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(54) Title: SYRINGE-SHAPED DOSE CALIBRATION SOURCE STANDARD

(57) Abstract: A dose calibrator source standard includes a container comprising a cylindrical barrel and a support member which extends radially, outward of the cylindrical barrel which mimics the shape of a syringe. A radioactive source- containing material is sealed within the container. The radioactive source- containing material comprising a radionuclide dispersed within a matrix material.



WO 2007/149139 A2

SYRINGE-SHAPED DOSE CALIBRATION SOURCE STANDARD

BACKGROUND

[0001] The present exemplary embodiment relates to radiopharmaceuticals. It finds particular application in conjunction with a dose calibrator or radioisotope calibrator, and will be described with particular reference thereto. However, it is to be appreciated that the present exemplary embodiment is also amenable to other like applications.

[0002] A dose calibrator (radioisotope calibrator) is a device used in nuclear medicine that measures the total energy of a specific radionuclide in units of Curies (Ci), millicuries (mCi), or microcuries (μ Ci). It includes a hollow, lead-shielded cylinder, into which radionuclides are lowered for measurement. Such devices can be programmed for specific radioisotopes, or adjusted for isotopes not preprogrammed. A dose calibrator is commonly used to obtain measurements of the total radioactivity of isotopes prior to administration to patients undergoing nuclear medicine diagnostic imaging procedures or radioisotope therapy procedures. Regulatory authorities specify when a radioisotope dose calibrator will be used and the timing of required quality control checks (constancy, accuracy, linearity, and geometrical dependence).

[0003] Currently, a dose calibration source standard is used for calibration of the dose calibrator. The calibration source includes a cylindrical vial comprising a predetermined amount of the radionuclide to be calibrated, together with a decay calendar, which allows a user to determine the amount of radionuclide present in the source at the time of testing. The current dose calibration source standards are designed to closely approximate the geometry of unit dose radiopharmaceuticals dispensed in vials by radiopharmacies (specifically, a Tc-99^m generator elution vial, of 30cc maximum volume) and may therefore only partially meet the standards implied in CEI-IEC 61145 "Calibration and Usage of Ionization Chamber Systems for Assay of Radionuclides;" CEI-IEC 1303 "Medical Electrical Equipment – Radionuclide Calibrators - Particular Method of Describing Performance;" ANSI N42.13-1986 "Calibration and Usage of 'Dose Calibrator' Ionization Chambers for

the Assay of Radionuclides;" and 10 CFR 35.50 "Possession, Use, Calibration, and Check of Dose Calibrators."

[0004] Nuclear medicine practitioners generally administer radiopharmaceuticals using a syringe. The practitioner places the syringe containing the radiopharmaceutical into the pre-calibrated dose calibrator to assay its content. The syringe has a different body shape from that of the calibration vials used as calibration standards and, due to the shape of the syringe and configuration of the dose calibrator, is positioned in the dose calibrator with the syringe body in a different location from the vial.

BRIEF DESCRIPTION

[0005] In one aspect of the invention, a dose calibrator source standard includes a container comprising a cylindrical barrel and a support member which extends radially outward of the cylindrical barrel. A radioactive source-containing material is sealed within the container, the radioactive source-containing material comprising a radionuclide dispersed within a matrix material.

[0006] In another aspect, a combination of a dose calibrator source standard and an ion chamber syringe scoop is provided. The dose calibrator source standard includes a barrel. A support member extends radially outwardly of the barrel. A radioactive source-containing material is sealed within the barrel. The radioactive source-containing material includes a radionuclide dispersed within a matrix material. The syringe scoop includes a syringe shelf configured for supporting an associated syringe thereon, the syringe shelf configured for engaging the support member.

[0007] In another aspect, a method of calibrating a dose calibrator includes providing a dose calibrator source standard comprising a container comprising a cylindrical barrel and a support member that extends radially outward of the cylindrical barrel and a radioactive source-containing material sealed within the container. One of a vial calibration mode and a syringe calibration mode is selected. When the vial calibration mode is selected, the dose calibrator source standard is supported in a cup of a scoop. When the syringe calibration mode is selected, the dose calibrator source standard is supported by the support member

on a shelf of the scoop. The shelf is spaced from the cup. The scoop and dose calibrator source standard are inserted into the dose calibrator. A measure of the radiation emitted from the dose calibrator source standard is recorded.

[0008] In another aspect, a dose calibrator source standard includes a container comprising a cylindrical barrel closed by a closure member, and a support member defined by one of the barrel and the closure member. The support member extends radially outward of the cylindrical barrel adjacent a first end of the barrel. The container defines an interior. The barrel includes a planar base at a second end, for supporting the dose calibrator thereon, and a sidewall having a length which is at least twice a diameter of the base for mimicking dimensions of a barrel of a syringe. A radioactive source-containing material is sealed within the container interior, the radioactive source-containing material comprising a radionuclide dispersed within a matrix material.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIGURE 1 is a side sectional view of a dose calibrator source standard according to a first aspect of the exemplary embodiment;

[0010] FIGURE 2 is a perspective view of the dose calibrator source standard being lowered into a dose calibrator with a scoop and a syringe containing a radionuclide to be calibrated;

[0011] FIGURE 3 is a side sectional view of the dose calibrator source standard, dose calibrator, and scoop of FIGURE 2, during a calibration;

[0012] FIGURE 4 is a side sectional view of a dose calibrator source standard according to a second aspect of the exemplary embodiment; and

[0013] FIGURE 5 is a side sectional view of a dose calibrator source standard according to a third aspect of the exemplary embodiment.

