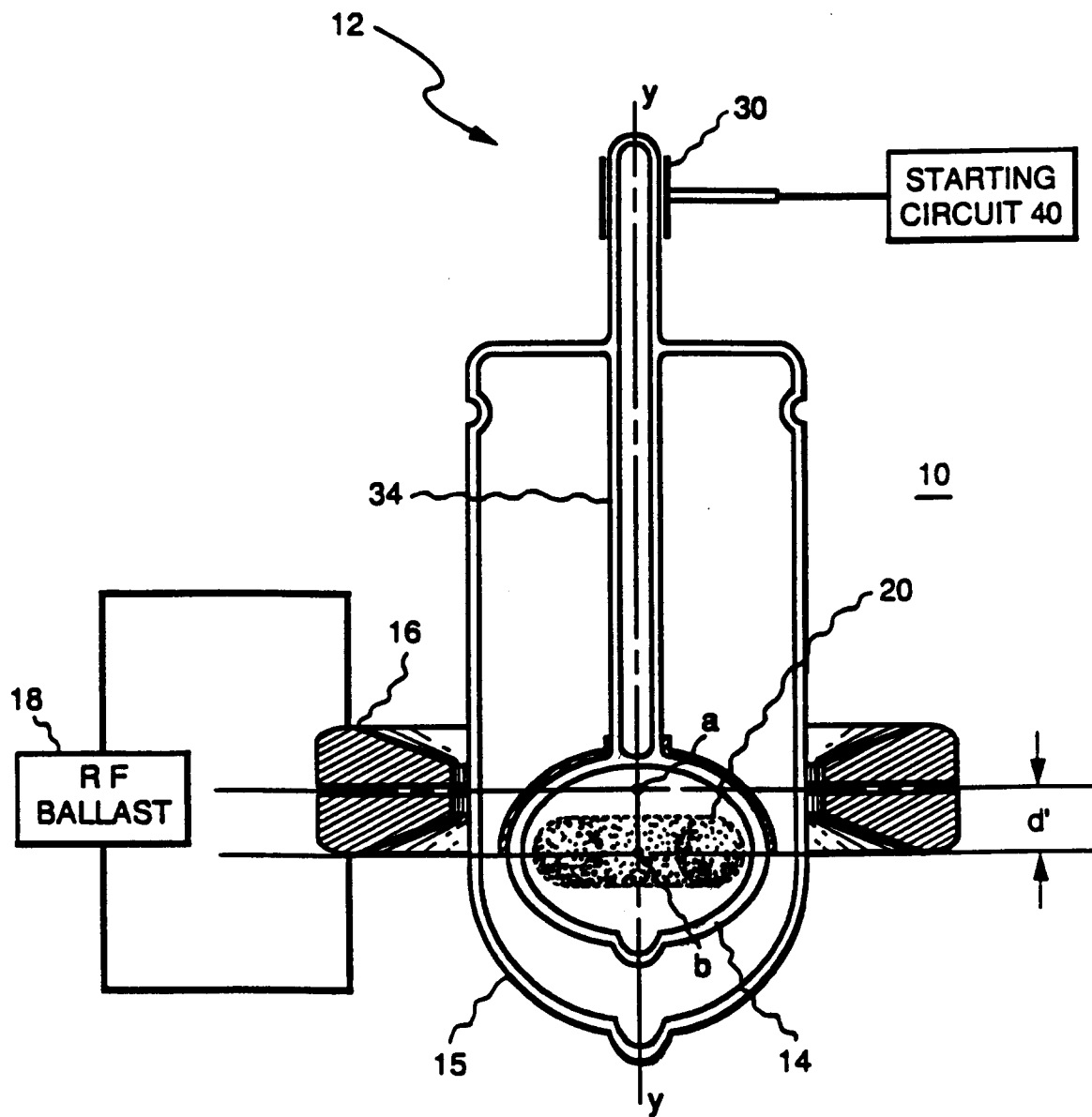


FIG. 2

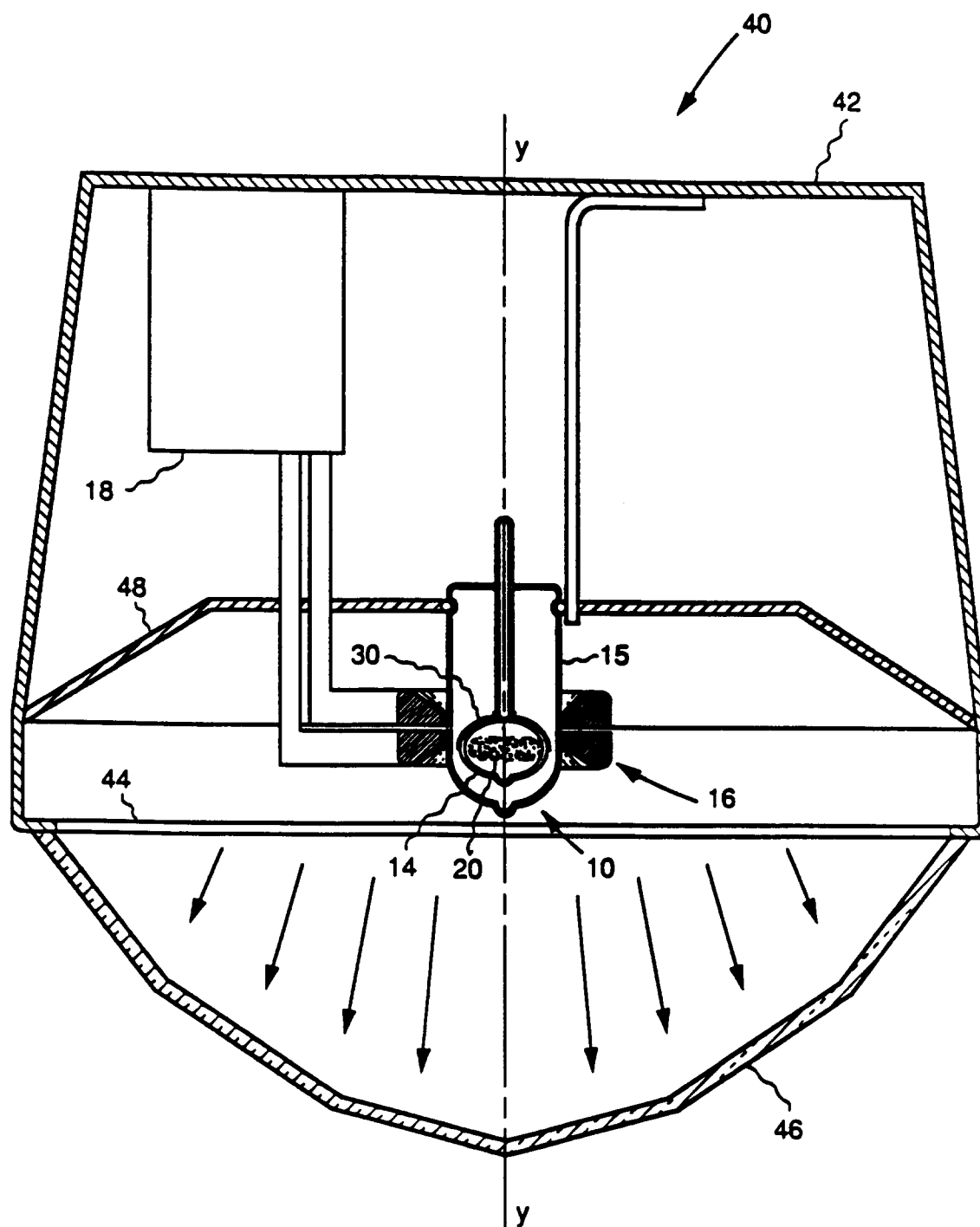


FIG. 3



European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number

EP 92 31 1529

| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                     |                                                   |                                               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|-----------------------------------------------|
| Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Citation of document with indication, where appropriate, of relevant passages                                                                       | Relevant to claim                                 | CLASSIFICATION OF THE APPLICATION (Int. Cl.5) |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | US-A-4 803 404 (ANDERSON)<br>* column 3, line 46 - column 4, line 15;<br>figure 4 *                                                                 | 1,2                                               | H01J65/04                                     |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | ---<br>EP-A-0 458 545 (GENERAL ELECTRIC COMPANY)<br>* column 7, line 18 - line 39; figure 2 *                                                       | 1-3                                               |                                               |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | ---<br>PATENT ABSTRACTS OF JAPAN<br>vol. 14, no. 142 (E-904)16 March 1990<br>& JP-A-02 007 352 ( MATSUSHITA ELECTRIC<br>WORKS LTD )<br>* abstract * | 1-4                                               |                                               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                     |                                                   | -----                                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                     |                                                   | TECHNICAL FIELDS<br>SEARCHED (Int. Cl.5)      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                     |                                                   | H01J                                          |
| The present search report has been drawn up for all claims                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                     |                                                   |                                               |
| Place of search<br>THE HAGUE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                     | Date of completion of the search<br>06 APRIL 1993 | Examiner<br>SCHAUB G.G.                       |
| <b>CATEGORY OF CITED DOCUMENTS</b><br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document<br>T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>.....<br>& : member of the same patent family, corresponding document |                                                                                                                                                     |                                                   |                                               |