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**Surgical suspension system**

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(71) Applicant(s)
**Steris Inc.; Ondal Industrietechnik GmbH**

(72) Inventor(s)
**Brahler, Manfred; Steger, Klaus; Hlebovy, James C**

(74) Agent / Attorney
**PIZZEYS, Level 14 ANZ Centre 324 Queen Street, Brisbane, QLD, 4001**

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(71) Applicants: **STERIS INC.** [US/US]; 43425 Business Park Drive, Temecula, CA 92590 (US). **ONDAL INDUSTRIETECHNIK GMBH** [DE/DE]; Wellastrasse 2-4, 36085 Hunfeld (DE).

(72) Inventors: **BRAHLER, Manfred**; Am Habersberg 9, 36137 Grossenlüder (DE). **STEGER, Klaus**; Milchstr. 5, 36132 Eiterfled (DE). **HLEBOVY, James, C.**; 12292 Pearl Road, Chardon, OH 44024 (US).

(74) Agents: **KOCOVSKY, Thomas, E., Jr.** et al.; Fay, Sharpe, Fagan, Minnich & McKee, LLP, 1100 Superior Avenue, 7th Floor, Cleveland, OH 44114-2518 (US).

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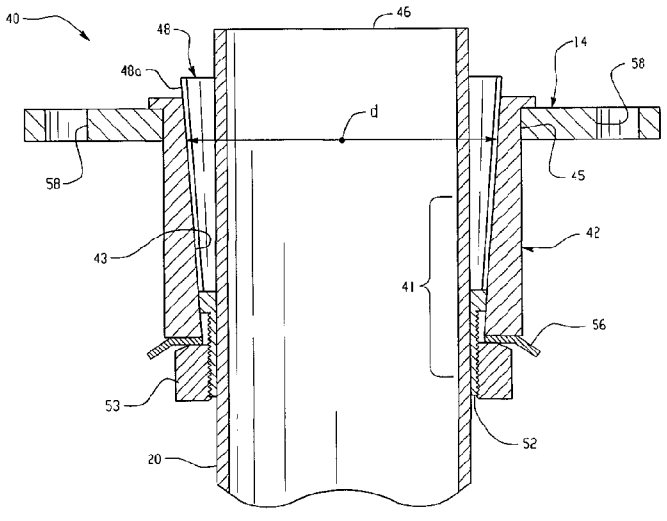
(54) Title: SURGICAL SUSPENSION SYSTEM




(57) Abstract: A suspension system (10) is disclosed for suspending lightheads (26), monitors (28, 30), cameras, or other medical apparatus from an overhead structure (12) at a selectable height. A drop tube (20) has a selected portion thereof surroundingly encompassed by a receiving element (42) that has a variable inside diameter substantially conforming to a frustum of a cone. A mounting plate (14) rigidly connects with the overhead structure (12) and with the receiving element (42). The mounting plate (14) has an opening through which an end of the drop tube (20) passes. A wedge-shaped element (48) has a variable outer diameter substantially conforming to a frustum of a cone. The wedge-shaped element (48) compressively inserts into the receiving element (42) and surroundingly encompasses the selected portion of the drop tube (20) to effectuate a compressive clamping of the selected portion of the drop tube (20) inside the receiving element (42).

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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

# SURGICAL SUSPENSION SYSTEM

## Background of the Invention

The present invention relates to the suspension system arts. It particularly relates to suspension systems for surgical operating room lightheads, monitors, cameras, and the like, and will be described with particular reference thereto. However, the invention will also find application in other ceiling-mounted apparatus and in fields outside the medical industry.

## Definitions

In the specification the term "comprising" shall be understood to have a broad meaning similar to the term "including" and will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps. This definition also applies to variations on the term "comprising" such as "comprise" and "comprises".

In operating theaters, intensive care rooms, and other hospital and clinical settings, medical equipment, such as overhead lighting and monitoring devices, is carried from overhead by suspension systems extending downward from a ceiling. This arrangement advantageously places the equipment out of the way of busy medical personnel and yet readily accessible when needed.

Suspended lighting, for example, can effectively illuminate the surgical site without physically interfering with the surgeon.

Such suspension systems usually include a mounting plate (sometimes called a "cheese plate") attached to a rigid overhead structure, a drop tube connected to the mounting plate, a rotatable spindle fixed to the drop tube which allows rotation about a vertical axis, and one or a plurality of extension and/or articulating arms which connect with and support equipment such as surgical lightheads, monitors, cameras, or other devices. The articulating arms are often multiply jointed to permit several degrees of mechanical freedom for the attached device.

The connection of the drop tube to the mounting plate most often uses a tube-in-tube design wherein the drop tube is fixed to a cylinder which is in turn fixed to the mounting plate using screws or other suitable fasteners. Because ceiling heights in hospitals and clinics vary from one facility to another, and because the suspension system preferably accommodates placement of medical devices in ergonomically acceptable positions for medical personnel relative to the floor, the suspension systems are advantageously adaptable for different ceiling heights.

However, existing suspension systems typically use a drop tube having a fixed length. Height adjustment of the overall system is accomplished either by selecting a drop tube of an appropriate standard or custom length, or by cutting the tube at the installation site and drilling the necessary holes into the tube at the proper locations to effect secure attachment.