DETAILED DESCRIPTION

[0014] Aspects of the exemplary embodiment relate to a dose calibrator source standard which is designed to closely approximate the geometry of unit dose radiopharmaceuticals dispensed in syringe form which meets the above-mentioned

CEI-IEC, ANSI, and CFR standards.

[0015] Current dose calibrator source standards are designed to approximate the geometry of a typical radiopharmaceutical multidose vial or radionuclide generator elution vial (10 milliliters volume and 30 milliliters volume, respectively). While a cylindrical vial was adequate a number of years ago, the dispensing of radiopharmaceuticals in a syringe for unit dosing no longer provides dose calibrator source standards that approximate radioactivity volume or physical geometry of a typical syringe assay. The exemplary dose calibrator source standard is designed to provide a National Institute of Science and Technology traceable standard where the radioactivity volume and physical geometry of the body of a syringe is reproduced, which may also serve as a vial standard.

[0016] With reference to FIGURE 1, a first embodiment dose calibrator source standard **10** according to the exemplary embodiment is illustrated. The source standard **10** includes a container **11** which includes a cylindrical encapsulation barrel **12** configured to mimic the barrel of a syringe and a closure member **13** mounted to the encapsulation barrel, which mimics the plunger of the syringe. The illustrated closure member **13** defines an enlarged diameter support member **14** in the form of a laterally extending annular flange and an interior socket **15**. The encapsulation barrel **12** includes a cylindrical wall **16** of substantially uniform cross section which is closed at a lower end by a base **18**. The base **18** may be integrally formed with the wall **16**, for example by molding. The illustrated base is flat and configured for unaided support of the dose calibrator source standard in an upright position thereon.

[0017] The upper end of the barrel **12** is closed by the closure member **13** to define a sealed interior **20**. A radioactive source-containing material **22** is sealed within the encapsulation barrel **12**. The barrel **12** includes an exterior threaded portion **24** at an upper open end **26** which is configured for threadably engaging corresponding interior threads on the socket **15** of the closure member. A sealant material (not shown), may be applied to the threads to provide an airtight and tamper-resistant seal between the barrel **12** and the closure member **13**. A void created between the radioactive source containing material **22** and the closure

member **13** may be backfilled with an appropriate polymer matrix **28**, such as epoxy, urethane, silicone, or other appropriate material. While FIGURE 1 shows the interior having an air space above the matrix **28**, it is contemplated that the entire interior space **20** above the radioactive material **22** may be backfilled with matrix **28**, leaving no air space.

[0018] The encapsulation barrel **12** and closure member **13** may be formed from a plastic polymer, such as Lucite®, or a low Z material, such as aluminum or other material which is transmissive to substantially all radiation emitted from the source. The barrel **12** has an outer diameter d and length L (as measured from the base to support member) similar to that of a barrel **30** of a syringe **32** containing a radiopharmaceutical **34** which is to be tested in a dose calibrator **36** of the type shown in FIGURES 2 and 3. In general the sidewall **16** has a length L which is at least twice a diameter d of the base **18**. For example, the diameter d and length L may be within $\pm 10\%$ of the actual syringe dimensions, e.g., within $\pm 5\%$, or identical thereto. The radioactive nuclide-containing material **22** thus occupies dimensions and a volume comparable to that of the radiopharmaceutical liquid **34** to be tested.

[0019] In one embodiment, the outer barrel diameter d may be up to about 2.5cm (1 inch) and the barrel length L up to about 10cm (4 inches). The volume of the interior **20** may be from about 3 to about 10 cm³. The closure member **13** may have a height C and/or other dimensions which are similar to that of a plunger **38** of the syringe **32** for ease of handling although in general, the dimensions of the closure member are not critical. In operation, the illustrated support member **14** extends radially outwardly from the barrel wall **16** to define an annular surface **40** suitable for seating on a syringe shelf **44** of an ion chamber syringe scoop **46** of the type shown in FIGURES 2 and 3. While in one embodiment, surface **40** is annular, it is also contemplated that the surface may be of any suitable configuration for resting on the shelf **44**. For example, the surface **40** may be defined by two (or more) radially extending wings. The surface **40** may extend about 0.3cm to about 2cm from the barrel **12**, e.g., at least about 0.5 cm. The exact dimension may depend on the configuration of the scoop **46**. The illustrated support member **14** includes an annular generally concave cavity **48**, spaced from the support surface,

for ease of transporting the dose standard **10**.

