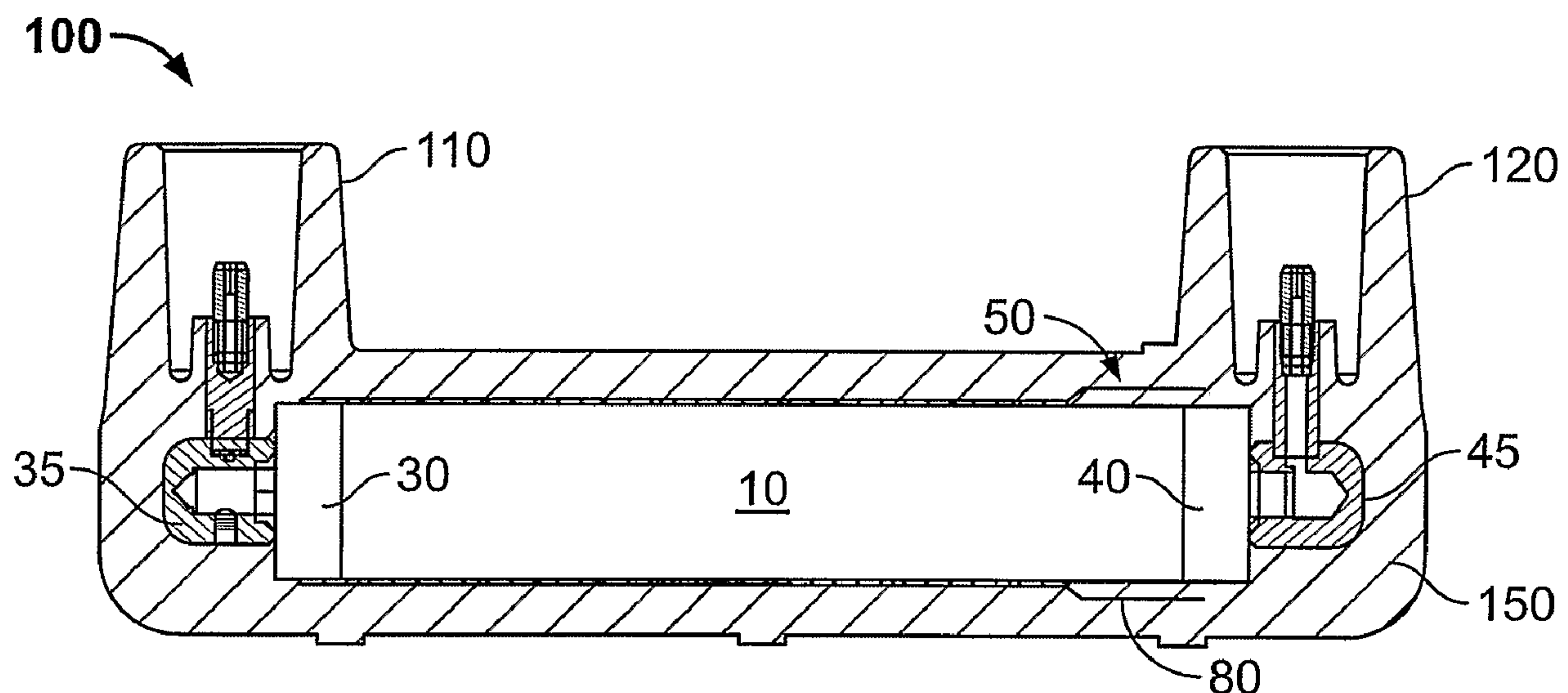




(86) Date de dépôt PCT/PCT Filing Date: 2004/10/05
(87) Date publication PCT/PCT Publication Date: 2005/04/28
(45) Date de délivrance/Issue Date: 2012/06/12
(85) Entrée phase nationale/National Entry: 2006/04/10
(86) N° demande PCT/PCT Application No.: US 2004/032681
(87) N° publication PCT/PCT Publication No.: 2005/038846
(30) Priorité/Priority: 2003/10/10 (US60/510,265)

(51) Cl.Int./Int.Cl. *H01H 85/175* (2006.01),
H01H 85/165 (2006.01)
(72) Inventeurs/Inventors:
MARTIN, DONALD R., US;
SHOOSHTARIZADEH, MOHAMMAD, US
(73) Propriétaire/Owner:
G & W ELECTRIC COMPANY, US
(74) Agent: BERESKIN & PARR LLP/S.E.N.C.R.L.,S.R.L.

(54) Titre : FUSIBLE ENCAPSULE AVEC ECRAN ANTI-EFFLUVES
(54) Title: ENCAPSULATED FUSE WITH CORONA SHIELD



(57) Abrégé/Abstract:

An encapsulated fuse (10) for power distribution systems and method for producing such fuses is provided. A fuse includes a body (20) with opposing terminals (30, 40). A corona shield (50) is generally coaxial with the fuse (10) and substantially extends the full length of the fuse body (20). The corona shield (50) is electrically coupled at its first end (70) with a first fuse terminal (30). The second end (80) of the corona shield (50) has a slightly larger cross-section than the first end (70) to provide electrical isolation from the second fuse terminal (40). The fuse (10) and attached corona shield (50) are molded in an encapsulating material (150).

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
28 April 2005 (28.04.2005)

PCT

(10) International Publication Number
WO 2005/038846 A1

(51) International Patent Classification⁷: **H01H 85/175,**
85/165

(21) International Application Number:
PCT/US2004/032681

(22) International Filing Date: 5 October 2004 (05.10.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/510,265 10 October 2003 (10.10.2003) US

(71) Applicant (for all designated States except US): **G & W ELECTRIC COMPANY** [US/US]; 3500 West 127th Street, Blue Island, IL 60406-1864 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **MARTIN, Donald, R.** [US/US]; 608 Bryan Trail, New Lenox, IL 60451 (US). **SHOOSHTARIZADEH, Mohammad** [IR/US]; 14628 Aston Way, Lockport, IL 60441 (US).

