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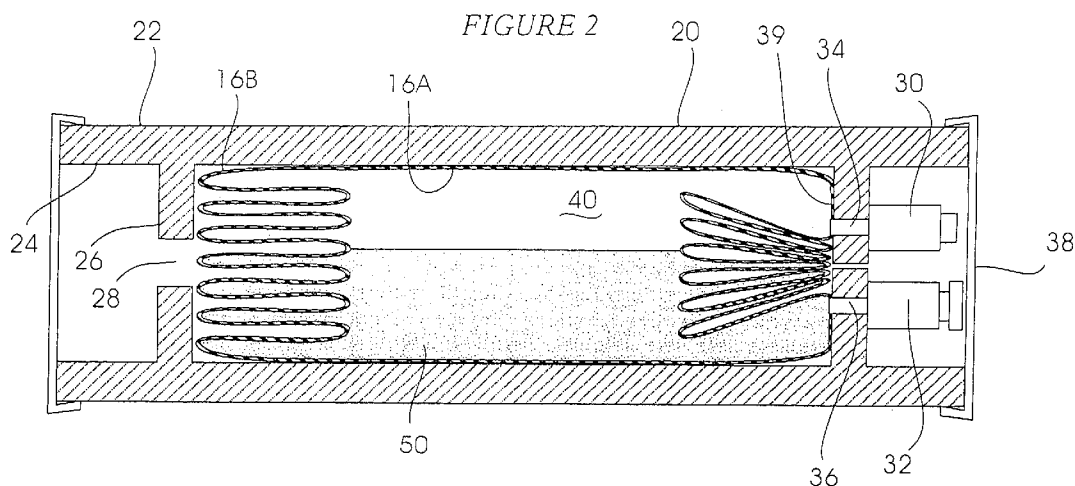
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(57) Abstract: An underground support which includes a gas-inflatable reinforced container into which, after inflation, water is introduced and allowed to react with a setttable substance inside the container.

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SUPPORT

BACKGROUND OF THE INVENTION

5 **[0001]** This invention relates to a support of the kind which is used in an underground excavation for providing load-bearing support between a foot wall and an opposing hanging wall.

10 **[0002]** Supports which are used in underground excavations must meet many demands, some of which are of conflicting nature. A support should, inherently, be strong enough to take the loads which are imposed on it in use yet, ideally, should be compact and light enough particularly to facilitate the transporting and installation thereof in the difficult and arduous conditions which generally prevail underground. Some supports are required to exhibit controlled load versus yield characteristics while in other instances a yield characteristic is not essential.

15 **[0003]** The distance between a hanging wall and an opposed foot wall in a given excavation, or in different excavations, can vary substantially. This works against the use of a support of a standard or predetermined length for, upon installation, some means for adjusting the effective length of the support is required.

[0004] The invention aims to provide a support which, at least partly, addresses the aforementioned requirements.

SUMMARY OF INVENTION

20 **[0005]** The invention provides a support which includes at least one container which is made from a flexible, fluid-impervious sheet material, a valve arrangement for inflating the container with a pressurised gas from a collapsed configuration to an operative position, and first and second load-bearing members which are engaged

with the container and which are respectively located at lower and upper ends of the container when the container is inflated.

[0006] The container may be made in any appropriate way and preferably includes a reinforced bladder. The bladder may be made from any appropriate material e.g. rubber, a plastics material or the like. The invention is not limited in this way.

[0007] The bladder may be reinforced in any appropriate way. For example reinforcing members of any appropriate kind may be incorporated in or otherwise attached to the bladder. Another possibility is to enclose the bladder at least partially in a sleeve which provides a reinforcing function. The sleeve may be made from a flexible material and, itself, may be fluid-impervious. The sleeve may be reinforced.

[0008] The container, when inflated, may be in the form of an elongate cylinder. If use is made of a sleeve for reinforcing the bladder then the sleeve may have a similar shape and the container may fit tightly inside the sleeve.

[0009] The load-bearing members at opposed ends of the inflated container may have substantially flat outer surfaces which are engageable, respectively with an opposing foot wall surface and an opposing hanging wall surface.

[0010] Each load-bearing member may include at least one formation, for example in the form of a circular rim, positioned to engage directly with an adjacent end of the container or sleeve. The load-bearing members may be made from steel, rubber, plastic or any other appropriate material. The invention is not limited in this respect.