[0020] While in the illustrated embodiment, the support member **14** is defined by the closure member **13**, in alternate embodiments, the support member may be defined by the barrel **12**, e.g., by being integrally formed therewith, for example as a lip

[0021] The radioactive source-containing material **22** may include one or more radionuclides encapsulated in a suitable solid matrix material. Exemplary nuclides include gamma radiation emitters, such as sodium 22 (Na-22), cobalt 57 (Co-57), cobalt 60 (Co-60), germanium 68 (Ge-68), barium 133 (Ba-133), thallium 204 (Tl-204), and cesium 137 (Cs-137) in appropriate quantities for serving as a standard for calibration. The matrix material may comprise an epoxy, silicone, urethane, ceramic, or similar type of matrix material in which the radionuclide may be uniformly dispersed.

[0022] To form the source standard **10**, appropriate quantities of a radionuclide and a liquid polymer composition are mixed to disperse the radionuclide uniformly. The polymer composition may include a polymer resin together with accelerators, crosslinking agents, and the like which cause the polymer to harden when cured (e.g., by UV-curing or an ambient cure). The liquid radionuclide/polymer composition is placed in the barrel **16** and cured to form a solid **22**. The barrel **16** may then be backfilled with polymer matrix material, which is also cured to form a solid. The barrel is then sealed to the closure member **13**, for example, by placing a small amount of the polymer matrix material around the threads **24** and threadably connecting the closure member **13** to the barrel **12**. The assembled source standard **10** is then calibrated e.g., against a traceable National Institute of Standards (NIST) solution. A custom decay calendar may then be derived and affixed by means of a label **50** to the source standard **10** or to a shielding container in which the source standard **10** is shipped and stored.

[0023] The source standard can be used in two different calibration modes. To calibrate the dose calibrator **36** for use with syringes (first mode), the source standard **10** is supported on the syringe shelf **44** of a suitably configured syringe scoop **46**. The scoop shelf **44** engages the support member surface **40**. In

particular, the scoop shelf **44** has a generally centrally positioned circular aperture **52** therein which is sized to accommodate the barrel **12** therethrough but which is smaller than the maximum diameter *D* of the support surface **40**. The scoop **46** is then lowered into an ion chamber **54** of the dose calibrator **36** by a vertically extending handle **55**. The shelf **44** of the scoop is vertically spaced along the handle from a base **56** of the scoop by a sufficient distance such that the syringe **30** can subsequently be accommodated by the scoop while being supported with a lip **58** of the syringe barrel resting on the shelf **44**. The illustrated scoop base **56** includes an upwardly open vial cup **60** comprising a cylindrical wall **62** of suitable diameter to receive a conventional cylindrical vial source standard (not shown) therein. The exemplary base **18** of the source standard **10** is sized to fit within the vial cup **54** and has a planar lower surface **64** whereby the source standard **10** can rest on a correspondingly sized planar base surface **66** of the vial cup **60** with the source standard **10** in an upright position (second mode). In this way, the source standard **10** can be used for calibrating the dose calibrator **34** for syringes (when suspended on the shelf **44**), or for vials (when seated in the cup **60**), simulating, for example, a 10cc multidosing vial. In both cases, the radiation source-containing material **22** is correctly positioned so as to be in a comparable location in the ion chamber **54** of the dose calibrator **34** to the actual dose of radiopharmaceutical **34** in the vial or syringe **32**. The radiation emitted by the source standard **10** is detected by a radiation detector **68** and a measure of the radiation, such as the amount of radiation emitted per unit time, is recorded on suitable instrumentation **70**.

[0024] The exemplary source standard **10** thus described meets or exceeds the American National Standards Institute (ANSI) safety classification of 97C22312 as described in Publication ANSI/HPS N43.6-1997 "Sealed Radioactive Source – Classification."

[0025] The source standard **10** may be color-coded for easy identification, e.g., as follows:

Green: Cs-137	Red: Co-57	Blue: Co-60	Yellow: Na-22
Black: Ba-133	White: Ge-68	Orange: Tl-204	

[0026] FIGURE 4 illustrates another embodiment of a source standard **100** which may be similarly configured to source standard **10**, except as noted. In this embodiment, similar elements are identified by a primed suffix (') and new elements are accorded new numbers. In this embodiment, a support surface **40'** is defined by two finger wings **102**, **104**, which extend approximately 1-2 cm beyond the barrel diameter **d**. The wings may be integrally formed with the barrel **12'** or with a cover member **13'** in the form of a mock plunger, which seals the open end of the barrel **12'**. The finger wings **102**, **104** extend in opposite directions to support the source standard **10** in existing ion chamber scoops, such as scoop **46**.