(74) Agent: **STERN, Martin, L.**; Michael Best & Friedrich LLP, 401 N. Michigan Avenue, Suite 1900, Chicago, IL 60611 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

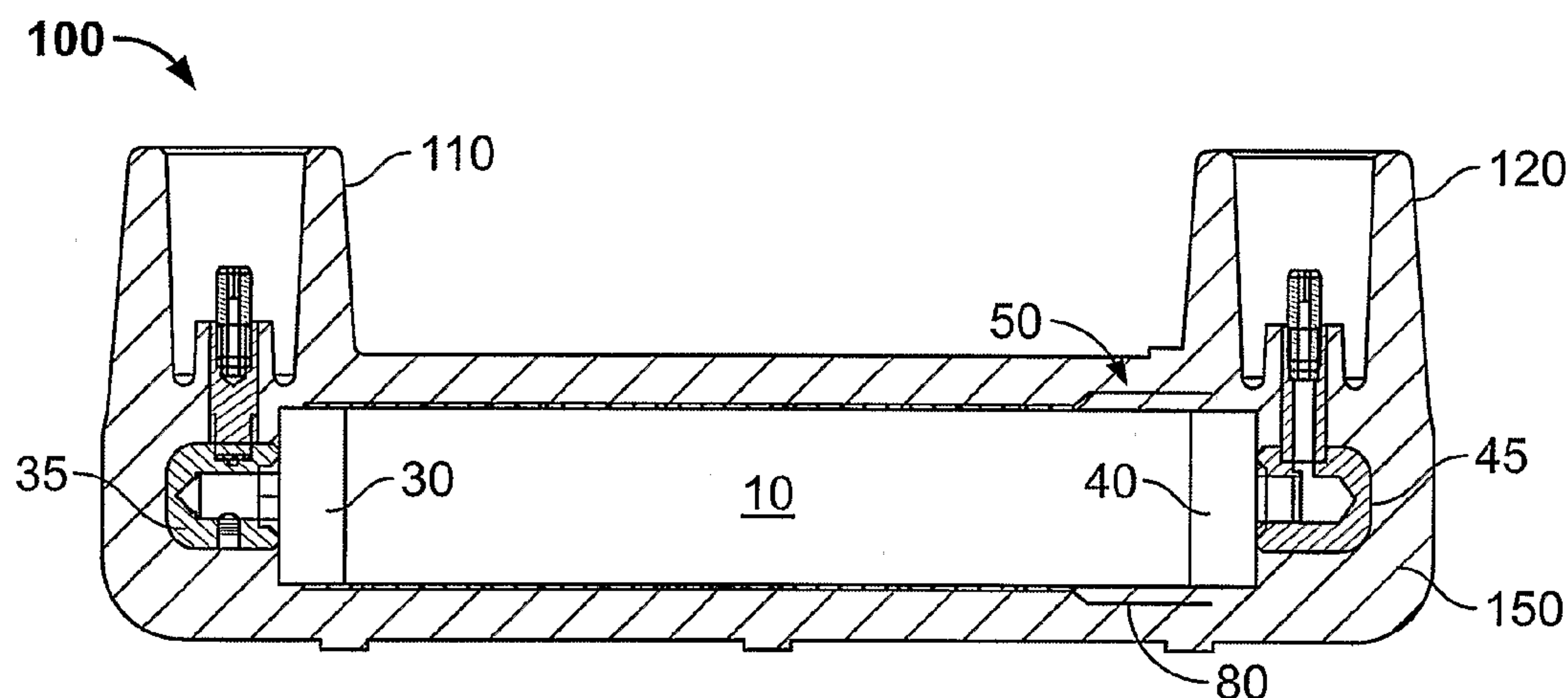
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

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.

(54) Title: ENCAPSULATED FUSE WITH CORONA SHIELD



(57) Abstract: An encapsulated fuse (10) for power distribution systems and method for producing such fuses is provided. A fuse includes a body (20) with opposing terminals (30, 40). A corona shield (50) is generally coaxial with the fuse (10) and substantially extends the full length of the fuse body (20). The corona shield (50) is electrically coupled at its first end (70) with a first fuse terminal (30). The second end (80) of the corona shield (50) has a slightly larger cross-section than the first end (70) to provide electrical isolation from the second fuse terminal (40). The fuse (10) and attached corona shield (50) are molded in an encapsulating material (150).

WO 2005/038846 A1

ENCAPSULATED FUSE WITH CORONA SHIELD

[0001] Blank.

FIELD OF THE INVENTION

[0002] The present invention pertains to current interrupting devices. More particularly, the present invention relates to encapsulated fuses for shielded power distribution systems.

BACKGROUND OF THE INVENTION

[0003] Now more than ever, electric utility power distribution systems are being constructed underground. Underground systems pose new operational and maintenance challenges by virtue of being largely unseen. In response to these challenges, organizations such as the Institute of Electrical and Electronics Engineers (IEEE) and the American National Standards Institute (ANSI) have implemented standards and codes to insure operating personnel safety and proper system performance. One such standard recommends the grounding (i.e., shielding) of individual underground distribution system components at multiple system points (e.g., cable splices, transformers, switches). Grounding system components (or their enclosures) helps eliminate accessibility to hazardous voltages by operating personnel.