[0011] The sleeve may be made from a woven polyester or similar plastics material and, may be reinforced by means of straps, webbing or the like at a plurality of locations on the sleeve.

[0012] When the container is in the collapsed configuration the load-bearing members may at least partly enclose the container between opposing surfaces of the members. Fasteners or any other appropriate mechanisms may be used to secure the load-bearing members in a close relationship with each other so that the container is kept in the collapsed configuration. To facilitate storage and handling of the support, when it is in the collapsed configuration, handles or similar devices may be provided. Preferably handles are provided which are fixed to the load-bearing members.

[0013] The valve arrangement may be of a simple or complex structure. For example a single valve may be used for inflating the container and for allowing the container to be deflated i.e. for fluid to escape from the container. Preferably though use is made of a non-return valve for inflating the container and a relief valve for allowing fluid to flow from the container.

[0014] In a preferred embodiment the valve arrangement includes a non-return valve located at what, in use, is a lower end of the inflated container and a pressure relief valve located at what, in use, is an upper end of the inflated container.

[0015] The container may be inflated in any appropriate way but preferably is inflated using pressurised air. A water-absorbing substance, which preferably is settable, may be located inside the container at any appropriate time for example under factory conditions or in situ immediately prior to use of the support.

[0016] The substance may be a super-absorbent powder such as sodium polyacrylate or a cementitious-based material.

[0017] The invention also extends to a method of installing a support which includes the steps of inflating a collapsed reinforced container made from flexible sheet material, with a pressurised gas source, to an operative position at which opposed

upper and lower ends of the container are brought into contact with opposing surfaces on a hanging wall and a foot wall, respectively, filling the container with a liquid and simultaneously allowing gas to escape from the container and then pressurising the liquid inside the container.

5 **[0018]** The gas is preferably air.

[0019] The liquid is preferably water.

[0020] The water used to fill the container may be allowed to react, inside the container with a water-absorbent and settable substance. Preferably the interior of the container is pressurised, by pressurising the water inside the container to a
10 required degree, prior to allowing the water and the settable substance to react.

[0021] The container may be inflated by introducing air under pressure through a non-return valve which is located at a lower end of the container and, as the container is filled with water, air inside the container may be allowed to escape from the container through a pressure relief valve located at an upper end of the
15 container.

[0022] Once the container is completely filled with water the pressure relief valve may be closed or adjusted to allow the pressure inside the container to be increased to a desired level.

[0023] The support may include structure for stabilising the inflated container in the
20 operative position.

[0024] The stabilising structure may take on any appropriate form and preferably includes one or more rings which encircle the inflated container or which are included in the inflated container.

[0025] The rings may be interconnected to each other in any appropriate way. For example each ring may include a formation which is engageable with a complementary formation on an adjacent ring. Another possibility is to make use of one or more elongate struts or braces which interconnect the rings and which impart stability to the inflated container in the operative position. The struts may be engaged with the load bearing members.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The invention is further described by way of examples with reference to the accompanying drawings in which:

Figure 1 is a perspective view of a support according to the invention in a collapsed configuration which is suited for storage and transport purposes;

Figure 2 is a cross-sectional view, from one side, on an enlarged scale of the support shown in Figure 1;

Figure 3 is a perspective view of the support of the invention in an operative or expanded position;

Figure 4 is a cross-sectional side view, again on an enlarged scale, of the support in an operative configuration installed between a hanging wall and an opposing foot wall in an underground excavation;

Figure 5 is a view from one side, in cross section, of a support according to a variation of the invention in a collapsed configuration;

Figure 6 shows the support of Figure 5 in an expanded mode;

Figure 7 is similar to Figure 5 and illustrates a support according to another variation of the invention;

Figure 8 shows the support of Figure 7 in an expanded configuration;

Figure 9 shows another form of the invention; and

Figure 10 is a cross sectional view of the support of Figure 9, taken on a line 10–10 .

DESCRIPTION OF PREFERRED EMBODIMENTS

5 **[0027]** Figure 1 of the accompanying drawings shows a support 10 according to the invention in a collapsed configuration. Figure 2 shows the support on a slightly enlarged scale in cross-section from one side.

