UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Ex parte NOBUHIKO OTA, TOSHIKAZU HAMAO, and YOSHIFUSA TSUBONE

Appeal 2008-1493
Application 10/471,180
Technology Center 2800

Decided: August 8, 2008

Before JOHN C. MARTIN, JOSEPH F. RUGGIERO, and MARK NAGUMO, *Administrative Patent Judges.*

MARTIN, *Administrative Patent Judge.*

DECISION ON APPEAL

STATEMENT OF THE CASE

This is an appeal under 35 U.S.C. § 134(a) from the Examiner's rejection of claims 1-4 under 35 U.S.C. § 103(a).

We have jurisdiction under 35 U.S.C. § 6(b).

We AFFIRM.

A. Appellants' invention and the admitted prior art

Appellants' invention is an improvement of vacuum motors employing resin materials that experience outgassing and thereby contaminate the vacuum environment (Abstract, Specification 11:1-6). Appellants reduce the rate of outgassing by applying an inorganic film, such as a metal, to the exposed parts of resin material (*id*. at 11:7-13).

Figures 9 and 10 are reproduced below.

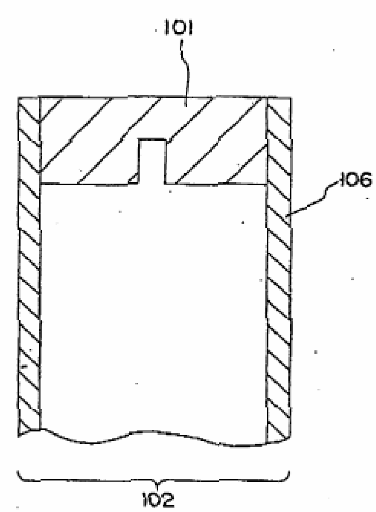


Fig. 9

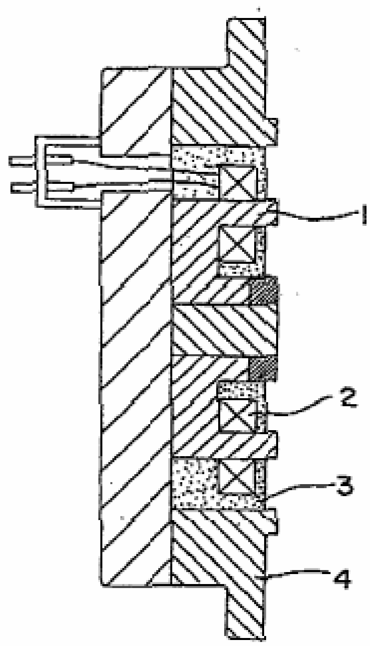


Fig. 10

Figures 9 and 10 depict prior-art vacuum motor structures.

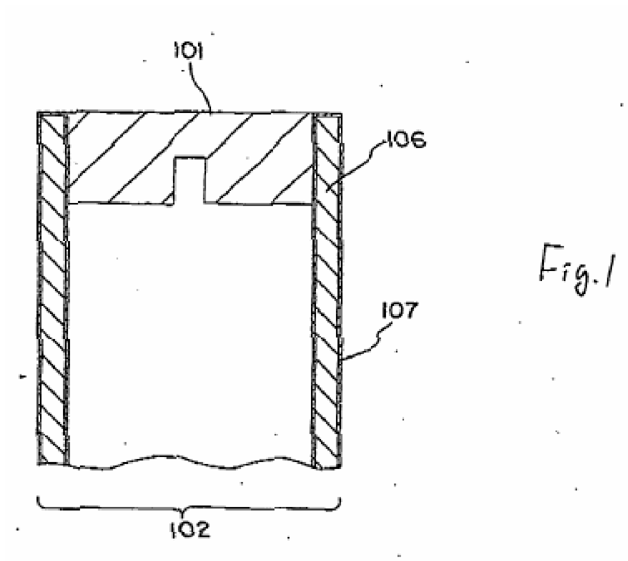
Figure 9 is a partial, sectional view of a conventional can structure 102 for use in a linear motor (Specification 1:15-22). The can structure includes a housing 101 and a resin plates 106. Figure 10 is a sectional side view of a portion of a conventional axial gap motor (*id*. at 1:33-34). The depicted structure includes a stator core 1, a coil 2, a mold resin 3, and a stator housing 4 (*id*. at 1:35 to 2:1).

Exposing the resin materials to a vacuum causes organic gases to be released, preventing the target pressure from being reached (*id*. at 2:6-8, 23-25) and contaminating the vacuum environment, including any silicon wafers contained therein (*id*. at 8-10 and 26-28).

One prior-art solution to the above outgassing problem has been to cover the resin material with a metallic can (*id*. at 2:11-13 and 29-30). Although this metallic can structure reduces outgassing, eddy currents generated therein reduce the efficiency of the motor and this can structure is difficult to manufacture, increasing production costs (*id*. at 2:30-34).

Appellants' solution to the outgassing problem is to cover the exposed surfaces of the resin material with a thin film of inorganic material.

Appellants' Figures 1 and 2 are reproduced below.



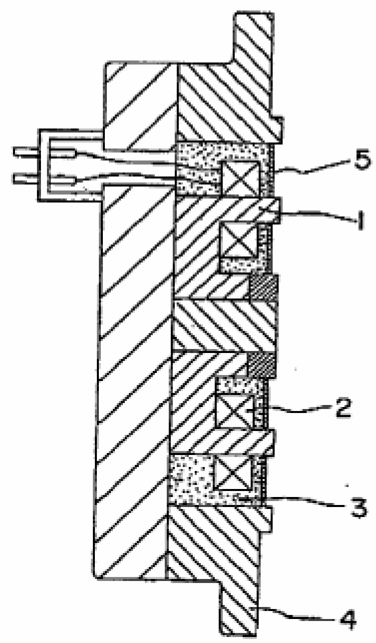


Fig. 2

Figures 1 and 2 show Appellants' invention applied to the prior-art motor structures depicted in Figures 9 and 10, respectively.