[0027] The embodiment of FIGURE 4 provides a double encapsulation for the source material **22**. An outer encapsulation is provided by the barrel and mock plunger **13'**, while inner encapsulation is provided by a cylindrical housing **108** made of a plastic polymer or low Z material, such as aluminum. The housing **108** is sized to fit within the interior **20'** of the barrel. For example, the housing **108** is no greater than about 2 cm (0.8 inches) in diameter **d'** and no greater than about 4 cm (about 1.50 inches) in length **l'** and may be centered in the barrel with the use of o-rings **110** secured around the housing prior to insertion into the outer barrel **12'**. The radiation source-containing material is sealed within the housing **108**. This embodiment provides for double encapsulation of the matrix **22** with metal, plastic, or a combination of both. However, it is also contemplated that the outer container **11'** need not be sealed and that the radiation source-containing material may be sealed within the container **11'** by virtue of the inner housing **108**.

[0028] The void created between the radioactive source encapsulation and the mock plunger may be backfilled with an appropriate matrix **28** such as epoxy, urethane, silicone, or other appropriate material.

[0029] In this embodiment, the outer container **11'** may be formed from a hollowed out rod of material which is machined exteriorly to define the mock plunger. The container **11'** is sealed at the end to form a base **18'** after insertion of the inner housing **108** containing radioactive material.

[0030] In another embodiment of a source standard **110**, illustrated in FIGURE 5, which may be similar in other respects to that of FIGURES 1-4, the base **18''** has

a V-shaped interior (e.g., conical or frustoconical shape) with a taper which mirrors the exterior taper of the base of certain types of syringe. For example, the taper may be about 118° . The interior cross section of the barrel chamber **20** thus decreases towards its lower end. However, the lower surface **64** of the base is flat, as in other embodiments. The tip of the V is closed such that the base **18** closes the bottom end of the barrel **12**. The wall thickness may be the same at the bottom of the point of the "V" as for the side walls **16** of the barrel.

CLAIMS:

1. A dose calibrator source standard comprising:
a container comprising a cylindrical barrel and a support member which extends radially outward of the cylindrical barrel; and
a radioactive source-containing material sealed within the container, the radioactive source-containing material comprising a radionuclide dispersed within a matrix material.
2. The dose calibrator source standard of claim 1, further characterized by the container including a closure member which is threadably mounted to the barrel.
3. The dose calibrator source standard of claim 1, further characterized by the support member being integrally formed with a closure member which closes an open end of the barrel.
4. The dose calibrator source standard of any one of preceding claims 1-3, further characterized by the barrel including a base which defines a planar lower surface.
5. The dose calibrator source standard of claim 4, further characterized by the barrel including a cylindrical wall, the lower surface of the base being generally perpendicular to the side wall for supporting the dose calibrator source standard in an upright position thereon.
6. The dose calibrator source standard of any one of preceding claims 1-5, further characterized by the barrel having a base which closes a lower end of the barrel, the base being interiorly tapered.

7. The dose calibrator source standard of any one of preceding claims 1-6, further characterized by the support member and barrel in cooperation defining an interior chamber.

8. The dose calibrator source standard of claim 7, further characterized by the interior chamber being sealed and housing the radioactive source-containing material.

9. The dose calibrator source standard of any one of preceding claims 1-8, further characterized by the support member being annular.

10. The dose calibrator source standard of any one of preceding claims 1-9, further characterized by the support member defining a surface configured for suspending the dose calibrator source standard on a shelf of an associated ion chamber syringe scoop.

11. The dose calibrator source standard of any one of preceding claims 1-10, further characterized by the support member extending at least 0.3cm from the barrel.

12. The dose calibrator source standard of any one of preceding claims 1-11, further characterized by the nuclide including a gamma radiation emitter selected from the group consisting of sodium 22, cobalt 57, cobalt 60, germanium 68, barium 133, thallium 204, cesium 137, and combinations thereof.

13. The dose calibrator source standard of any one of preceding claims 1-11, further characterized by the radioactive source-containing material being a solid.

14. In combination, the dose calibrator source standard of any one of preceding claims 1-13 and ion chamber syringe scoop comprising a syringe shelf

configured for supporting an associated syringe thereon, the syringe shelf configured for engaging the support member.

15. The combination of claim 14, further characterized by the barrel being of similar dimensions to a barrel of the associated syringe.

16. The combination of either one of preceding claims 14 and 15, further characterized by the syringe scoop further including a vial cup, spaced from the shelf, for receiving an associated vial containing a source of radiation and wherein the barrel of the dose calibrator source standard includes a base which closes a lower end of the barrel, the base being shaped for receipt within the vial cup.

17. The combination of claim 16, further characterized by the barrel including a sidewall substantially perpendicular to an exterior surface of the base.

18. The combination of any one of preceding claims 16 and 17, further characterized by the base being interiorly tapered.

19. The combination of any one of preceding claims 14-18, further characterized by the syringe shelf supporting member defining an aperture which receives the barrel therethrough.

20. A system comprising the combination of any one of preceding claims 14-19 and a dose calibrator which receives the scoop therein.

21. A method of calibrating a dose calibrator comprising:
providing a dose calibrator source standard comprising a container comprising a cylindrical barrel and a support member which extends radially outward of the cylindrical barrel and a radioactive source-containing material sealed within the container;

selecting one of a vial calibration mode and a syringe calibration mode;
when the vial calibration mode is selected, supporting the dose calibrator source standard in a cup of a scoop;

when the syringe calibration mode is selected, supporting the dose calibrator source standard by the support member on a shelf of the scoop, the shelf being spaced from the cup;

inserting the scoop and dose calibrator source standard into the dose calibrator; and

recording a measure of the radiation emitted from the dose calibrator source standard.