10 **[0028]** The support includes opposed upper and lower load-bearing members 12 and 14 respectively with a container 16 enclosed in a volume between opposing surfaces of the load-bearing members.

[0029] The load-bearing members are substantially identical. Each is made from a suitable material such as steel, rubber or a tough plastics. The invention is not restricted in this regard.

15 **[0030]** In this example each load-bearing member has a circular substantially flat plate 20 with a smooth outer surface 22 and an inner surface 24 which has an upstanding rim or wall 26 which is circular in outline and which forms part of a cavity 28 in which the container 16 is located.

20 **[0031]** The load-bearing member 12 has a pressure relief valve 30 fixed to it. Preferably this valve can be adjusted to control the point at which a fluid can pass through the valve i.e. the point at which it exhibits its pressure-relieving function.

[0032] A one-way filler valve 32 is attached to the wall of the lower member 14.

[0033] Each valve is in communication, via a respective passage 34 and 36, with an interior of the cavity 28 between opposing surfaces of the members 12 and 14.

[0034] Figure 2 shows the support in a collapsed configuration and in cross-section. Ties or fasteners 38 of any appropriate kind are used to retain the load-bearing members close to each other with the container sandwiched between them.

[0035] The container 16 is shown in a folded concertina-like shape. The container is firmly secured to an inner surface of each wall 26, at a zone 39 which is adjacent the passages 34 and 36, and is perforated so that a clear communication path exists between each valve 30 and 32 on the one hand and an interior 40 of the container on the other hand.

[0036] The container is made from any suitable fluid-impervious and flexible sheet material. Preferably the sheet material is reinforced. In one preferred form of the invention the container 16 has a two-part construction which includes an inner bladder, designated 16A, which is made from a rubber or plastic or similar flexible sheet material which is water and air-impervious and an outer sleeve 16B which is used primarily for reinforcing purposes. As is evident from Figures 3 and 4 the container 16, when expanded, takes up an elongate cylindrical form.

[0037] The sleeve is made from any appropriate material such as woven polyethylene. Reinforcing straps or webbing 42 can be attached, preferably to an inner side of the sleeve, before it is engaged with the bladder to provide further reinforcing. The sleeve, itself, could be fluid-impervious material.

[0038] Another approach is to make the bladder as a compound structure with the sleeve. Various techniques are possible in this regard. An objective however is to ensure that the container is gas and liquid tight, is shaped, when expanded, into a suitable form and has adequate strength to enable it to be used in a support application, as is described hereinafter.

[0039] A water absorbent substance 50 is placed inside the container 16 either under factory conditions or immediately prior to deployment of the support 10. The substance is highly water-absorbent and for example is sodium polyacrylate or a cementitious mixture which is capable of absorbing water and then setting. It is desirable for the substance to have a setting characteristic so that once activated it hardens and forms a rigid structure of a desired shape which is capable of bearing substantial loads.

[0040] It is apparent from the foregoing description that the support can be made to any appropriate size and configuration. The support should however not be so large that it is difficult to handle and install bearing in mind the arduous conditions which are encountered in underground locations. It is also possible, if necessary, to use two or more supports adjacent each other or to position one support on top of another, according to the working circumstances.

[0041] The load-bearing members 12 and 14 are preferably provided with handles 54 to facilitate manual handling of the support 10 when it is in a collapsed configuration. When the support is to be installed it is firstly transported to the installation location. The fasteners 38 are then released. Air from a pressurised source, not shown, is connected to the non-return valve 32 and is used to inflate the container. Depending on the distance between a hanging wall 60 and a foot wall 62, at the installation location, the container is fully extended or partially extended. This is a significant benefit of the invention i.e. if the length of the container, when expanded, is greater than the spacing between the opposing surfaces at the installation location no adjustment is required for the container is simply expanded to bring the two load-bearing members into contact with the hanging and foot wall respectively. It may be that the container, once expanded, does not take on a neat

cylindrical shape as is shown in Figures 3 and 4 but there are no adverse consequences associated with incomplete extension of the container, in this regard.

[0042] During inflation of the container the pressure relief valve 30 is kept closed.