Providing pre-selected custom length drop tubes that are pre-cut at the factory to match the ceiling height disadvantageously introduces logistical problems, long lead times, and the possibility that the drop tubes will not fit with the actual relative ceiling to floor spacing.

Cutting a tube at the installation site risks poorly executed cutting and/or drilling of the tube resulting in a damaged suspension system and possible safety issues. Another disadvantage of cutting the tube at the installation site is that it is usually not possible to machine properly the end of the tube which is cut. The rough cut end is accommodated by including relatively large tolerances for the tube-in-tube connection and may require adjustment screws or the like. However, abnormal clearances can nonetheless result and cannot always be corrected by the adjustment screws.

Yet another disadvantage of existing suspension systems is that the height of the finished system is not subsequently adjustable in the vertical direction. Thus, when the suspension system is moved to a different

operating theater having a different ceiling height the drop tube is either replaced or, if the new operating theater has a lower ceiling, re-cut to accommodate the lower ceiling.

The present invention contemplates an improved surgical suspension apparatus which overcomes the aforementioned limitations and others.

**Summary of the Invention**

According to one aspect of the invention, a suspension system for suspending one or more of lightheads, monitors, task lights, cameras, and other medical apparatus from an overhead structure at a selectable height is provided. The suspension system includes a drop tube configured for supporting the one or more of lightheads, monitors, cameras, and other medical apparatus. A receiving element receives the drop tube such that a distal end of the drop tube extends below a lower end of the receiving element. A collar is received by the receiving element and surrounds a portion of the drop tube to effectuate a compressive clamping of the portion of the drop tube inside the receiving element, a distance of the drop tube which extends below the lower end of the receiving element being variable. A means is provided for mounting the receiving element to the overhead structure.

According to another aspect of the invention, a method of variably adjusting a distance, relative to a fixed surface, of a distal end of a drop tube for supporting a medical device is provided. The method includes rigidly supporting a receiving element from the fixed surface. The method further includes loosely inserting a collar into a bore of the receiving element, inserting the drop tube into the collar such that an end of the drop tube extends a selected distance below the receiving element, the distance of the drop tube which

extends below a lower end of the receiving element being variable, and drawing the collar into the receiving element bore such that the drop tube is compressively clamped by the receiving element and collar.

One advantage of the present invention resides in the enablement of continuous height adjustment over a range

of positions in installing a surgical suspension system.

Another advantage of the present invention is the ability to adapt the suspension system height to different surgical theaters or other ceiling height changes.

Another advantage of the present invention resides in the elimination of circumferential tube-in-tube fitting clearances which are replaced in the preferred embodiment of the invention by a compressed wedge element that surroundingly clamps onto the drop tube.

Yet another advantage of the present invention is the elimination of on-site installation work including precision tube cutting and drilling. The drop tube can be "rough cut" at the installation site to provide a desired nominal tube length, but precision machining is not necessary.

Still yet another advantage of the present invention is the elimination of a precise length specification in pre-selected custom length drop tubes.

Numerous additional advantages and benefits of the present invention will become apparent to those of ordinary skill in the art upon reading the following detailed description of the preferred embodiment.

## Brief Description of the Drawings

The invention may take form in various components and arrangements of components, and in various steps and arrangements of steps. The drawings are only for the purpose of illustrating preferred embodiments and are not to be construed as limiting the invention.

FIGURE 1 shows a plurality of medical devices including lightheads and monitoring equipment connected to a suspension system formed in accordance with an embodiment of the invention;

FIGURE 2 shows an exploded sectional view of a suspension system formed in accordance with an embodiment of the invention;

FIGURE 3 shows an assembled sectional view of the suspension system of FIGURE 2;

FIGURE 4 shows an exploded perspective view of the suspension system of FIGURES 2 and 3 with additional ornamental cover plate and connecting components; and

FIGURE 5 shows an assembled view, in partial section, of the suspension system of FIGURE 3 with a safety ring assembly attached to the drop tube.

## Detailed Description of the Preferred Embodiments

With reference to FIGURE 1, an overhead lighting system **10** is mounted from a fixed overhead structure **12** which in the illustrated case is an overhead beam **12**. A mounting plate or "cheeseplate" **14** is secured at a selected distance $d_1$ below the overhead structure **12** by a plurality of long-shank fasteners **16**. Typically, the distance $d_1$ corresponds to a distance of an operating room ceiling **18** below the structural component **12**.

A drop tube **20** connects at a proximal end to the mounting plate **14** and has a distal end **22** extending downward. One or more articulating arms **24** are disposed at the distal end **22**. Each articulating arm **24** has a medical device, such as a lighthead **26**, CRT monitor **28**, flat panel monitor **30**, manual task light **34**, or the like attached at a distal end **35**. Typically, the proximal end of each articulating arm **24** connects to the drop tube **20** via a rotatable spindle **32** which is rotatable about a vertical axis **V**. Each articulating arm **24** usually includes one or multiple joints **36** which are adjustable about one or more axes each to provide additional degrees of motion freedom.

The overhead lighting system **10** optionally includes additional features, such as a cosmetic ceiling cover **38**. Those skilled in the art will also appreciate that the system **10** can be employed for mounting other devices besides lightheads and monitors, such as cameras, fiber optical light pipes, and the like. It will further be appreciated that the overhead lighting system **10** is not limited in application to surgical theaters, or even to medical or clinical settings. The overhead mounting of devices is beneficial in any setting where it is

advantageous to have devices conveniently accessible and yet not "in the way" of people's usual movements.