Figure 1 shows the surfaces of resin plate 106 covered with an inorganic coating 107, while Figure 2 shows the surfaces of resin molds 3 covered with an inorganic film 5 (*id*. at 6:3-21). In a first embodiment, the inorganic film is a metal film, such as an electroless nickel plating film having a thickness from 0.5 µm to 50 µm (*id*. at 6:24-25 and 31-33). As a means for providing a film 5 of a metal, it is also possible to use a method such as a hot dipping method, a vacuum evaporation method, or a thermal spraying method in addition to the electroless plating (*id*. at 7:26-29). Moreover, it is possible to use aluminum, copper, gold, or silver in addition to nickel for the material of the metal (*id*. at 7:29-31).

In a second embodiment, the inorganic film is a ceramics film, such as a titanium nitride (TiN) film formed by an ion plating treatment (*id*. at 7:33-34) with a thickness from 0.5 μm to 50 μm (*id*. at 8:5-6). As a means for providing a film of ceramics, it is also possible to use a method such as a sol-gel method, a plasma CVD method, or a thermal spraying method in addition to the ion plating treatment (*id*. at 8:35 to 9:2). Moreover, it is also possible to use silicon dioxide (SiO_2), alumina (Al_2O_3) or diamond-like carbon (DLC) in addition to the TiN for the metal or the ceramics (*id*. at 9:2-4).

B. The claims

Claims 1 and 2, the only independent claims, read as follows:

> 1. A linear motor for a vacuum use having a can enclosing at least a coil used for a stator or a movable member, said can being formed of a resin, wherein at least a part of a surface of the resin of the can is covered with an inorganic film.
>
> 2. A motor for a vacuum use having a coil used for a stator is molded with a resin, wherein a surface to be exposed to a vacuum atmosphere of the resin is covered with an inorganic film.

C. The references and rejections

The rejections are based on the following prior art:

The admitted prior art depicted in Appellants' Figures 9 and 10 and described at pages 1 and 2 of the Specification ("admitted prior art").

Xia et al. ("Xia")	5,963,840	Oct. 5, 1999

Gabrys et al. ("Gabrys") 6,798,092 B1 Sep. 28, 2004

Gabrys issued from nonprovisional Application 09/976,506, which was filed on October 12, 2001, subsequent to the March 31, 2001, filing date of Appellants' Japanese priority document JP-2001-70899, of which Appellants have been the accorded benefit under 35 U.S.C. § 119(a) by the Examiner (Suppl. Answer[1] 2).

Gabrys explains that it "is related to U.S. Provisional Application No. 60/241,575"[2] (Gabrys, col. 1, ll. 4-5). The Examiner accorded the subject matter relied on in Gabrys a § 102(e)(2) date of October 12, 2000, the filing date of the Provisional Application (Suppl. Answer 2).

Claims 1-3 stand rejected under 35 U.S.C. § 103(a) for obviousness over the admitted prior art in view of Gabrys.

Claim 4 stands rejected under 35 U.S.C. § 103(a) for obviousness over the admitted prior art in view of Gabrys and Xia.

Appellants separately argue the merits of only independent claims 1 and 2.

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[1] References herein to the Supplemental Answer are to the August 1, 2007, Supplemental Examiner's Answer, which repeats the Examiner's position as stated in the February 13, 2007, Supplemental Examiner's Answer. References to the Reply Brief are to the April 6, 2007, Reply Brief Pursuant to 37 C.F.R § 41.41, which is effectively incorporated by reference into the September 28, 2007, Response to the Supplemental Examiner's Answer.

THE ISSUES[3]

1. Does the subject matter relied on by the Examiner in Gabrys have support in the Provisional Application?[4]

2. Is the subject matter relied on in Gabrys analogous art?

3. Would the claimed subject matter have been obvious over the admitted prior art in view of Gabrys (to the extent supported by the Provisional Application)?

ISSUE 1: DOES THE SUBJECT MATTER RELIED ON BY THE EXAMINER IN GABRYS HAVE SUPPORT IN THE PROVISIONAL APPLICATION?

A. Principles of law

As correctly noted by Appellants, "In order to rely on the filing date for the parent '575 provisional application, it needs to provide support for the teaching for which Gabrys is relied upon" (Br. 9).

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[2] A copy of the Provisional Application is enclosed.

[3] Appellants have the burden on appeal to this Board to show reversible error by the Examiner in maintaining the rejection. *See In re Kahn*, 441 F.3d 977, 985-86 (Fed. Cir. 2006) ("On appeal to the Board, an applicant can overcome a rejection by showing insufficient evidence of *prima facie* obviousness or by rebutting the *prima facie* case with evidence of secondary indicia of nonobviousness.") (quoting *In re Rouffet*, 149 F.3d 1350, 1355 (Fed. Cir. 1998)).

[4] Referred to in Appellants' briefs as "Gabrys '575."

> The 35 U.S.C. 102(e) critical reference date of a U.S. patent or U.S. application publications and certain international application publications entitled to the benefit of the filing date of a provisional application under 35 U.S.C. 119(e) is the filing date of the provisional application with certain exceptions if the provisional application(s) properly supports the subject matter relied upon to make the rejection in compliance with 35 U.S.C. 112, first paragraph.

MPEP § 2136.03 (III) (8th ed., rev. 6, Sept. 2007).

B. Analysis

The Examiner has indicated that Gabrys is not being relied upon for subject matter found in the admitted prior art. *See* Answer 4 ("Regarding claims 1-3, the applicant's admitted of [sic] prior art shows all of the limitations of the claimed invention except for the surface of the resin being covered with an inorganic film selected from nickel, aluminum, and copper.").

As explained above, the admitted prior art depicted in part in Appellants' Figure 9 and described at page 1, lines 15-29, includes a conventional can 102 for use in a conventional linear motor (Specification 1:19-22). Appellant does not deny that a conventional can used in a conventional linear motor encloses a coil for a stator or a movable member, as recited in claim 1. As a result, the only language of claim 1 that is not satisfied by the admitted prior art is: "wherein at least a part of a surface of the resin of the can is covered with an inorganic film." Similarly, the admitted prior art depicted in Appellants' Figure 10 and described at page 1, line 30 to page 2, line 10, satisfies the following language of claim 2: "A motor for a vacuum use having a coil used for a stator is molded with a resin," with the result that the only unsatisfied claim 2 language is: "wherein a surface to be exposed to a vacuum atmosphere of the resin is covered with an inorganic film."

The Examiner relies on Gabrys only for its teaching of "us[ing] aluminum to cover the surface of resin for the purpose of preventing outgas problem in a vacuum environment." Answer 4. *See also id*. at 5 ("Gabrys et al. does not have to show the motor that has a can because the applicant's admitted of [sic] prior art already shows it in Figure 9.").