[0004] Fuses are well known for use in power distribution systems for reliable interruption of fault current where reclosing is not required. When used in underground applications such as direct burial, switchgear, or vaults where there is a high probability of submersion, it is desirable for fuses to be compact and enclosed or encapsulated in electrically insulating, high dielectric strength material. To ground an underground fuse in order to protect personnel from hazardous voltages, the entire exterior must be conductive, producing a ground plane thereon. As a result, steep voltage gradients throughout the insulating material of the fuse are formed. The high system voltages present in the fuse are separated from the ground plane by a relatively thin insulating material. Under these conditions there is a tendency for the fuse to become electrically stressed and corona to discharge or arc within the fuse (e.g., discharge through the insulating material from the

high voltage fusible element to the exterior ground plane). After the fuse has been subjected to such corona discharge for a long period of time, the fusible elements can be damaged and may not operate properly under short circuit or fault-interrupting conditions.

[0005] In order to mitigate corona discharge within the fuse, high voltage stress to the fusible elements must be eliminated. One established method to eliminate the high voltage stress inside the fuse is to envelope the fuse with a conductive surface that is at the same potential as the fusible element. This method of enveloping the fuse finds support in the Faraday Cage theory in which a conductive enclosure acts as a shield against electric fields and electromagnetic waves. Previous attempts to enclose the fuse have focused on applying a conductive or semiconductive coating such as paint to the fuse exterior surface. Although the applied coating may help eliminate voltage stress, often the coating provides fault current with a secondary conductive path (e.g., flashover) during a "blown" fuse condition thereby rendering the fuse useless.

[0006] Effective elimination of corona in encapsulated fuses for power distribution systems has been elusive. In view of the foregoing, it would be desirable to provide an encapsulated fuse that resists both corona discharge and flashover.

BRIEF SUMMARY OF THE INVENTION

[0007] In one aspect, the present invention provides a fuse assembly which includes a fuse having a first terminal, a second terminal and a current conducting fusible element disposed therebetween and electrically connecting the first terminal and the second terminal. A single electrically conductive member is disposed about the fuse and is electrically coupled with the first terminal and, upon failure of the current conducting fusible element, is electrically isolated from the second terminal. The single electrically conductive member includes a first end having a first diameter, a second end having a second diameter larger than the first diameter and a conical transition portion positioned between the first end and the second end. An electrically insulating housing encapsulates the single conductive member in the fuse and an electrically conductive or semi conductive material is disposed about the electrically conductive housing and configured to provide a ground plane for the fuse assembly.

2a

[0007a] In another aspect, the invention provides a method for producing a fuse assembly including a single corona shield, the method comprising forming the single corona shield to have a first end with a first diameter, a second end with a second diameter larger than the first diameter, and a conical transition portion positioned between the first end and the second end;

electrically coupling the single corona shield with a fuse;

disposing the fuse and single corona shield in a mold;

casting the fuse and single corona shield in electrically isolating material so that, upon failure of the fuse, the corona shield is electrically isolated from a second terminal of the fuse; and

disposing an electrically conductive or semiconductive material about the electrically isolating material.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 illustrates an exemplary embodiment of a corona shield and an exemplary fuse;

[0009] FIG. 2 illustrates the exemplary corona shield and fuse of FIG. 1 coupled together;

[0010] FIG. 3 is a perspective close-up view of FIG. 2 illustrating a radial gap between the fuse and corona shield;

[0011] FIG. 4 illustrates a perspective view of an exemplary encapsulated fuse; and

[0012] FIG. 5 illustrates a side cross-sectional side view of the exemplary encapsulated fuse of FIG. 4.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

[0013] Referring now to the Figures and particularly FIG. 1 an exemplary current limiting fuse 10 is shown. The fuse 10 includes a cylindrical body 20, a first fuse endcap terminal 30 and a second fuse endcap terminal 40. The fuse body 20 encloses a fusible element that electrically connects the first terminal 30 to the second terminal 40. The fuse body 20 may be made of a fiberglass or dielectric material whereas the terminals 30, 40 are conductive. As known in the art, one of the terminals 30, 40 may be vented. When installed in a power distribution system one of the first and second terminals 30, 40 is connected to an electrical source such as a feeder and the other of the first and second terminals 30, 40 is connected to a load so that the fuse 10 completes an electrical circuit therebetween. With reference to the exemplary embodiments herein, terminal 40 may be vented and associated with the load, whereas terminal 30 is associated with the line (i.e., source), but the terminal venting and associated connections thereto may be otherwise. The fuse 10 operates to conduct current at or below its predetermined (i.e., steady state) current rating. Above the predetermined current rating of the fuse 10, the fusible element disconnects the first terminal 30 from the second terminal 40 by melting, gas extinguishing an arc or a combination thereof or other means known in the art, thereby opening the electric circuit. In this open state, the fuse 10 is referred to in the art as "blown". Depending on the ratings and time-current characteristics of the fuse 10, it may be used for various applications where circuit reclosing is not required including steady state overcurrent protection, fault protection, or both. Such current limiting fuses are well known for use in overhead and underground applications in power distribution systems.

[0014] As is known in the art, for underground applications where submersion is probable such as direct burial, vaults and switchgear, the fuse 10 is preferably encapsulated such as in an environmental housing. An exemplary encapsulated fuse assembly 100 comprising the fuse 10 is illustrated in FIG. 4. To ensure the safety of operating personnel, the encapsulated fuse assembly 100 is shielded (i.e., grounded) by coating the outer surface of the encapsulation with a conductive or semiconductive layer (not shown). One exemplary coating for the fuse assembly 100 is Electrodag 502 semi-conductive paint available from the Acheson Colloids Company of Port Huron, Michigan, but other suitable coatings may be employed. Thus, when the fuse assembly 100 is installed in a shielded distribution system the encapsulation outer surface provides a ground plane (i.e., is at ground potential). However, since the outer surface of the encapsulated fuse assembly 100 is at ground potential during fuse operation, the grounded surface, which is in close proximity to the fuse 10, causes voltage stresses inside the assembly 100 that may cause corona discharge and damage to the fusible element over time. To prevent corona discharge within the fuse assembly 100 a corona shield is provided.