An important parameter of the overhead lighting system **10** is the height of the distal end **22** of the drop tube **20** relative to the floor. For example, many surgical lightheads include reflectors designed to reflect light around the surgeon's head. The lighthead is thus positioned behind the surgeon's head, and the light reflects around the surgeon's head and onto or into the surgical opening. The precise positioning of the lighthead relative to the surgeon's head is thus critical, and improper positioning can result in partial blockage of the illumination by the surgeon's head, or a collision. Similarly, the monitors **28**, **30** should be placed at an ergonomically advantageous position so that the surgeon can easily view the monitors during the operation, with the ability to glance back-and-forth between the surgical opening and the monitors.

With reference to FIGURES 2 and 3, an adjustably positionable drop tube locking mechanism **40** is described. The locking mechanism **40** selectively clamps an intermediate portion **41** of the drop tube between the distal and proximal ends. The locking mechanism includes a drop tube receiving element in the form of a cylinder **42** with an axially extending bore **43**, with an interior wall surface **43a**, which defines an upper opening **44**. The bore **43** preferably has an inner diameter **D** which decreases, towards a lower end. The cylinder is thus internally shaped as a frustum of a cone and is rigidly attached inside a centrally located opening **45** of the mounting plate **14**, for example by welding. The mounting plate **14** together with the welded cylinder **42** provide a securing element **14**, **42** for rigidly securing the drop tube **20** (shown in part in FIGURES 2 and 3). As best seen in the assembled view of FIGURE 3, the drop tube **20** passes through the opening **44** and narrowing bore **43**. The drop tube **20** has a distal end **22** (FIGURE 1) extending downward below the cylinder **42**, and a proximal end 46 extending upward adjacent the cylinder **42**. The drop tube

20 has a smaller outer diameter than the narrowest portion of the narrowing bore 43 and is therefore adjustably positionable within the cylinder 42 with its distal end 22 extending a selected distance below a lower narrow open end 47 of the bore.

Although a separate drop tube receiving element, namely the cylinder 42, is shown in the illustrated embodiment, it is also contemplated to form the mounting plate 14 and the cylinder 42 as a single integral piece. That is, in a contemplated alternative embodiment the mounting plate includes an opening corresponding to the opening 44. However, as can be discerned from FIGURES 2 and 3, such an alternative embodiment may include a thicker mounting plate.

With continuing reference to FIGURES 2 and 3, a locking tube or collar 48 surroundingly encompasses the drop tube 20. The collar 48 is preferably wedge-shaped and has an outside surface 48a with a diameter D which decreases toward a lower end thereof. The collar is thus essentially shaped as a frustum of a cone and is similarly sized to the similarly shaped narrowing bore 43 of the cylinder 42. The taper of the outer surface may be the same as the taper of the bore, although it is also contemplated that the taper may be somewhat greater or lesser than that of the bore. The collar 48 includes at least one and preferably a plurality of longitudinally extending slots 50 spaced apart along the outer surface of the collar 48. As shown in FIGURE 2, some of the slots 50 extend downward from a wider or upper end 51 of the collar, while other slots extend upward from a narrow or lower end 52 of the collar, although it is also contemplated that the slots need not extend fully to either end 51, 52. The resiliently flexible strips 49 thus defined between the slots are able to flex inwardly when the 48 collar is exteriorly compressed. Where the strips 49 extend fully to one or other end 51, 52, this allows the free ends of the strips to move into a somewhat overlapping relation when compressed.

The wedge-shaped collar **48** acts as a collet which passes through the cylinder opening **44** and is wedged into the bore **43**, with the lower end **52**, extending slightly beyond the lower open end **47** of the bore **43**. The wedging compresses the collar **48**, with the slots **50** facilitating the compression. During compression, the inner diameter of the collar decreases. As the collar **48** compresses, it presses against the drop tube **20** to effectuate a compressive clamping of the drop tube **20** inside the cylinder **42**. The collar 48 is preferably formed from metal of a sufficient thickness for the strips **49** to flex inward when compressed and return to their original positions when released.

To enable a secure compressive locking, a tightening nut **53** preferably is used. The nut **53** is internally threaded at **54** and threadedly attaches to external threads **55** disposed on the narrow end **52** of the collar **48**. As can be seen from FIGURE 2, the narrow end **52** is not tapered, in the region of the threads. As the nut **53** is tightened, the collar **48** is compressively drawn into the opening **44** of the cylinder **42** to effectuate the compressive clamping. In place of threads, other means of tightening the nut onto the collar are also contemplated. Optionally, a lock washer **56** is included to prevent the nut **53** from loosening. Furthermore, although a slotted wedge-shaped collar **48** is illustrated, other wedge-shaped elements are suitably substituted therefore as desired. For example, a collet or other type of locking tube is also contemplated. In another embodiment, only one of the collar **42** and cylinder **42** has a taper, for example, the cylinder bore **43** may have a constant diameter **D** while the collar is tapered, or the collar have a constant diameter d while the cylinder **42** is tapered.