22. The method of claim 21, further characterized by the supporting of the dose calibrator source standard by the support member on the shelf including resting the support member on the shelf with the barrel extending through an aperture in the shelf.

23. The method of either one of preceding claims 21-22, further characterized by the supporting of the dose calibrator source standard in the cup including supporting a base of the barrel on a mating support surface of the cup.

24. The method of any one of preceding claims 21-23, further characterized by

in the vial calibration mode, the radioactive source-containing material is positioned within the dose calibrator in the location of an associated vial of a radiopharmaceutical to be calibrated with the dose calibrator; and

in the syringe calibration mode, the radioactive source-containing material is positioned within the dose calibrator in the location of a syringe of a radiopharmaceutical to be calibrated with the dose calibrator.

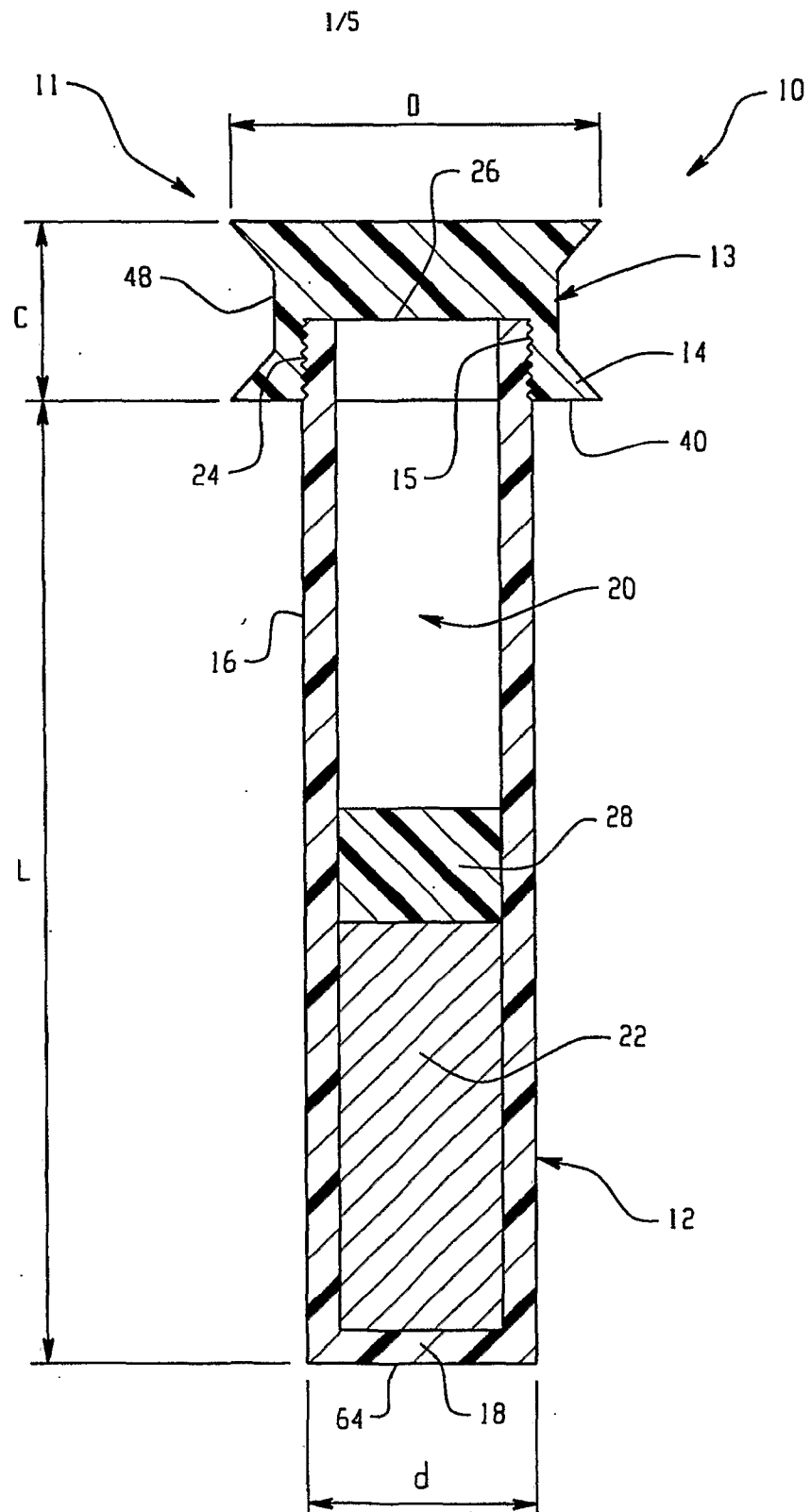


Fig. 1

2/5

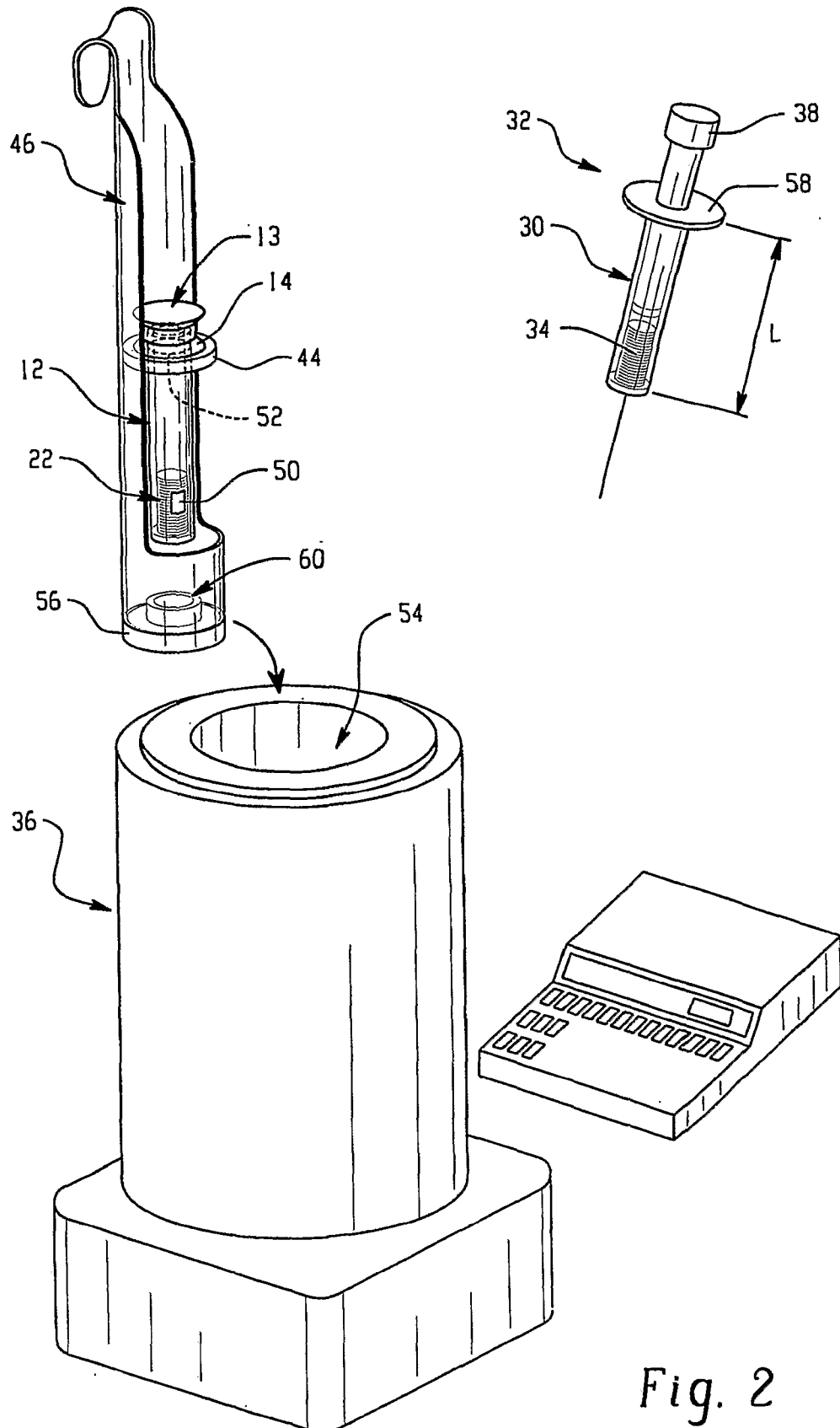


Fig. 2

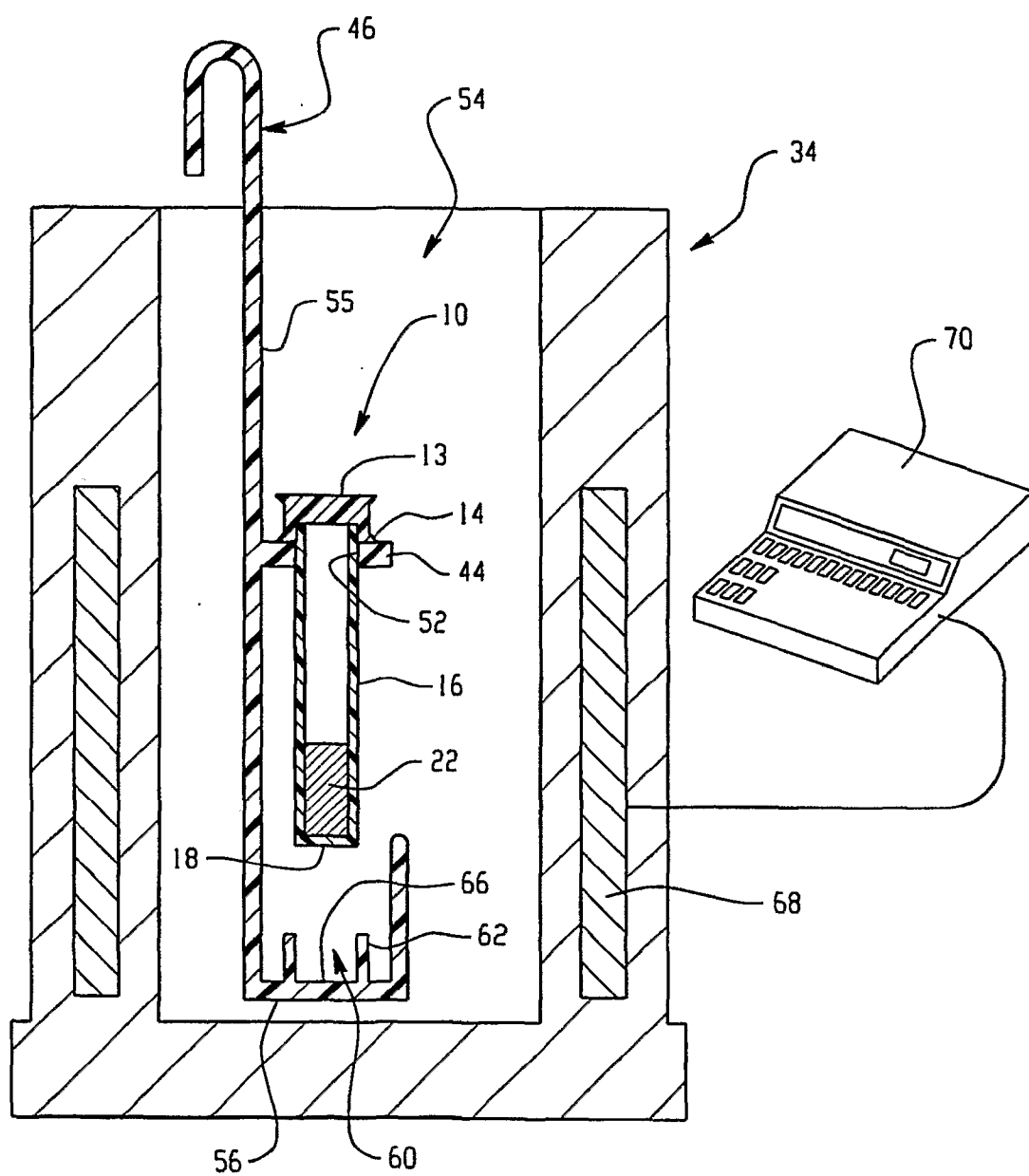


Fig. 3

4/5

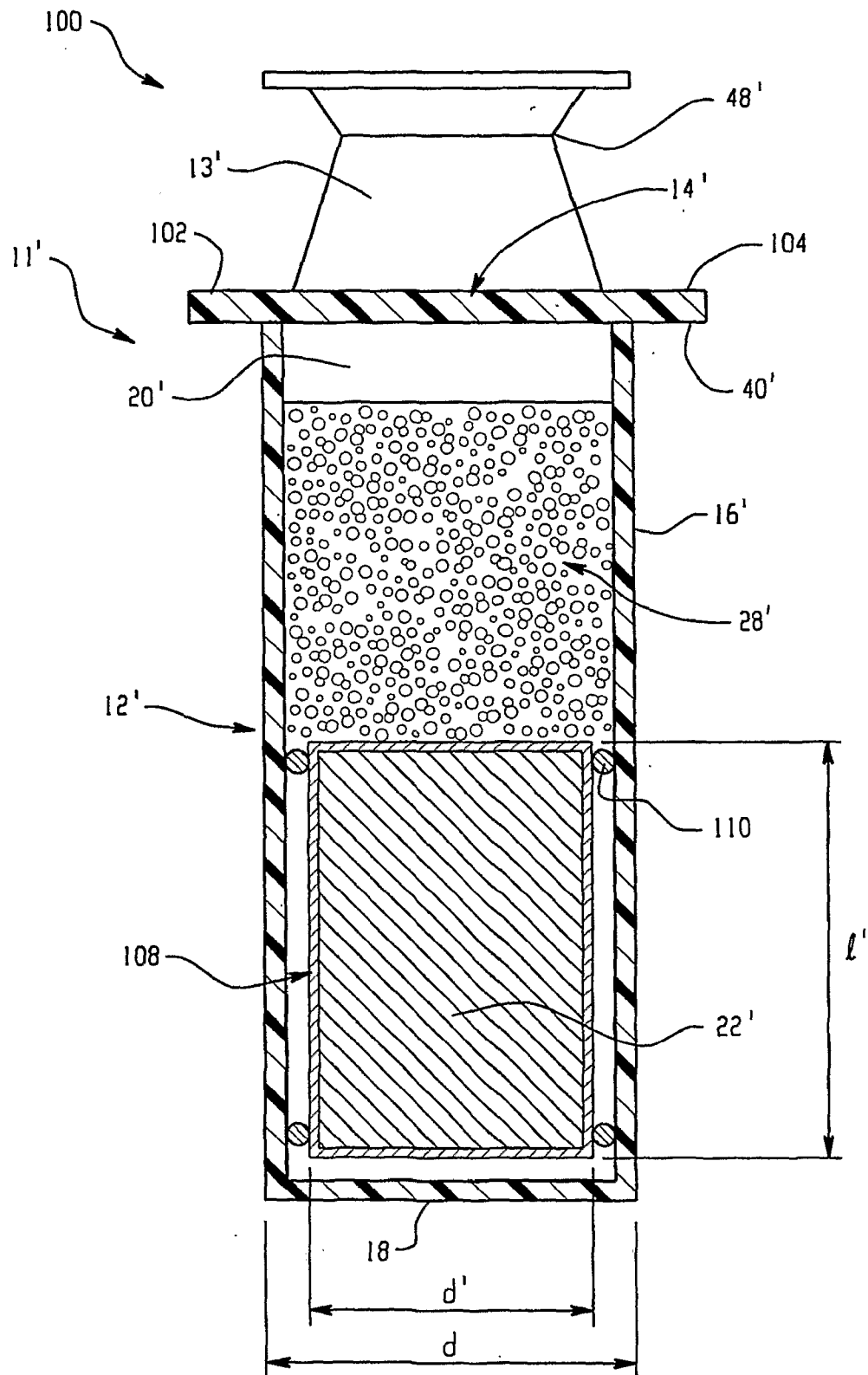


Fig. 4

5/5

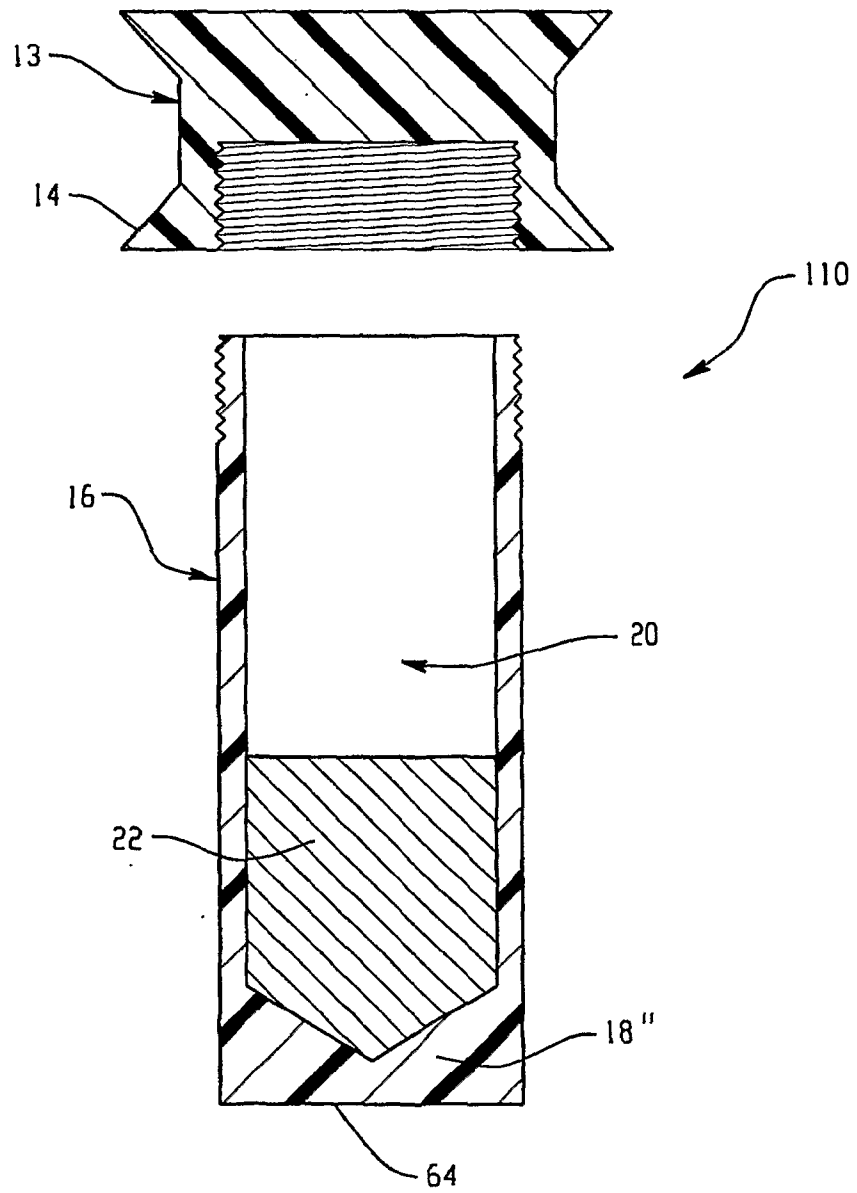


Fig. 5