[0015] As shown in FIGs. 1 and 2 an exemplary corona shield 50 includes an elongated cylindrical body 60 which is adapted to substantially encompass the entire length of the fuse body 20. The corona shield 50 is metallic or otherwise conductive and includes a coupling end 70 and an opposing end 80. One exemplary shield 50 is formed of aluminum. The coupling end 70 has a substantially similar diameter as the fuse body 20 and terminals 30, 40 to couple therewith such as by a friction fit or the like. As shown in FIG. 2, the corona shield 50 is placed over the fuse 10 and is coaxial therewith. Although the fuse 10 and shield 50 are illustrated and described herein such that the coupling end 70 is attached with the first terminal 30 and the opposing end 80 is associated with the second terminal 40, this arrangement is not to be restrictive and may be reversed such that the coupling end 70 is attached to the second terminal 40 and the opposing end 80 is associated with the first terminal. The shield 50 may taper or flare slightly outward from the coupling end 70 to a point proximate the opposing end 80 to facilitate installation of the shield 50 onto the fuse 10.

[0016] The coupling end 70 of the shield 50 is attached to and in electrical contact with the first terminal 30 of the fuse, and the opposing end 80 bells out slightly from the diameter

of the coupling end 70 to have a somewhat larger diameter than the fuse body 20 and terminals 30, 40. As best illustrated in FIG. 3, a radial gap G exists between the opposing end 80 of the corona shield 50 and the proximate fuse terminal 40. The coupling end 70 of the shield 50 may be attached to the first terminal 30 of the fuse by soldering, gluing, welding or other suitable means known in the art so that the shield 50 assumes the voltage potential of the first terminal 30. One exemplary attachment means is Epic S7076 manufactured by Epic Resins of Palmyra Wisconsin. As is known, Epic S7076 is a carbon-filled, electrically conductive epoxy system that can be easily applied by hand or automatic dispensing equipment. Other electrically conductive epoxy systems may be suitably substituted.

[0017] As previously mentioned, the opposing end 80 of the shield 50 has a slightly larger diameter than the coupling end 70 and is radially spaced away from the second terminal 40 of the fuse 10. As shown in FIGs. 2 and 3, the coupling end 70 and opposing end 80 each axially overlap a portion of their respective terminals 30, 40 so that the fuse body 20 is encompassed by the shield 50. In one exemplary embodiment, the length of the shield 50 is slightly longer than the fuse body 20 so that when the coupling end 70 is attached to the terminal 30 the opposing end 80 of the shield 50 overlaps a portion of the second terminal 40 proximate the fuse body 20 by approximately a quarter of an inch. By substantially encompassing the fuse body 20 with a conductive element, steep voltage gradients and corona discharge are prevented since the shield 50 is at the same potential as the fuse element. Additionally, the transition portion T (FIG.3) of the shield 50, which is proximate the opposing end 80, transitions from a first diameter to a second diameter in a curved or otherwise smooth manner. In this way, the transition portion T further obviates corona discharge, which is known to generally occur near sharp edges and abrupt transitions.

[0018] As shown in FIG. 2, the corona shield 50 may be formed from a perforated metallic sheet so that dielectric material such as viscous epoxy or the like may flow freely around and through the shield 50 during the encapsulation/molding process. Alternatively, the shield 50 may be a metallic screen or mesh material suitable to withstand the molding process. As can be appreciated from FIGs. 3 and 4, when the combination fuse 10 and shield 50 is fully encapsulated, the second terminal 40 of the fuse 10 is radially isolated

from the opposing end 80 of the shield by a generally annular portion of the dielectric encapsulation material that fills the gap G. Since the encapsulation has a high dielectric withstand capability, the annular dielectric portion between the isolated end 80 and the second terminal 40 operates to prevent flashover when the fuse 10 is blown.

[0019] The exemplary fuse assembly 100 may be formed or cast in a mold to have bushings 110, 120 (FIG. 4) oriented generally perpendicular to the lengthwise body of the assembly 100 to facilitate connections with the line (i.e., source) and load, but other molds may provide for other suitable shapes of the fuse assembly 100. To this end, as shown in FIG. 5, adapters 35, 45 such as right angle connectors may be coupled with the terminals 30, 40 to provide the electrical connections for bushings 110, 120. One or more of the adapters 35, 45 may be vented as required relative to the venting of the terminals 30, 40. As can be appreciated from FIG. 5, the housing 150 is cast in one piece about the fuse 10 and corona shield 50. As is known, the fuse 10 and corona shield 50 are disposed in a mold and a resin, epoxy or other viscous dielectric material is introduced. Provisions are made in the mold so that electrical connections to the terminals 30, 40 and/or adapter 35, 45 are not impeded by the dielectric housing 150. One exemplary process for producing the assembly 100 includes the steps of: cleaning the shield 50 and fuse 10 exterior by sandblasting; coupling the shield 50 to the fuse 10 by applying an electrically conductive adhesive; coupling the fuse adapters 34, 45 to the fuse 10 terminals 30, 40; disposing the fuse 10 and coupled shield 50 into a mold; and casting the assembly 100 with a viscous dielectric material. Thereafter, a coating of a semi-conductive or conductive material may be applied to the exterior surface of the fuse assembly 100.