FIGURE 3 particularly illustrates the subject wedge lock mechanism **40** and selected suspension system components in their assembled configuration. As can be appreciated, by tightening the nut **53**, the wedge **48** is drawn further into the narrowing bore **43** of the securing

element **14**, **42** and is clamped into place. The slots **50** within the wedge **48** allow the wedge **48** to compress and tighten around the outer surface of the drop tube **20**. The drop tube **20** is essentially thereby fixed within the wedge-shaped collar **48** and the cylinder **42** through frictional forces created between the component parts. The wedge lock mechanism **40** advantageously provides for continuous and repeatable height adjustment, by simply loosening the nut **53**, sliding the drop tube **20** to its new position relative to the cylinder **42** and, more importantly, to the floor, and retightening the nut **53**.

The length of drop tube **20** which extends below the cylinder **42** is thus infinitely variable between an upper position, in which the uppermost spindle **32** is flush with the nut **53**, and a lower position, in which the upper end of the tube **20** is clamped by the collar. The excess, upper portion of the drop tube **20** is thus "stored" until needed within the cylinder **42** and may extend upward, into the space above the ceiling **18**, thus providing for the portion of the drop tube below the cylinder **42** to be increased or decreased in length, as the need arises.

With continuing reference to FIGURES 1 through 3 and with further reference to FIGURE 4 which shows a perspective exploded view of the suspension system **10**, the suspension system **10** is connected using the fasteners **16** (FIGURE 1) which insert into a selected plurality of the openings **58** in the cheeseplate **14**. The cosmetic ceiling cover **38** (FIGURES 1 and 4) is secured by locking half-rings **60** (FIGURE 4). Since the cosmetic ceiling cover 38 is not a weight-bearing component, the securing does not need to be particularly strong, and various securing components are contemplated in place of the rings **60**.

Preferably, a safety ring assembly **70** is provided to prevent the tube **20** from pulling through the collar **48** in the unlikely event that the system loosens. The safety ring assembly attaches to the tube **20** above the collar **48** using suitable fasteners **72**, such as bolts, screws or the like (FIGURE 5). In that way, if the tube **20** slides

relative to the collar **48**, contact is made between the split rings of the safety ring and the upper end of the tapered collar urging the collar into further compression against the tube and also mechanically preventing the tube from pulling through the collar.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A suspension system for suspending one or more of lightheads, monitors, task lights, cameras, and other medical apparatus from an overhead structure at a selectable height, the suspension system comprising a drop tube configured for supporting the one or more of lightheads, monitors, cameras, and other medical apparatus, characterized by:

a receiving element which receives the drop tube such that a distal end of the drop tube extends below a lower end of the receiving element;

a collar which is received by the receiving element and surrounds a portion of the drop tube to effectuate a compressive clamping of the portion of the drop tube that is inside the receiving element such that a length of the drop tube which extends below the lower end of the receiving element is variable; and

means for mounting the receiving element to the overhead structure.

2. The suspension system of claim 1, further characterized by:

the means for mounting including a mounting plate rigidly connected with the receiving element and configured for mounting to the overhead structure, the mounting plate having an opening through which an end of the drop tube passes.

3. The suspension system of claim 1 or claim 2, further characterized by:

the receiving element having an inside diameter D which decreases toward the lower end.

4. The suspension system of claim 3, further characterized by:

the receiving element inside diameter being defined by a generally frustoconical bore.

5. The suspension system of any one of preceding claims 1-4, further characterized by:

the collar having an outer diameter d which decreases toward a lower end thereof.

6. The suspension system of claim 5, further characterized by:

the outer diameter of the collar being greater than a minimum inside diameter of the receiving element.

7. The suspension system of any one of preceding claims 1-6, further characterized by:

a tightening nut adapted to thread onto a portion of the collar to compressively draw the collar into the receiving element.

8. The suspension system of any one of preceding claims 1-7, further characterized by:

the collar including at least one longitudinally extending slot.

9. The suspension system of claim 8, further characterized by:

the collar including a plurality of longitudinally extending slots.

10. The suspension system of either one of preceding claims 8 and 9, further characterized by:

the at least one slot defining a flexible strip which deflects radially inward when compressive exterior force is applied to the collar.

11. The suspension system of any one of preceding claims 1-10, further characterized by: the drop tube comprising a cylinder of generally uniform exterior diameter.

12. The suspension system of any one of preceding claims 1-11, further characterized by:

a rotatable spindle disposed at a lower end of the drop tube.

13. The suspension system of claim 12, further characterized by:

an articulating arm attached to the rotatable spindle, the articulating arm having at least one adjustable joint and an attachment end adapted to receive one of the lightheads, monitors, task lights, cameras, and other medical apparatus.

14. The suspension system of any one of preceding claims 1-13, further characterized by:

a length of the distal end of the drop tube which extends below the receiving element being infinitely variable between upper and lower limits.

15. The suspension system of any one of preceding claims 1-14, further characterized by:

the collar having a substantially frustoconical exterior surface, the frustoconical exterior surface engaging a substantially frustoconical interior surface of the receiving element.

16. The suspension system of any one of preceding claims 1-14, further characterized by:

the collar having a bore shaped to receive the drop tube slidingly therethrough, absent a compressive force being applied to the collar.