[0043] Once the container has been expanded to bring the load-bearing members firmly into contact with opposed surfaces on the hanging and foot wall the pressure relief valve is set to release air, from the interior of the container, when the air pressure rises above a predetermined limit. To do this water is introduced into the container through the non-return valve 32. The water collects at the bottom of the interior of the container and gradually rises. The water flowing into the container pressurises the air above the water and the air is ultimately forced through the pressure relief valve. The pressure relief valve has a high enough setting to ensure that, during this process, the air does not escape freely from the container for this would allow the container to collapse. It is only as the water enters the container and sufficiently pressurises the interior that the air pressure becomes sufficiently high to open the pressure relief valve which then allows the air to escape.

[0044] Once all the air has been expelled from the interior of the container the pressure relief valve setting is increased and water under pressure is introduced into the container so as to prestress the support.

[0045] The water which is introduced into the container mixes with the substance 50. This is highly water-absorbent and reacts with the water and then sets to provide a load-bearing column. Depending on the nature of the substance the set material can exhibit load-bearing characteristics. For example the substance 50 may consist of an aggregate for a light-weight aerated cementitious mixture. The aerating components in the mixture form gas voids inside the set column and these are capable of collapsing at a controlled rate as the load which is carried by the column

increases, during use of the support, and so can provide an acceptable load versus yield characteristic.

[0046] Thus, in use, the support is inflated using pressurised air, to a desired extent. Thereafter a settable load-bearing mixture is created inside the support. Once set the mixture provides a load-bearing column. To achieve the aforementioned objectives use is made of a bladder or container which is air-tight and water-tight and which is reinforced, as necessary, in order for the container to withstand the pressures which are generated particularly during the prestressing phase. The reinforcing sleeve (or the bladder as the case may be) can include additional reinforcing so that the strength of the set column is increased. For example the sleeve may include rings or wires made from steel or high-tensile fibres so as to increase the resistance of the set column to radial expansion when the column is axially loaded.

[0047] The support can also be protected against the effects of blasting and the like by adding steel plates or pipes or similar shields to outer surfaces of the sleeve.

[0048] It has been found that the container, when inflated and prior to water being introduced into the container, may extend to a substantial height and, as a result, may not be entirely stable – a factor which can hinder subsequent installation steps. To address this problem the techniques shown in Figures 5 to 9 can be adapted.

[0049] Figure 5 of the accompanying drawings shows a support 110 which has opposed upper and lower load-bearing members 112 and 114 respectively with a container 116 enclosed in a volume between opposing surfaces of the load-bearing members. Valves 130 and 132 are fixed to the members 112 and 114 respectively and are used to introduce pressurised gas or water or any other fluid into the interior of the container as appropriate.

[0050] A number of fasteners 170 are fixed to or are formed integrally with, the container 116 at regular intervals. The fasteners are aligned with outer extremities 172 of folds 174 in the container which is made from a fluid-impervious and flexible sheet material. Each fastener is made in an appropriate way.

5 **[0051]** Each fastener carries an eyelet 176. The eyelets are spaced from each other at regular intervals along the circumference of the container.

[0052] The eyelets are positioned, as well, so that the eyelets are aligned with one another in an axial sense.

10 **[0053]** When the container is inflated the eyelets are moved, together with the container, to different heights as is shown in Figure 6. A sturdy brace which is in the form of an elongate steel rod 180 is then passed through the registering eyelets 176. The rod is also anchored using a suitable fastener, not shown, to each of the members 112 and 114. Preferably the support assembly includes at least three of the rods which are attached to the container at regular, circumferentially-spaced
15 locations. Consequently the container, when inflated, is stable and during subsequent installation steps, the support remains in position until the settable composition inside the container has been activated and forms a structure which is capable of bearing substantial loads.

20 **[0054]** In a variation the fasteners are replaced by steel rings which encircle the container. The rings carry the eyelets 176 which are engaged with the rods 180, as described.

[0055] Figure 7 shows a support 110A according to a different form of the invention. Like reference numerals are used to designate like components. Rings 170A, are made from flat sheet material which is fairly broad, circumferentially extend around
25 the container 116. The bands are of different diameters and at opposing edges are

formed with differently oriented hook-formations 182 and 184. The arrangement and sizing are such that when the container is inflated an innermost band, which is attached to the container 116 at an upper end 186 is elevated as the container starts rising. The hook formation 182 at a lower end of this band then engages with the complementary hook-formation 184 at an upper end of an adjacent outer band. The process then continues in this way with the bands moving telescopically out of each other but engaging in a hook-manner with each other to form a generally tubular structure 190 which is fairly rigid. Although the structure is kept in the extended configuration by the inflated container it provides stable support for the container inside the structure. Figure 8 shows the support fully extended.