[0020] Exemplary embodiments of this invention are described herein. Variations of those embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

What is claimed is :

1. A fuse assembly comprising:
 - a fuse including a first terminal, a second terminals, and a current conducting fusible element disposed therebetween and electrically connecting the first terminal and the second terminal;
 - a single electrically conductive member extending around the fuse, wherein the single electrically conductive member is electrically coupled with the first terminal and, upon failure of the current conducting fusible element, electrically isolated from the second terminal;
 - wherein the single electrically conductive member includes a first end having a first diameter, a second end having a second diameter larger than the first diameter, and a conical transition portion positioned between the first end and the second end;
 - an electrically insulating housing encapsulating the single conductive member and the fuse; and
 - an electrically conductive or semi-conductive material disposed about the electrically conductive housing and configured to provide a ground plane for the fuse assembly.
2. The assembly of claim 1 wherein the electrically conductive member is coaxial with the fuse.
3. The assembly of claim 2 wherein the electrically conductive member is generally cylindrical between the conical transition portion and the first end.
4. The assembly of claim 1 wherein the electrically conductive member comprises a metallic sheet.
5. The assembly of claim 4 wherein the metallic sheet is perforated.
6. The assembly of claim 1 wherein the electrically conductive member comprises a metallic mesh.
7. The assembly of claim 1 wherein the electrically conductive member comprises a metallic screen.

8. The assembly of claim 1 wherein the second end of the electrically conductive member axially overlaps one of the first and second terminals.
9. The assembly of claim 8 wherein the second end axially overlaps the second terminal by about 0.25 inches.
10. The assembly of claim 1 wherein the housing comprises a one-piece material.
11. The assembly of claim 1 wherein the electrically conductive member comprises aluminum.
12. A fuse assembly that reduces corona discharge, the assembly made by the process of:
 - forming a single corona shield to have a first end with a first diameter, a second end with a second diameter larger than the first diameter, a conical transition portion positioned between the first end and the second end, and a length substantially corresponding with a length of a fuse;
 - electrically coupling the single corona shield to a first terminal of the fuse;
 - disposing the fuse and single corona shield in a mold;
 - casting the fuse and single corona shield in electrically insulating material so that, upon failure of the fuse, the single corona shield is electrically isolated from a second terminal of the fuse; and
 - coating the electrically insulating material with an electrically conductive material or semiconductive material.
13. The assembly of claim 12 wherein the corona shield comprises an electrically conductive material.
14. The assembly of claim 12 wherein the corona shield comprises a metallic sheet.
15. The assembly of claim 14 wherein the metallic sheet comprises aluminum.

16. The assembly of claim 12 wherein the electrically insulating material comprises a dielectric material.
17. A method for producing a fuse assembly including a single corona shield, the method comprising:
 - forming the single corona shield to have a first end with a first diameter, a second end with a second diameter larger than the first diameter, and a conical transition portion positioned between the first end and the second end;
 - electrically coupling the single corona shield with a fuse;
 - disposing the fuse and single corona shield in a mold;
 - casting the fuse and single corona shield in electrically isolating material so that, upon failure of the fuse, the corona shield is electrically isolated from a second terminal of the fuse; and
 - disposing an electrically conductive or semiconductive material about the electrically isolating material.
18. The method claim 17 further comprising the step of cleaning the fuse and corona shield.
19. The method of claim 18 wherein the cleaning step comprises sandblasting.
20. The method of claim 17 wherein the coupling step comprises:
 - applying an electrically conductive adhesive to a terminal of the fuse; and
 - bonding the corona shield to the terminal.
21. The method of claim 17 wherein the electrically isolating material includes a dielectric material.
22. The method of claim 17 wherein the dielectric material is chosen from the group consisting of resin and epoxy.
23. A fuse assembly comprising:
 - a fuse with a first terminal and a second terminal;

a single electrically conductive member substantially surrounding and coupled with the fuse, wherein the single electrically conductive member includes a first end having a first diameter, a second end having a second diameter larger than the first diameter, and a conical transition portion positioned between the first end and the second end;

a one-piece electrically isolating enclosure substantially encapsulating the fuse and the single electrically conductive member so that, upon failure of the fuse, the single electrically conductive member is electrically isolated from the second terminal; and

an electrically conductive or semiconductive material disposed about the electrically isolating enclosure member.

24. The assembly of claim 23 wherein the single electrically conductive member overlaps the second terminal of the fuse.

25. The assembly of claim 23 wherein the single electrically conductive member is generally cylindrical and coaxial with the fuse.