17. The suspension system of any one of preceding claims 1-16, further characterized by:

the collar including:

an outer surface of narrowing diameter terminating at a narrow end, which outer surface compressively wedges at least partially into an axial bore of the receiving element; and

an inner surface which compresses against the drop tube at a selected point responsive to the wedging to secure the drop tube in the drop tube bore at the selected point.

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18. A method of variably adjusting a distance, relative to a fixed surface, of a distal end of a drop tube for supporting a medical device, the method comprising rigidly supporting a receiving element from the fixed surface, the method characterized by:

loosely inserting a collar into a bore of the receiving element;

inserting the drop tube into the collar such that an end of the drop tube extends a selected distance below the receiving element, the distance of the drop tube which extends below a lower end of the receiving element being variable; and

drawing the collar into the receiving element bore such that the drop tube is compressively clamped by the receiving element and collar.

19. The method of claim 18, further characterized by:

the step of drawing the collar into the bore including tightening a nut on a portion of the collar.

20. The method of either one of claims 18 and 19, further characterized by:

the collar including a plurality of longitudinally extending, spaced slots, step of drawing the collar into the bore including compressing portions of the collar defined between the slots.

21. A suspension system substantially as herein described in any one of the embodiments in the detailed description of the invention with reference to the drawings.

22. A method of variably adjusting a distance, relative to a fixed surface, of a distal drop tube for supporting a medical device substantially as herein described in any one of the embodiments in the detailed description of the invention with reference to the drawings.

DATED THIS TWENTY-NINTH DAY OF OCTOBER, 2004.

STERIS INC.; ONDAL INDUSTRIETECHNIK GMBH
BY
PIZZEYS PATENT AND TRADE MARK ATTORNEYS

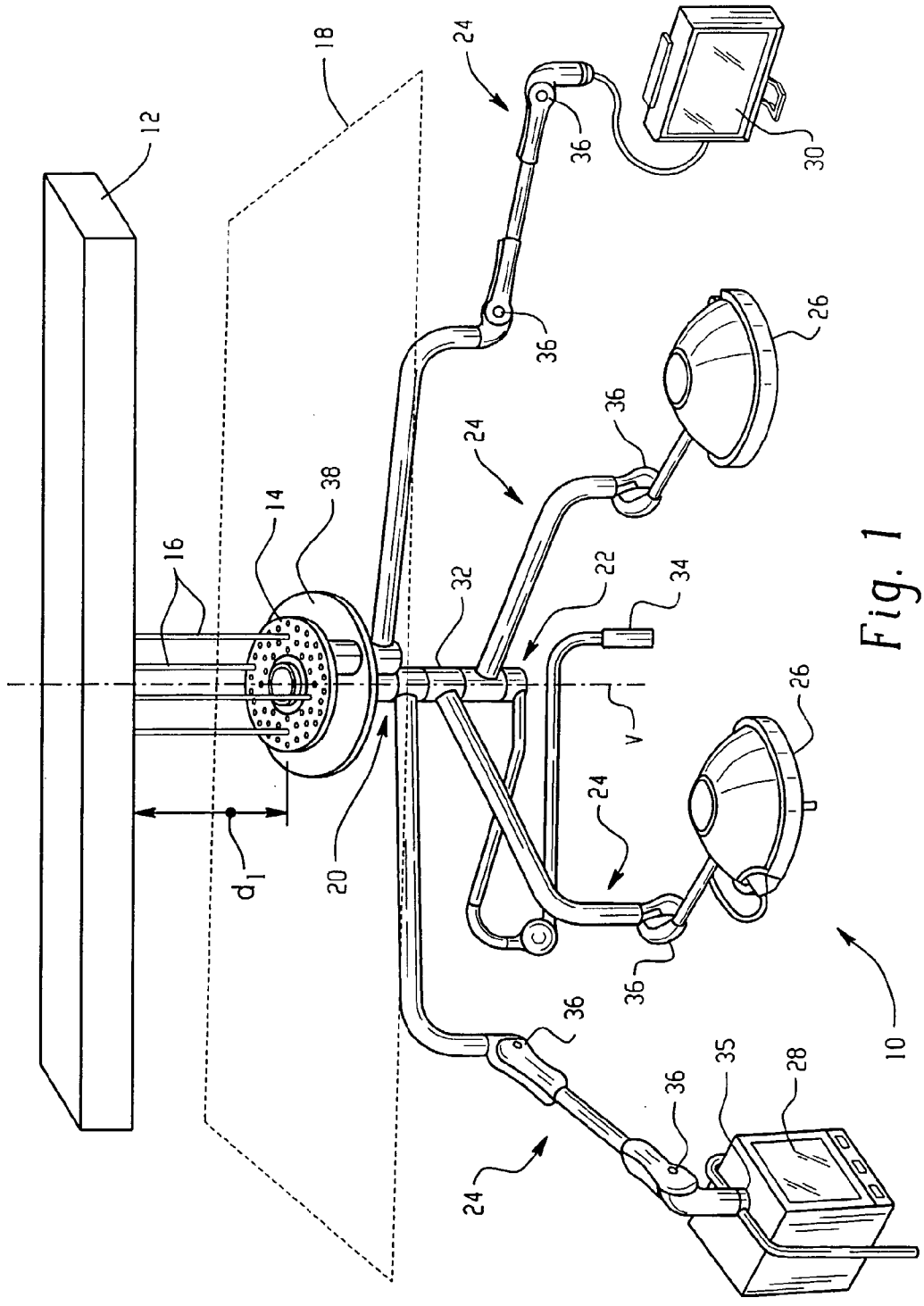
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Fig. 1