At page 5 of the Answer and pages 2-3 of the Supplemental Answer, the Examiner identified the page and line numbers and the figure being relied on in Gabrys and the page and line numbers of the allegedly supporting material in the Provisional Application. Although Appellants argue that "the Examiner is believed to be incorrect in his position that Gabrys' patent 6,798,092 is supported by Provisional Application No. 60/241,575" (Reply to Suppl. Answer 4), Appellants do not explain which material relied on by the Examiner in Gabrys lacks support in the Provisional Application. Instead, Appellants compare the claims to the subject matter of the Provisional Application and argue that the claimed subject matter would have been unobvious over the admitted prior art in view of the Provisional Application (Br. 9-12), thereby treating the Provisional Application as representative of all of the subject matter in

Gabrys on which the Examiner is permitted to rely.[5] We will likewise treat the rejection as though it is based on the admitted prior art in view of the Provisional Application.

ISSUE 2: IS THE SUBJECT MATTER RELIED ON IN GABRYS ANALOGOUS ART?

A. Principles of law

As explained in *In re Kahn*, 441 F.3d 977 (Fed. Cir. 2006),

> [t]he analogous-art test requires that the Board show that a reference is either in the field of the applicant's endeavor or is reasonably pertinent to the problem with which the inventor was concerned in order to rely on that reference as a basis for rejection. *In re Oetiker*, 977 F.2d 1443, 1447 [24 USPQ2d 1443] (Fed. Cir. 1992). References are selected as being reasonably pertinent to the problem based on the judgment of a person having ordinary skill in the art. *Id*. ("[I]t is necessary to consider 'the reality of the circumstances,'—in other words, common sense—in deciding in which fields a person of ordinary skill would reasonably be expected to look for a solution to the problem facing the inventor." (quoting *In re Wood*, 599 F.2d 1032, 1036 [202 USPQ 171] (C.C.P.A. 1979))).

Kahn, 441 F.3d at 986-87. *See also In re Clay*, 966 F.2d 656, 659 (Fed. Cir. 1992) ("[a] reference is reasonably pertinent if, even though it may be in a different field from that of the inventor's endeavor, it is one which, because

[5] In thus relying on the Provisional Application, Appellants effectively concede that all of its relevant subject matter was carried forward into Gabrys.

of the matter with which it deals, logically would have commended itself to an inventor's attention in considering his problem.").

B. Analysis

The Provisional Application discloses a solution to outgassing problems experienced by vacuum-encapsulated flywheel uninterruptable power supplies, which includes a "motor generator" having a "motor portion" that converts electrical energy into mechanical energy by spinning up the flywheel 40 and a "generator portion" that converts the mechanical energy back into electrical energy by spinning down the flywheel 40 (Provisional Application 2:16-22). Such power supplies experience problems with gas desorption (i.e., outgassing):

> One of the most challenging problems associated with the production of vacuum-encapsulated flywheel uninterruptible power supplies is how to maintain a specific pressure over the lifetime of the system. The problem stems from the fact that all materials desorb gas, albeit different gas species at different rates. Since all materials desorb gas, the question of how to maintain a specific pressure devolves into a question of how to minimize the rate of gas desorption. Plastics used on electrical wires and in composite and varnishes used on magnet wires and motor laminations desorb gas at rates several orders of magnitude faster than metallic components used within the uninterruptible power supply. In addition, plastics and varnishes can also desorb gas species, such as aliphatic hydrocarbons, that are difficult to adsorb or absorb with a getter pump. Historically, electrical and magnet wire have been coated with enamel and motor and generator laminations have been produced using vacuum impregnation techniques to

> minimize gas desorption. These techniques, however, are costly, while only modestly effective.

Id. at 1:10-22. Appellants concede that the above-mentioned "plastics used on electrical wires" are "resins." *See* Br. 11 ("The only mention of a resin in Gabrys '575 relates to the use of plastics in wires (see page 1, line 15 of Gabrys).").

Appellants argue that "the present invention and the admitted prior art are related to canned motors, a completely non-analogous art compared to the field of vacuum-encapsulated flywheels" (Br. 12). This argument is unconvincing because it addresses only one of the two inquires that make up the test for analogous art. Even assuming for the sake of argument that vacuum-encapsulated flywheel power supplies are not in the same field of endeavor as the admitted prior art or Appellants' invention, Appellants have not explained why a patent explaining how to reduce outgassing in a vacuum-encapsulated flywheel power supply employing motor generators would not have been considered to be reasonably pertinent to the problem with which the inventor was concerned, which is how to reduce outgassing in resins used in motors that operate in vacuum environments.

ISSUE 3: WOULD THE CLAIMED SUBJECT MATTER HAVE BEEN OBVIOUS OVER THE ADMITTED PRIOR ART IN VIEW OF GABRYS?

A. Principles of law

"[T]he examiner bears the initial burden, on review of the prior art or on any other ground, of presenting a *prima facie* case of unpatentability." *In re Oetiker*, 977 F.2d 1443, 1445 (Fed. Cir. 1992). A rejection under 35 U.S.C. § 103(a) must be based on the following factual determinations: (1) the scope and content of the prior art; (2) the level of ordinary skill in the art; (3) the differences between the claimed invention and the prior art; and (4) any objective indicia of non-obviousness. *DyStar Textilfarben GmbH & Co. Deutschland KG v. C.H. Patrick Co.*, 464 F.3d 1356, 1360 (Fed. Cir. 2006) (citing *Graham v. John Deere Co*., 383 U.S. 1, 17 (1966)).

"The combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results." *Leapfrog Enter., Inc. v. Fisher-Price, Inc.*, 485 F.3d 1157, 1161 (Fed. Cir. 2007) (quoting *KSR Int'l Co. v. Teleflex, Inc.*, 127 S. Ct. 1727, 1739 (2007)). Discussing the obviousness of claimed combinations of elements of prior art, *KSR* explains:

> When a work is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a person of ordinary skill can implement a predictable variation, §103 likely bars its patentability. For the same reason, if a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar

> devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill. *Sakraida* [*v. AG Pro, Inc.*, 425 U.S. 273 (1976)] and *Anderson's-Black Rock*[*, Inc. v. Pavement Salvage Co*., 396 U.S. 57 (1969)] are illustrative—a court must ask whether the improvement is more than the predictable use of prior art elements according to their established functions.