1/3

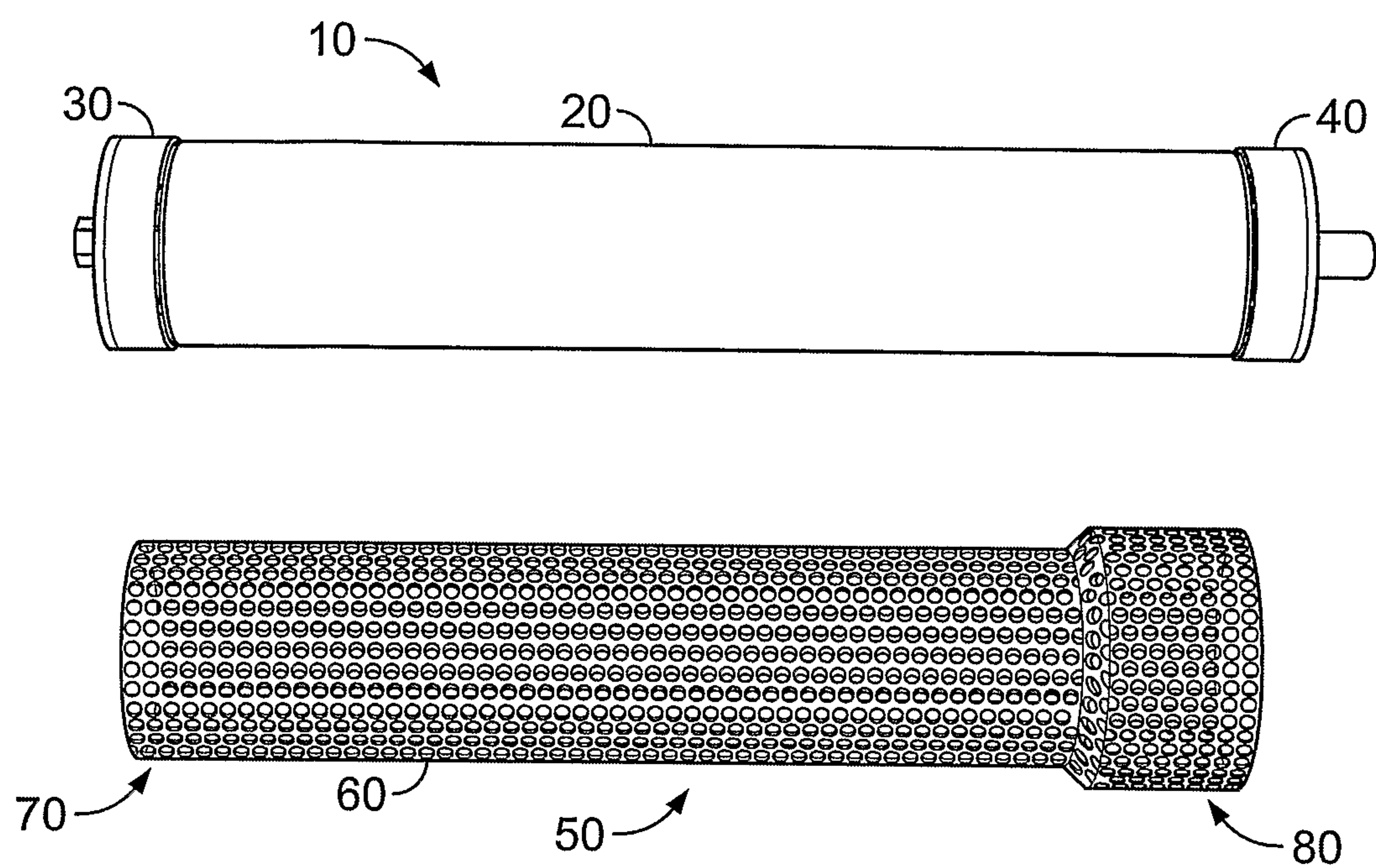


FIG. 1

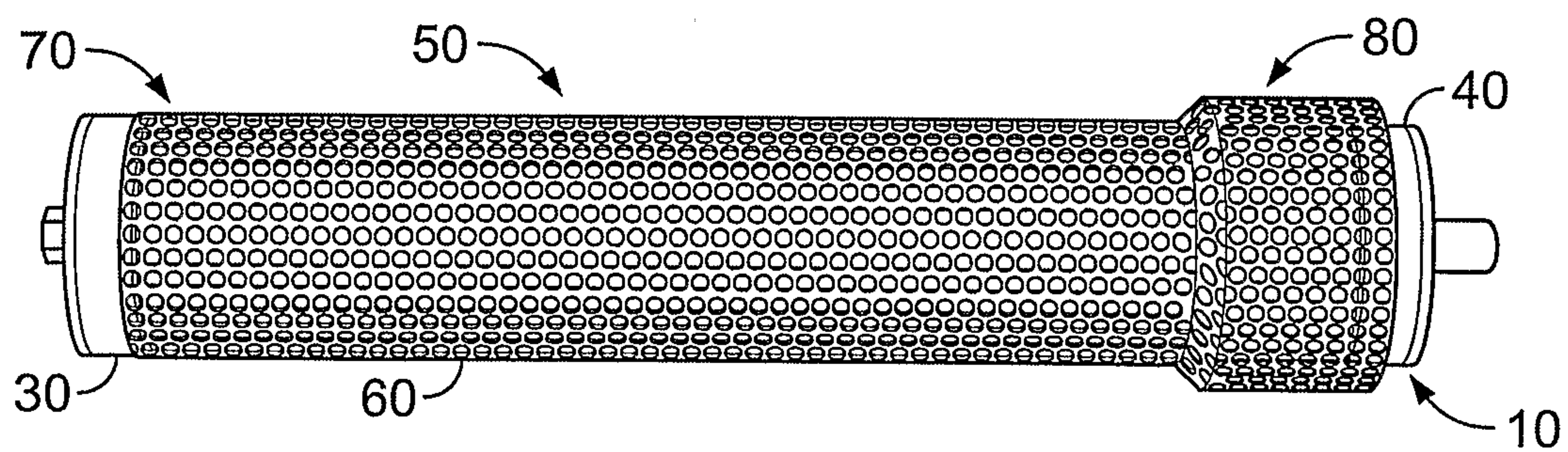