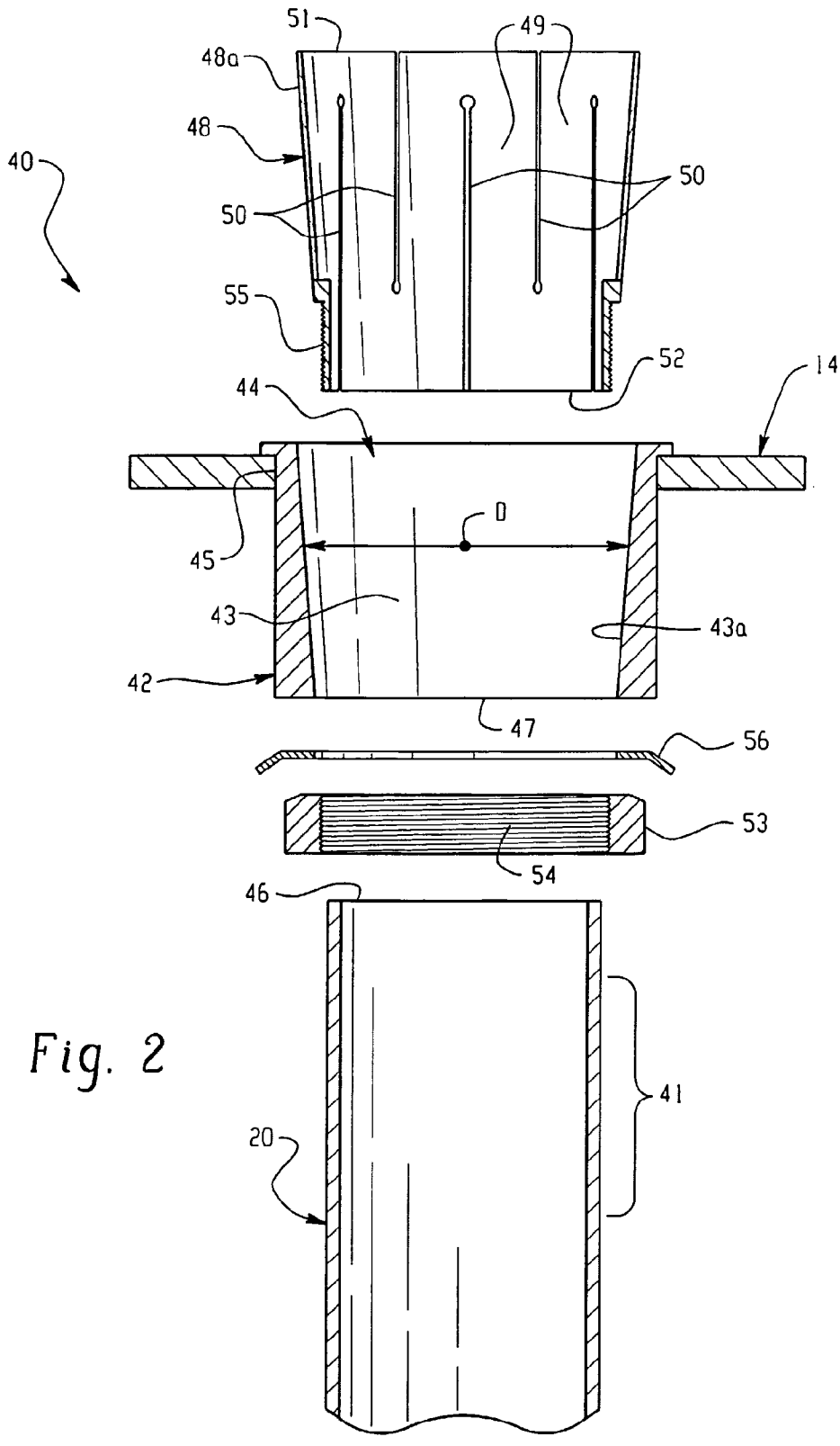


Fig. 2