KSR, 127 S. Ct. at 1740. If the claimed subject matter "involve[s] more than the simple substitution of one known element for another or the mere application of a known technique to a piece of prior art ready for the improvement," *id*.,

> it will be necessary . . . to look to interrelated teachings of multiple patents; the effects of demands known to the design community or present in the marketplace; and the background knowledge possessed by a person having ordinary skill in the art, all in order to determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue.

Id. at 1740-41. "To facilitate review, this analysis should be made explicit." *Id*. at 1741. That is, "there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness." *Id*. (quoting *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006)). *See also PharmaStem Therapeutics Inc. v. Viacell Inc*., 491 F.3d 1342, 1360 (Fed. Cir. 2007) (proponent of obviousness based on combination of references must show "that a person of ordinary skill in the art would have had reason to attempt to make the composition or device, or carry out the claimed process, and would have had a reasonable expectation of success in doing so.") (citations omitted).

The rationale for combining reference teachings is not limited to the problem the patentee was trying to solve: "any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed." *In re Icon Health and Fitness Inc.*, 496 F.3d 1374, 1380 (Fed. Cir. 2007) (quoting *KSR*, 127 S. Ct. at 1742).

Also, a rationale for combining or modifying reference teachings can be based on common knowledge or common sense rather than coming from the references themselves. "[T]he [obviousness] analysis need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court can take account of the inferences and creative steps that a person of ordinary skill in the art would employ." *KSR*, 127 S. Ct. at 1741.

Furthermore, a reference may be understood by the artisan to be suggesting a solution to a problem that the reference does not discuss. *See KSR*, 127 S. Ct. at 1742 ("The second error of the Court of Appeals lay in its assumption that a person of ordinary skill attempting to solve a problem will be led only to those elements of prior art designed to solve the same problem. . . . Common sense teaches . . . that familiar items may have obvious uses beyond their primary purposes, and in many cases a person of ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle. . . . A person of ordinary skill is also a person of ordinary creativity, not an automaton.”).

B. Analysis

As a solution to the problem of outgassing from the materials used in vacuum-encapsulated flywheel power supplies, the Provisional Application discloses using vapor deposition to apply a thin layer of coating material, such as aluminum, to the surfaces of the outgassing components of the motor/generator (Provisional Application 1:31-32; 2:39-40). The coating operation can be achieved in either of two ways. The first, depicted in Figure 1, is to coat the surfaces of all of the components *in situ*, such as by using a high current to resistance heat and vaporize the coating material 71 (*id*. at 2:6, 38-40; 3:17-19).[6] The second technique, depicted in Figure 2 (on which the Examiner relies -- *see* Answer 5), is to use a vacuum chamber 31 to coat individual components 44 prior to assembly of the power supply (*id*. at 3:41-42). The components to be coated are the “[c]omponents that have substantial rates of gas desorption or desorb gas species that are difficult to absorb with a getter pump, such as the motor, generator, magnets, magnetic bearing laminations, magnet wires or the flywheel 40” (*id*. at 3:41-45).

[6] “Rather than use the preferred thermal evaporation technique described above, the components can be negatively biased, a reactant gas (e.g. N_2, O_2, CH_4, C_2H_2) can be used and the coating material 71 can be vaporized using an electron beam, magnetic sputtering, anodic arc or other
(Continued on next page.)

Appellants do not deny that a coating applied by vapor deposition in the foregoing manner constitutes an "inorganic film," as required by the claims.

The Examiner concluded that it would have been obvious in view of Gabrys to use a vapor deposition apparatus like that depicted in Figure 2 of the Provisional Application to coat the resin in the admitted prior art with an aluminum film for the purpose of "preventing" outgassing from the resin (Answer 4).

Appellants have not pointed out any reversible error in the Examiner's reasoning. Appellants criticize the Provisional Application on the ground that

> there is no teaching related to a motor/linear motor that has a can. Further, there is no teaching related to a can that is made of resin as in claim 1 or a motor whose stator is molded with resin as in claim 2. The only mention of a resin in [the Provisional Application] relates to the use of plastics in wires (see page 1, line 15 of [the Provisional Application]). However, there is no mention of any component of the uninterrupted power supply as being made of resin. Specifically, even if the flywheel arrangement is construed to be a motor, it is not disclosed to have a stator coil that is enclosed in a can made of a resin or a stator coil that is itself molded with resin.

Br. 11. This argument is unresponsive to the rejection, which relies on the admitted prior art as teaching a "can formed of resin" (claim 1) and a "stator molded with a resin" (claim 2) and also as teaching that these resins were

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source" (Provisional Application 5:14-17).

recognized to be sources of outgassing. The Provisional Application is relied on only for its teaching that outgassing problems with materials used in a vacuum atmosphere, including materials in motors and generators, can be reduced by application of a protective film, such as an aluminum film, which is an inorganic film. The artisan would have recognized that this solution is applicable to any sources of outgassing, including the resins used in the admitted prior art. In fact, as noted above, Appellants have conceded that the "plastics on electrical wires" described in the Provisional Application as a source of "desorption gas" are resins (Br. 11).

Appellants also argue that

> [a] skilled artisan would not have been able to practice the present invention, as recited in claims 1 and 2, from the combined teachings of the admitted prior art and [the Provisional Application]. Specifically, a skilled artisan would not have been able to make a canned motor with the can being formed of resin and at least a part of the can being covered with an organic film.

Reply Br. 6. This nonenablement argument is unconvincing because it lacks any supporting reasoning.

For the foregoing reasons, the rejection of claims 1 and 2 under 35 U.S.C. § 103(a) for obviousness over the admitted prior art in view of Gabrys is affirmed, as is the rejection on that ground of unargued dependent claim 3.

The rejection of dependent claim 4 under 35 U.S.C. § 103(a) for obviousness over the admitted prior art in view of Gabrys and Xia is affirmed because that rejection has not been separately argued.

DECISION

The Examiner's decision that claims 1-4 are unpatentable for obviousness over the prior art is affirmed.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a). *See* 37 C.F.R. §§ 41.50(f) and 41.52(b).

AFFIRMED

SD

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Enclosure: Copy of Gabrys Provisional Application 60/241,575.