FIG. 2

2/3

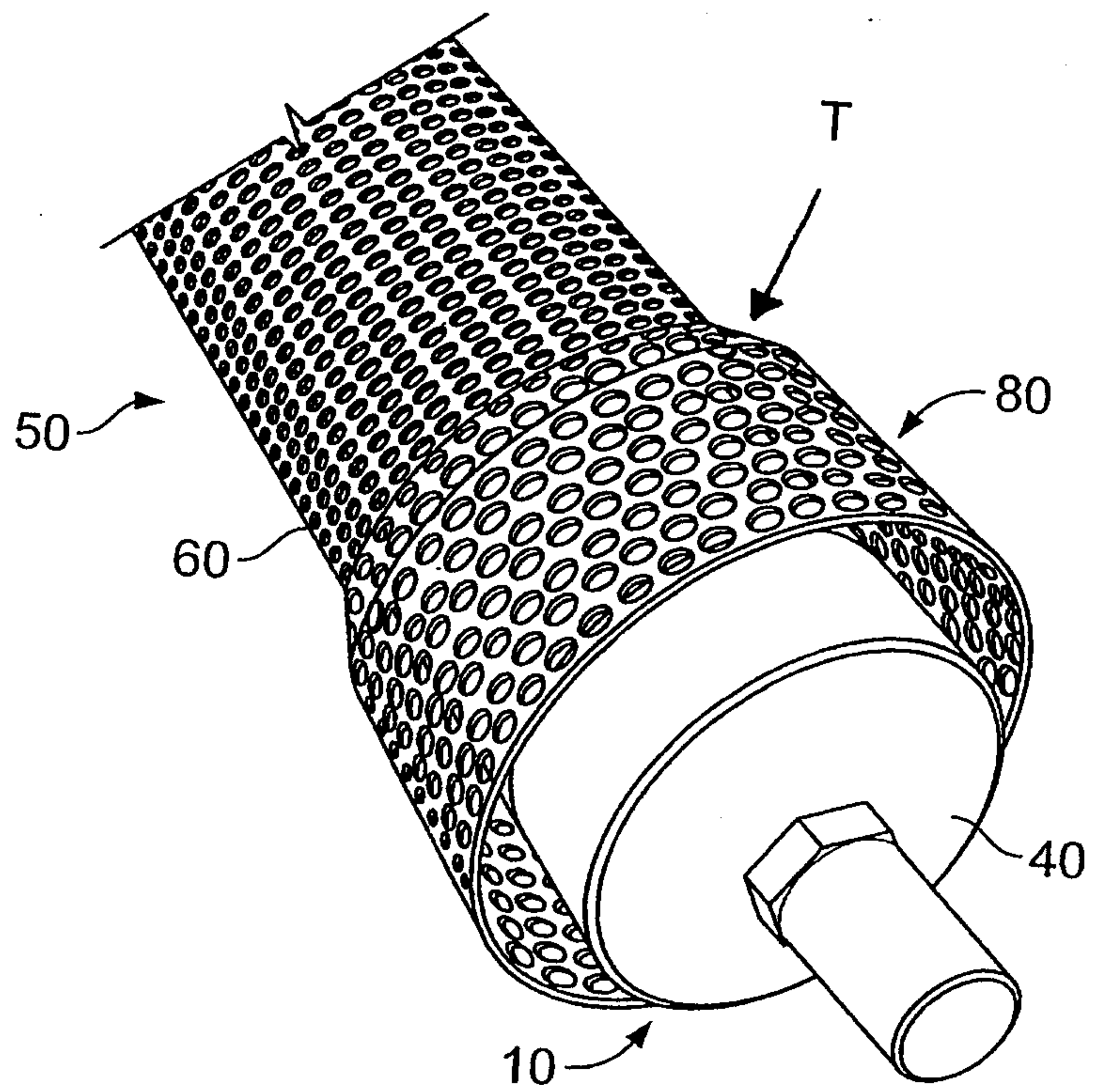


FIG. 3