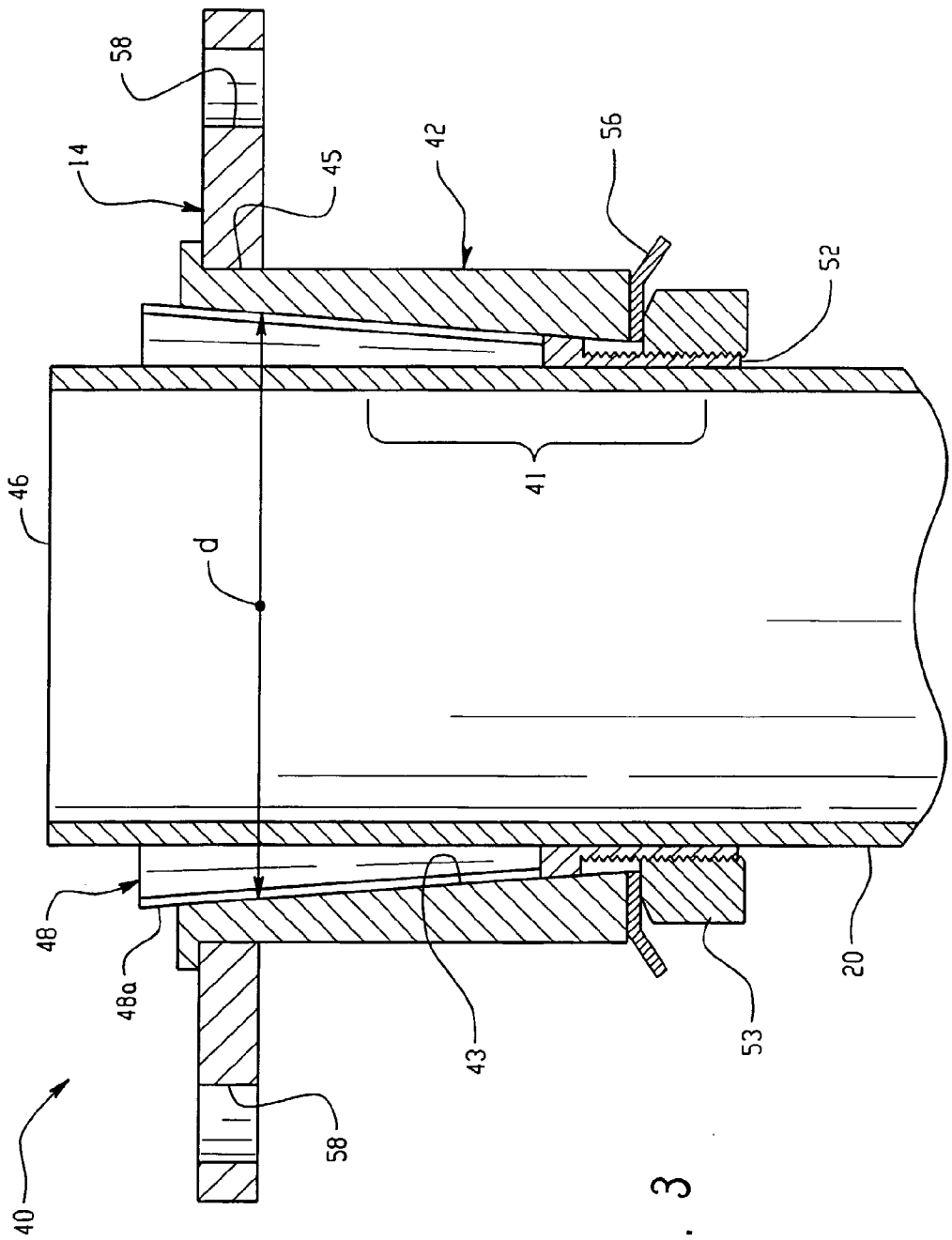


Fig. 3

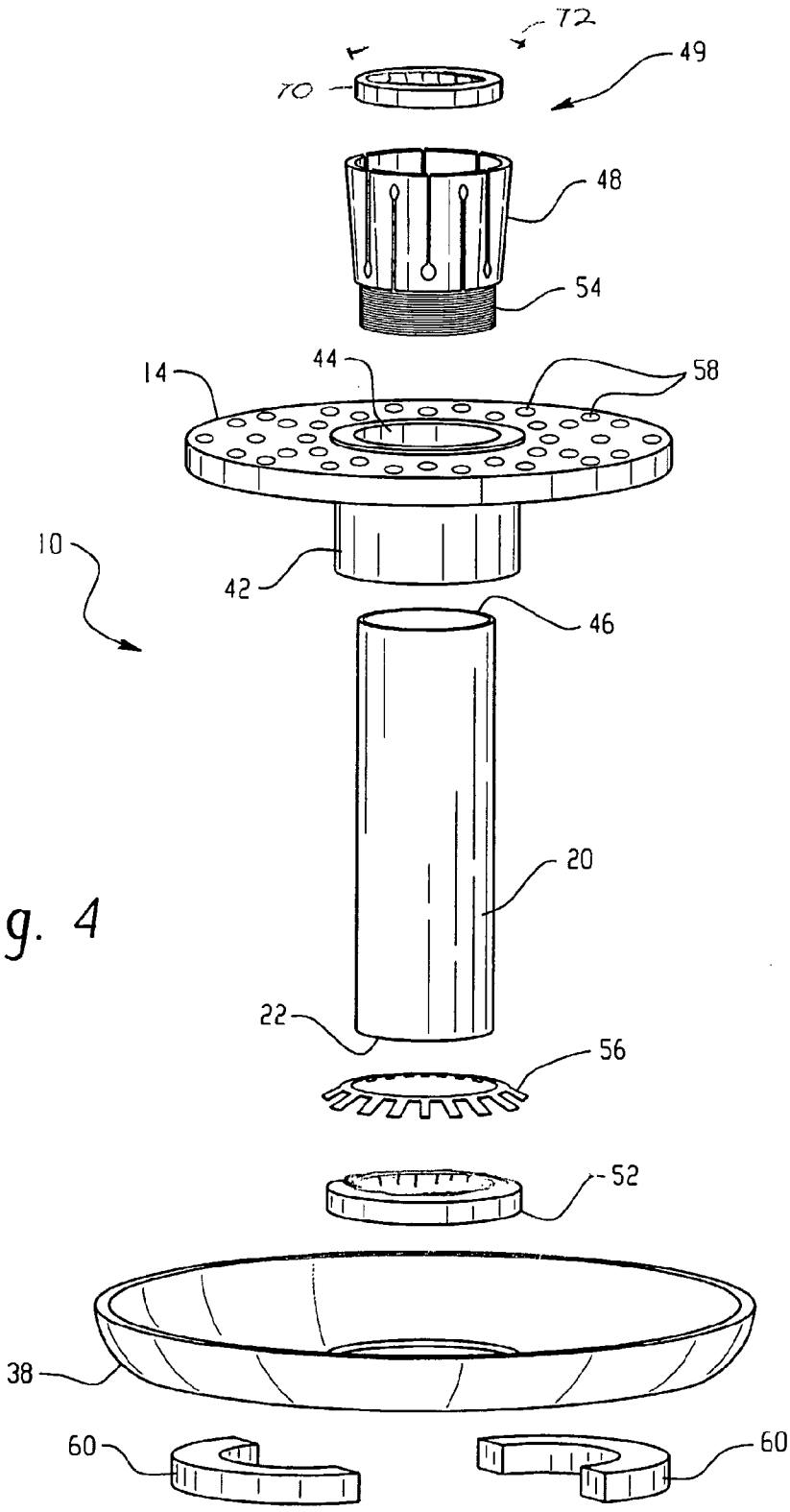