Express Mail Label No. EF 087 306 468 US

A / PROV
PATENT

PROVISIONAL APPLICATION FOR PATENT
COVER SHEET

This is a request for filing a Provisional Patent Application under 37 CFR 1.53(c).

Inventor

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Q Power, Inc.

Title

PHYSICAL VAPOR DEPOSITION OF A VACUUM-ENCAPSULATED FLYWHEEL UNINTERRUPTIBLE POWER SUPPLY

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Papers enclosed in Application

- 7 pages of specification including 41 claims
- 2 sheets of drawings
- A check including the amount of $75.00 for the filing fee. **Applicant claims small entity status.**
- A receipt postcard

This invention was not made by an agency of the U.S. Government or under any contract with an agency of the U.S. Government.

CERTIFICATE OF MAILING

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J. Michael Neary — 10/12//00 Date

Respectfully submitted,

J. Michael Neary, Reg. No. 25,453
Attorney for Applicant

Physical Vapor Deposition of a Vacuum-Encapsulated Flywheel Uninterruptible Power Supply

This invention consists of a method for coating a vacuum-encapsulated flywheel uninterruptible power supply by physical vapor deposition.

Background of the Invention

One of the most challenging problems associated with the production of vacuum-encapsulated flywheel uninterruptible power supplies is how to maintain a specific pressure over the lifetime of the system. The problem stems from the fact that all materials desorb gas, albeit different gas species at different rates. Since all materials desorb gas, the question of how to maintain a specific pressure devolves into a question of how to minimize the rate of gas desorption. Plastics used on electrical wires and in composite and varnishes used on magnet wires and motor laminations desorb gas at rates several orders of magnitude faster than metallic components used within the uninterruptible power supply. In addition, plastics and varnishes can also desorb gas species, such as aliphatic hydrocarbons, that are difficult to adsorb or absorb with a getter pump. Historically, electrical and magnet wire have been coated with enamel and motor and generator laminations have been produced using vacuum impregnation techniques to minimize gas desorption. These techniques, however, are costly while only modestly effective.

Physical vapor deposition is typically used for encapsulating microelectronics to alleviate problems associated with electro-magnetic interference (EMI) and radio frequency interference (RFI). Physical vapor deposition is also commonly used for filling circuit pathways in microelectronic devices and producing hardened layers on machine tools.

Summary of the Invention

The present invention consists of a method for coating the surfaces of an uninterruptible power supply by vapor deposition in a high vacuum. In the first embodiment, vapor deposition is performed within the vacuum encapsulated uninterruptible power supply itself. In the second alternative embodiment, individual components of the uninterruptible power supply are coated.

Description of the Drawings

Figure 1 – illustration of an in-situ method of physical vapor deposition of an uninterruptible power supply.

Figure 2 – illustration of an ex-situ method of physical vapor deposition of an uninterruptible power supply.

Description of the Preferred Embodiment

FIGS. **1** and **2** are provided to further illustrate the present invention. Like reference characters designate identical or corresponding parts.

In FIG. **1**, the in-situ embodiment is illustrated. An uninterruptible power supply **20** is connected to a vacuum pumping system **21**. The uninterruptible power supply **20** is comprised of the following nine components. The first component, the vacuum housing **30,** has three functions. The vacuum housing **30** isolates the electrical and mechanical components of the uninterruptible power supply **20** from the exterior environment, functions as the structural backbone of the system and serves as the vacuum enclosure. The second component, the flywheel **40** mechanically stores energy in the form of rotational inertia. The flywheel is preferably steel, but titanium, aluminum or another metal or a composite material could be used. The third component, the bearing housing **41** supports the weight of the flywheel. The bearings may be mechanical, i.e., ball, or magnetic, in the form of electromagnets or permanent magnets. The combined motor generator and bearing housing **42** is the fourth component. It is similar to the bearing housing **41** in that it contains one or more types of bearings to support the flywheel, but it also contains the motor generator. The motor portion of the motor generator converts electrical energy into mechanical energy by spinning up the flywheel **40.** The generator portion of the motor generator converts the mechanical energy back into electrical energy by spinning down the flywheel **40.** The electrical feedthrough **43** is the fifth component. The electrical feedthrough is a hermetically sealed device that allows electrical wires to pass into the vacuum housing **30** without causing the vacuum to be lost. The vacuum inlet port **55** is the sixth component. The inlet port, preferably copper though stainless steel could be used, serves as the physical junction between the uninterruptible power supply **20** and the vacuum pumping system **21.** The port originally is a part of the connection tube **54**, but is crimped off once the vacuum pumping system **21** is no longer needed. Crimping off the vacuum inlet port **55** from the connection tube **54** is the preferred method of disconnecting the uninterruptible power supply **20** from the vacuum pumping system **21**, but a valve between the connection tube **54** and the vacuum inlet port **55** is an effective alternative. The seventh component is the non-evaporable getter (NEG) pump **60.** The NEG pump **60** is used to maintain the vacuum within the vacuum chamber once the vacuum pumping system **21** has been disconnected. A NEG pump is preferable, but other types of pump technologies, such as ion pumps, can be used. The eighth component of the uninterruptible power supply **20** is a high-current electrical feedthrough **70.** This electrical feedthrough is similar to the electrical feedthrough **43** in that it is a hermetically sealed device. The high-current electrical feedthrough **70,** unlike the electrical feedthrough **43,** is rated for a much higher current. The ninth component is the coating material **71** to be vaporized, preferably a non-ferromagnetic material such as aluminum. Ferromagnetic materials can be used as the coating material **71**, however, slight magnetic flux losses may occur when used on magnetic devices such as motors, generators, magnetic bearing laminations, magnets or magnetic sensors.

The vacuum pumping system **21** is comprised of a combined diaphragm and turbo-drag pump **50**, an ultra-high vacuum Bayard-Alpert ion gauge **51**, a right-angle valve **52**, a bellows **53** and connection tubes **54** and **55**. The first item, the combined diaphragm and turbo-drag pump **50**, reduces the pressure in the uninterruptible power supply **20** from 1 atmosphere (760 torr) to 10^{-6} torr. The low pressure ensures that the coating material **71** is uncontaminated by residual gases within the system. The adhesion strength of a contaminated vapor deposited material is substantially less than the adhesion strength of a non-contaminated vapor deposited material. The second item, the ultra-high vacuum Bayard-Alpert ion gauge **51**, is used to measure the pressure of the system. The third item, the right-angle valve **52**, is used to isolate the ultra-high vacuum Bayard-Alpert ion gauge **51** from atmospheric pressure when the vacuum inlet port **55** is crimped from the connection tube **54**. If the gauge were to be exposed to atmospheric pressure while energized, it would be destroyed. In addition, the right-angle valve **52** minimizes the amount of water-vapor contamination the vacuum pumping system **21** is exposed to. The fourth item, the bellows **53**, is a flexible-piping element that is used to avoid the hassles involved with slight misalignment between the two independent systems **20** and **21**. The fifth item is the connection tubes **54** and **55**. Their function was previously described.