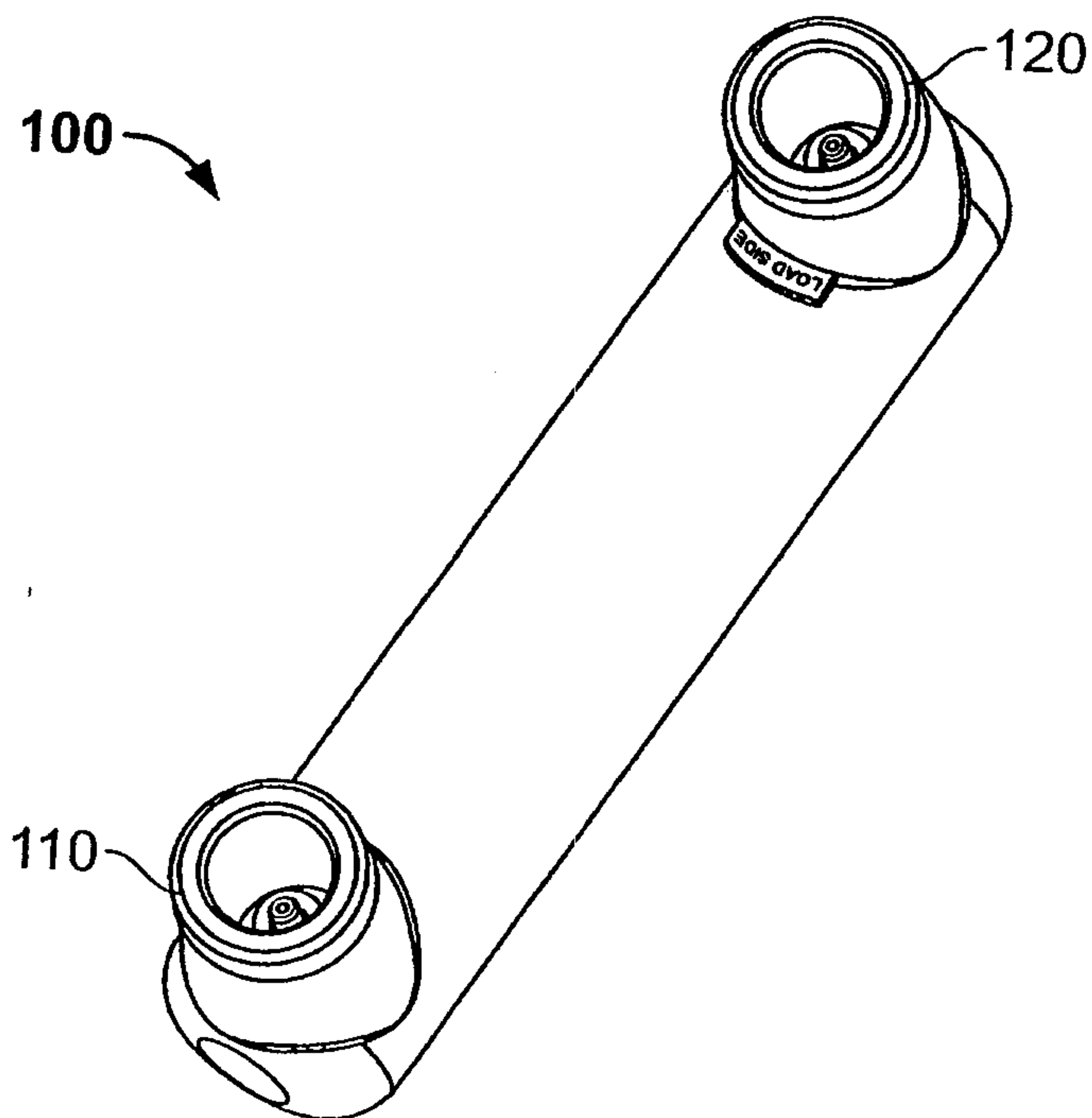


FIG. 4

3/3

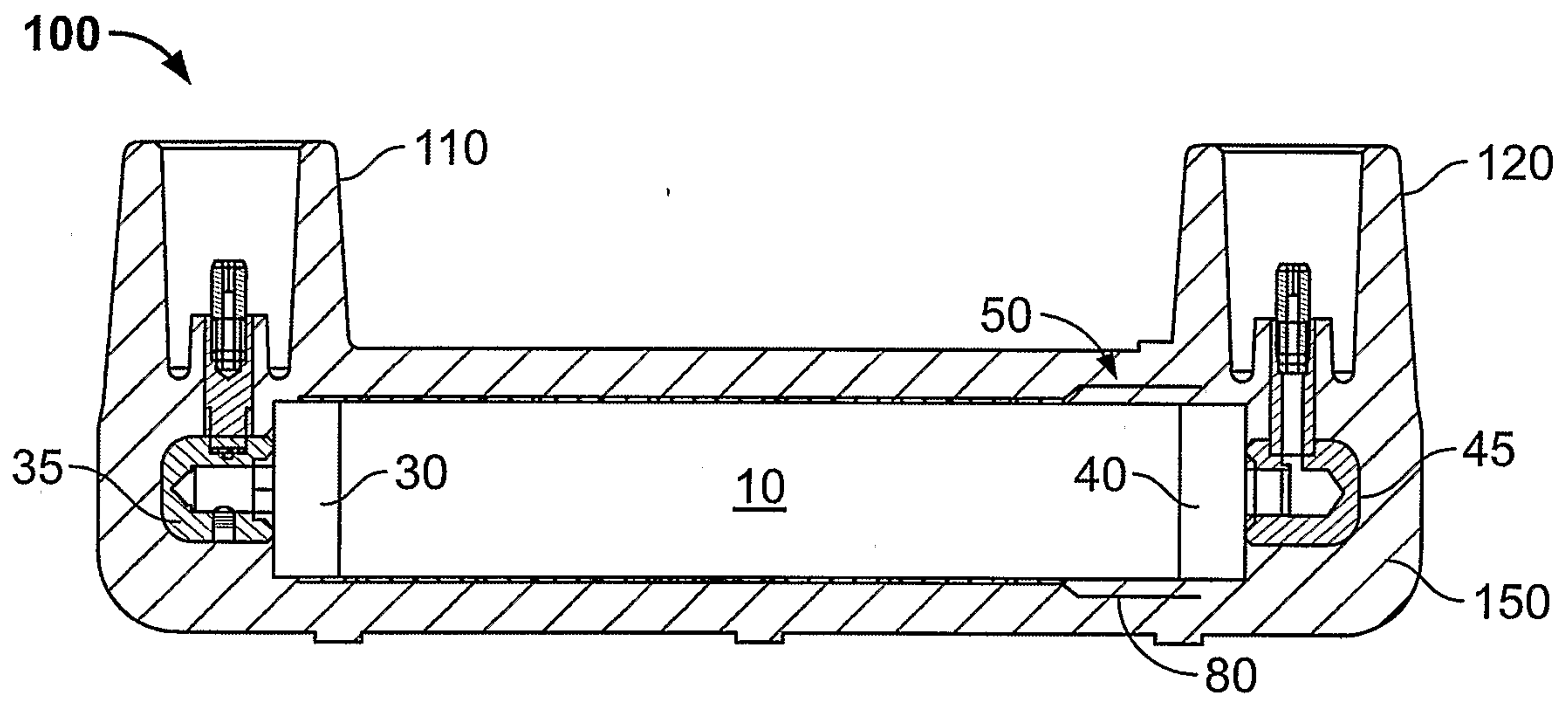


FIG. 5

100