Fig. 4

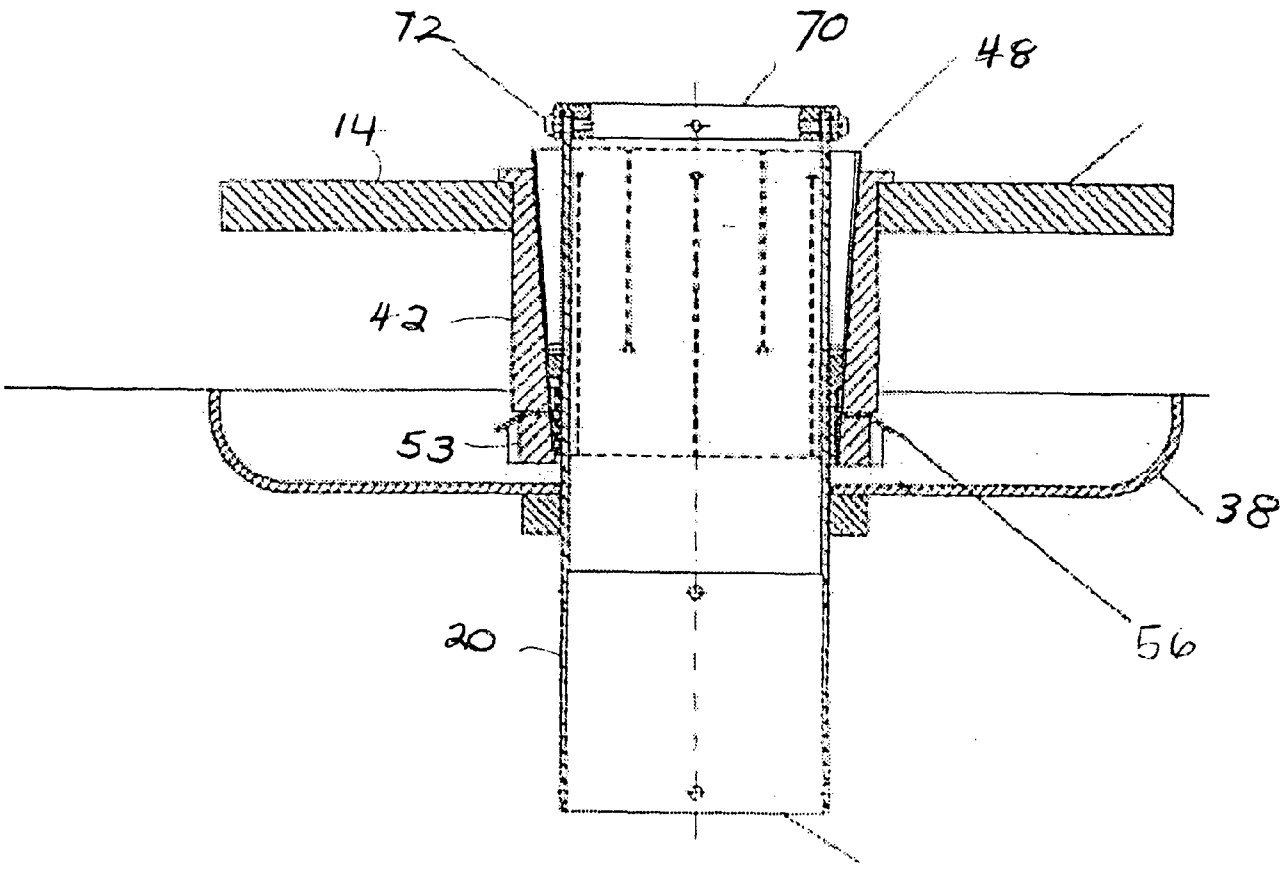


FIG. 5