Once the uninterruptible power supply **20** is joined to the vacuum pumping system **21**, the vacuum pump **50** is turned on and allowed to pump on the gas molecules within the vacuum housing **30**. Once the system has been evacuated to a pressure level of 10^{-6} torr, the right-angle valve **52** is closed to isolate the ion gauge **51**. At this point, a high current is passed through the high-current electrical feedthrough **70** which will resistance heat the coating material **71** until it is vaporized. The vaporized material will then spread throughout the uninterruptible power supply **20**, through the connection tube **54**, through the bellows **53** and to the closed off right-angle valve **52**. The pressure in the chamber will climb to approximately 10^{-4} torr. As the evaporant condenses and solidifies, a certain amount of the latent heat of evaporation will heat the deposition surfaces within the uninterruptible power supply **20**. The heat transferred to the deposition surface should not exceed approximately 100°C so as to minimize thermal degradation. Once the heat in the chamber is dissipated, the vacuum pump **50** is turned on once again to evacuate the chamber to a pressure level of 10^{-6} torr. The right-angle valve **52** is then closed off and the connection tube **55** is crimped off.

The subsequent gas desorption rate of the aluminum or alumina coated components of the uninterruptible power supply **20** should approach the gas desorption rate of aluminum or alumina, that is 10^{-8} torr-liters per second per cm^2 (350 billion gas molecules per second per cm^2). The desorption rate of aluminum and alumina can be as much as 10,000 times lower than the gas desorption rate of plastic or varnish. In addition, the gas species that effectively diffuse through the aluminum or alumina coating and desorb from the coating surface is principally hydrogen, rather than hydrocarbons and water which typically desorbs from plastic and varnish. A typical NEG pump has the capacity to pump more than 10 times the amount of hydrogen than oxygen. A NEG pump also can only pump a very limited number of hydrocarbon molecules.

Rather than coat every component within the uninterruptible power supply **20** as is illustrated in FIG. **1**, as an alternative, individual components can be coated. Components that have substantial rates of gas desorption or desorb gas species that are difficult to absorb with a getter pump, such as the motor, generator, magnets, magnetic bearing laminations, magnet wires or the flywheel **40**, can be coated.

In FIG. **2**, this ex-situ embodiment is illustrated. A vapor deposition system **23** is connected to a vacuum pumping system **24**. The vapor deposition system **23** is comprised of a vacuum chamber **31**, the uninterruptible power supply **20** component 44 (or substrate) to be coated, a high-current electrical feedthrough **70** and a vaporizable material **71**, preferably a non-magnetic material such as aluminum.

The vacuum pumping system **24** is comprised of a combined diaphragm and turbo-drag pump **50**, an ultra-high vacuum Bayard-Alpert ion gauge **51**, a right-angle valve **52** and a bellows **53**. The first item, the combined diaphragm and turbo-drag pump **50**, reduces the pressure in the vapor deposition system **23** from 1 atmosphere to 10^{-6} torr. The low pressure ensures that the vaporized material **71** is uncontaminated by residual gases within the system. The second item, the ultra-high vacuum Bayard-Alpert ion gauge **51**, is used to measure the pressure of the system. The third item, the right-angle valve **52**, is used to isolate the ultra-high vacuum Bayard-Alpert ion gauge **51** while parts are being coated. If the gauge were to be exposed to the vaporized material, the gauge would be rendered useless. In addition, the right-angle valve **52** minimizes the amount of water-vapor contamination the vacuum pumping system **24** is exposed to. The fourth item, the bellows **53**, is a flexible-piping element that is used to avoid the hassles involved with slight misalignment between the two independent systems **23** and **24**.

Once the vapor deposition system **23** is joined to the vacuum pumping system **24**, the vacuum pump **50** is turned on and allowed to pump on the gas molecules within the vacuum chamber **31**. Once the system has been evacuated to a pressure level of 10^{-6} torr, the right-angle valve **52** is closed to isolate the ion gauge **51**. At this point, a high current is passed through the high-current electrical feedthrough **70** which will resistance heat the coating material **71** until it is vaporized. The vaporized material will then spread throughout the vapor deposition system **20**, through the bellows **53** and to the closed off right-angle valve **52**. The pressure in the chamber will climb to approximately 10^{-4} torr. During the coating process, a certain amount of heat input to the vapor deposited surfaces of the component 44 will occur as a result of the latent heat of evaporation. The heat input should be minimized to approximately 100°C to prevent thermal degradation. Once the heat in the component 44 is dissipated, the pressure in the vapor deposition system **23** is allowed to return to atmospheric pressure. The now coated component 44 is placed within the uninterruptible power supply.

The subsequent gas desorption rate of the aluminum or alumina coated components **44** should approach the gas desorption rate of aluminum or alumina, that is 10^{-8} torr-liters per second per cm^2 (350 billion gas molecules per second per cm^2). The desorption rate of aluminum and alumina can be as much as 10,000 times lower than the gas desorption rate of plastic or varnish. In addition, the gas species that effectively diffuse through the aluminum or alumina coating and desorb from the coating surface is principally hydrogen, rather than hydrocarbons and water which typically desorbs from plastic and varnish. A typical NEG pump has the capacity to pump more than 10 times the amount of hydrogen than oxygen. A NEG pump also can only pump a very limited number of hydrocarbon molecules.

For those components **44** that can withstand temperatures in excess of 100°C, it is preferable to heat them while inside the vapor deposition system **23**. The higher temperature improves the bond strength between the vapor deposited coating and the component 44. A temperature of approximately 300°C or greater is preferable. The component **44** heating (not shown) can be accomplished by: incorporating a radiant heater with the vapor deposition system **23**; resistively heating the component **44** by passing a current through it; or, conduction through a separately heated platform on which the component **44** is placed within the vapor deposition system **23**. It is preferable to maintain the component **44** at the elevated temperature after the coating has been deposited to relieve thermal stresses in the coating and at the coating interface. Excessive thermal stresses may cause the coating to flake off.

While the vapor deposition system **23** is common in the manufacturing of semiconductors for the creation of complex circuit paths, it is a unique process for reducing the desorption rate of gas from components of an uninterruptible power supply. It is also a unique process for reducing the gas desorption rate of motors, generators, magnets and magnet wire used in vacuum applications.

Rather than use the preferred thermal evaporation technique described above, the components can be negatively biased, a reactant gas (e.g. N_2, O_2, CH_4, C_2H_2) can be used and the coating material **71** can be vaporized using an electron beam, magnetic sputtering, anodic arc or other source.

Obviously, numerous modifications and variations of the described preferred embodiment are possible and will occur to those skilled in the art in light of this disclosure of the invention. Accordingly, I intend that these modifications and variations, and the equivalence thereof, be included with the spirit and scope of the invention as defined in the following claims, wherein I claim:

1. A method to reduce the rate of gas desorption of a vacuum-encapsulated flywheel energy storage system by in-situ physical vapor deposition.
2. A method to substantially inhibit the diffusion and/or desorption of hydrocarbons, in particular aliphatic hydrocarbons, and other gas species that are difficult to absorb with a getter pump of a vacuum-encapsulated flywheel energy system by in-situ physical vapor deposition.
3. Physical vapor deposition as described in claim 1 wherein:
   The said vapor deposited material is chemically active, readily absorbing gas species within the vacuum and on the internal surfaces of the said vacuum-encapsulated flywheel energy storage system.
4. Physical vapor deposition as described in claim 2 wherein:
   The said vapor deposited material is chemically active, readily absorbing gas species within the vacuum and on the internal surfaces of the said vacuum-encapsulated flywheel energy storage system.
5. A method to reduce the rate of gas desorption of a vacuum-encapsulated flywheel energy storage system by ex-situ physical vapor deposition.
6. A flywheel of a vacuum-encapsulated flywheel energy storage system as defined in claim 5 wherein:
   The said flywheel is metallic.
7. A method to substantially inhibit the diffusion and/or desorption of hydrocarbons, in particular aliphatic hydrocarbons, and other gas species that are difficult to absorb with a getter pump of a vacuum-encapsulated flywheel energy system by ex-situ physical vapor deposition.

8. A method to reduce the rate of gas desorption from laminations used in motors, generators and magnetic bearings by physical vapor deposition.
9. A method to substantially inhibit the diffusion and/or desorption of hydrocarbons, in particular aliphatic hydrocarbons, and other gas species that are difficult to absorb with a getter pump from laminations used in motors, generators and magnetic bearings by physical vapor deposition.
10. A method to reduce the rate of gas desorption from magnet wire by physical vapor deposition.
11. A method to substantially inhibit the diffusion and/or desorption of hydrocarbons, in particular aliphatic hydrocarbons, and other gas species that are difficult to absorb with a getter pump from magnet wire by physical vapor deposition.
12. Physical vapor deposition as defined in claim 1 wherein:
The evaporant is a non-ferromagnetic material.
13. Physical vapor deposition as defined in claim 2 wherein:
The evaporant is a non-ferromagnetic material.
14. Physical vapor deposition as defined in claim 5 wherein:
The evaporant is a non-ferromagnetic material.
15. Physical vapor deposition as defined in claim 7 wherein:
The evaporant is a non-ferromagnetic material.
16. Physical vapor deposition as defined in claim 8 wherein:
The evaporant is a non-ferromagnetic material.
17. Physical vapor deposition as defined in claim 9 wherein:
The evaporant is a non-ferromagnetic material.
18. Physical vapor deposition as defined in claim 10 wherein:
The evaporant is a non-ferromagnetic material.
19. Physical vapor deposition as defined in claim 11 wherein:
The evaporant is a non-ferromagnetic material.
20. A non-ferromagnetic material as defined in claim 12 wherein:
The said non-ferromagnetic material is aluminum.
21. A non-ferromagnetic material as defined in claim 13 wherein:
The said non-ferromagnetic material is aluminum.
22. A non-ferromagnetic material as defined in claim 14 wherein:
The said non-ferromagnetic material is aluminum.
23. A non-ferromagnetic material as defined in claim 15 wherein:
The said non-ferromagnetic material is aluminum.
24. A non-ferromagnetic material as defined in claim 16 wherein:
The said non-ferromagnetic material is aluminum.
25. A non-ferromagnetic material as defined in claim 17 wherein:
The said non-ferromagnetic material is aluminum.
26. A non-ferromagnetic material as defined in claim 18 wherein:
The said non-ferromagnetic material is aluminum.
27. A non-ferromagnetic material as defined in claim 19 wherein:
The said non-ferromagnetic material is aluminum.
28. A physical vapor deposition process as defined in claim 1 wherein:
The evaporant is resistively evaporated.
29. A physical vapor deposition process as defined in claim 2 wherein:
The evaporant is resistively evaporated.
30. A physical vapor deposition process as defined in claim 5 wherein:

The component to be coated is heated to 300°C during the coating process.

31. A physical vapor deposition process as defined in claim 7 wherein:
The component to be coated is heated to 300°C during the coating process.

32. A physical vapor deposition process as defined in claim 8 wherein:
The component to be coated is heated to 300°C during the coating process.

33. A physical vapor deposition process as defined in claim 9 wherein:
The component to be coated is heated to 300°C during the coating process.

34. A physical vapor deposition process as defined in claim 10 wherein:
The component to be coated is heated to 300°C during the coating process.

35. A physical vapor deposition process as defined in claim 11 wherein:
The component to be coated is heated to 300°C during the coating process.

36. A physical vapor deposition process as defined in claim 5 wherein:
The temperature of the coated component is maintained at 300°C after deposition so as to reduce thermally induced residual stresses.

37. A physical vapor deposition process as defined in claim 7 wherein:
The temperature of the coated component is maintained at 300°C after deposition so as to reduce thermally induced residual stresses.

38. A physical vapor deposition process as defined in claim 8 wherein:
The temperature of the coated component is maintained at 300°C after deposition so as to reduce thermally induced residual stresses.

39. A physical vapor deposition process as defined in claim 9 wherein:
The temperature of the coated component is maintained at 300°C after deposition so as to reduce thermally induced residual stresses.

40. A physical vapor deposition process as defined in claim 10 wherein:
The temperature of the coated component is maintained at 300°C after deposition so as to reduce thermally induced residual stresses.

41. A physical vapor deposition process as defined in claim 11 wherein:
The temperature of the coated component is maintained at 300°C after deposition so as to reduce thermally induced residual stresses.

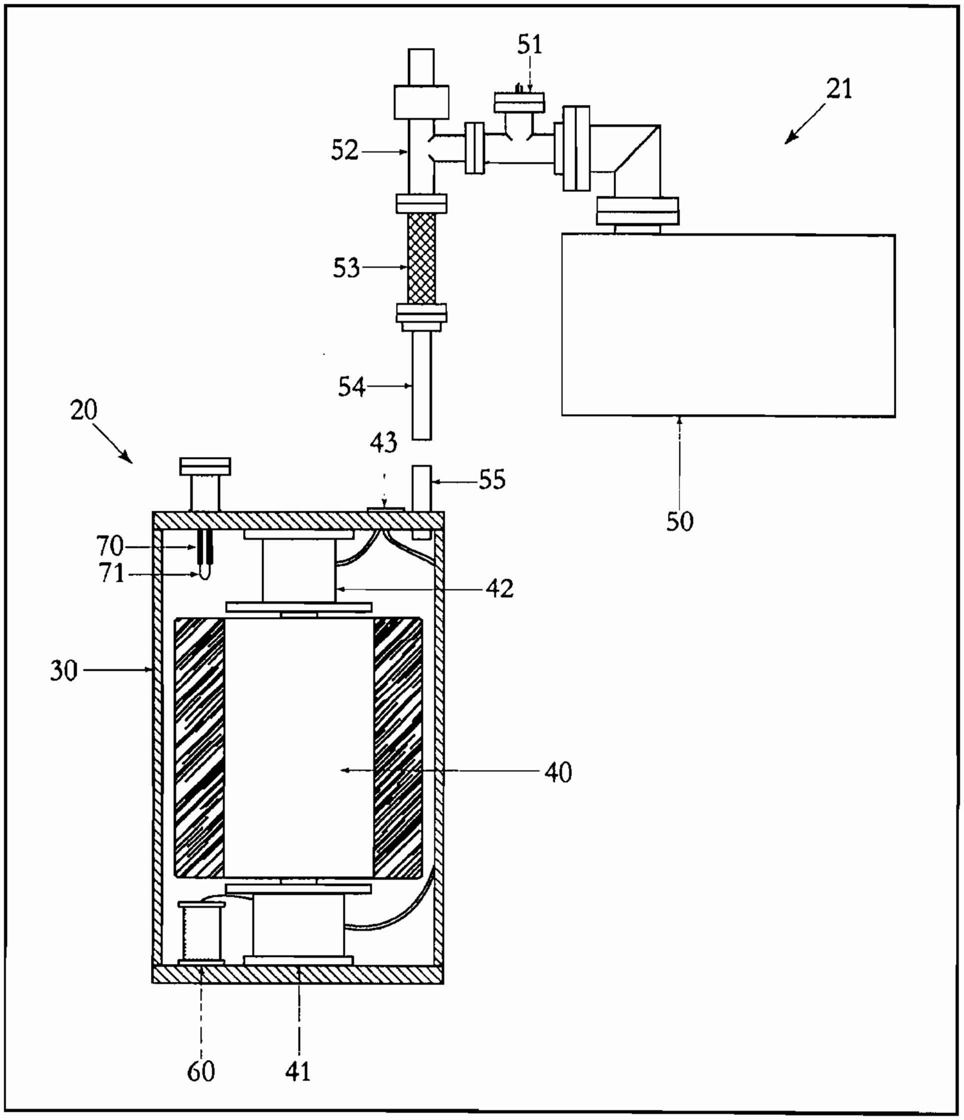

FIG. 1

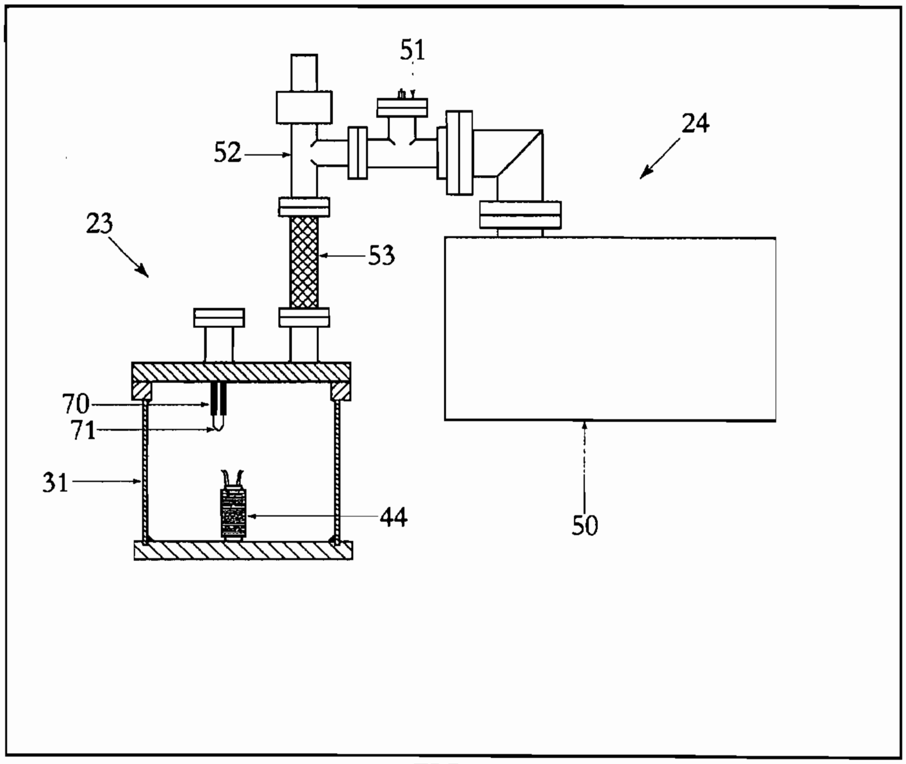

FIG. 2