[0056] Other support mechanisms are of course possible. For example Figures 9 and 10 show a support 110B in cross section from one side and in plan respectively in which stabilizing is provided by three rods 192 which are not attached to the container but which have ends which are engaged with sockets 194 in the members 112 and 114 thereby bracing the members apart and, in the process, imparting stability to the container 116.

CLAIMS

1. A support which includes at least one container which is made from a flexible, fluid-impervious sheet material, a valve arrangement for inflating the container with a pressurised gas from a collapsed configuration to an operative position,
5 and first and second load-bearing members which are engaged with the container and which are respectively located at lower and upper ends of the container when the container is inflated.
2. A support according to claim 1 which includes a water-absorbing settable substance inside the container.
- 10 3. A support according to claim 1 wherein the container includes a reinforced bladder and a flexible sleeve which encloses the bladder at least partially.
4. A support according to claim 1 wherein each load bearing member has a substantially flat outer surface and a rim positioned to engage directly with an adjacent end of the container and wherein, with the container in the collapsed
15 configuration, the load-bearing members at least partly enclose the container between opposing surfaces of the members.
5. A support according to claim 1 wherein the valve arrangement includes a non-return valve for inflating the container and a relief valve for allowing fluid to flow from the container.
- 20 6. A support according to claim 1 which includes structure for stabilising the inflated container in the operative position, the stabilising structure being selected from one or more rings which encircle the inflated container and elongate struts which extend between the load-bearing members.

7. A method of installing a support which includes the steps of inflating a collapsed reinforced container made from flexible sheet material, with a pressurised gas, to an operative position at which opposed upper and lower ends of the container are brought into contact with opposing surfaces of a hanging wall and a foot wall, respectively, filling the container with a liquid and simultaneously allowing gas to escape from the container and then pressurising the liquid inside the container.
8. A method according to claim 7 wherein the container is inflated by introducing air under pressure through a non-return valve which is located at a lower end of the container and, as the container is filled with the liquid, air inside the container is allowed to escape from the container through a pressure relief valve located at an upper end of the container.
9. A method according to claim 7 wherein the liquid is water and is allowed to react, inside the container, with a water-absorbent and settable substance.

FIGURE 3

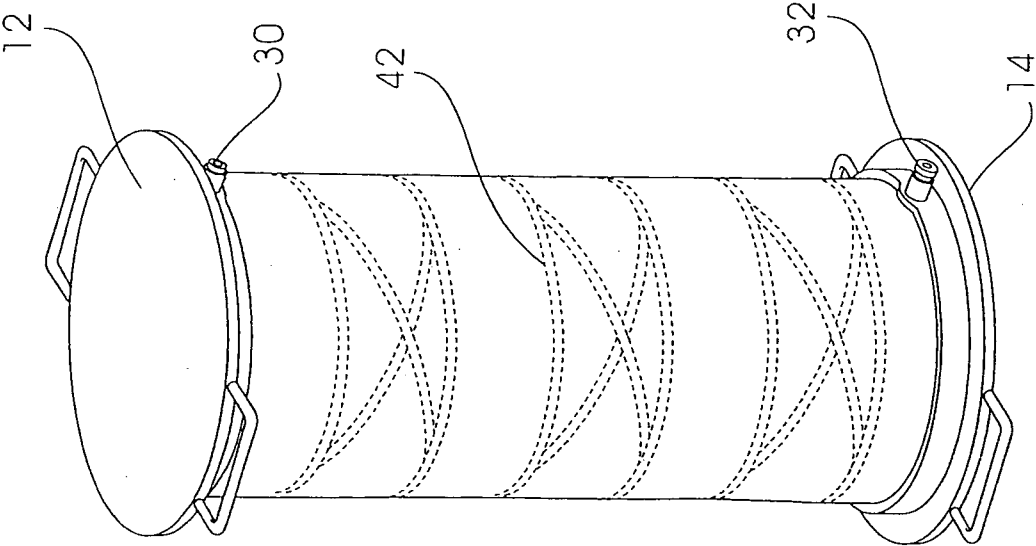
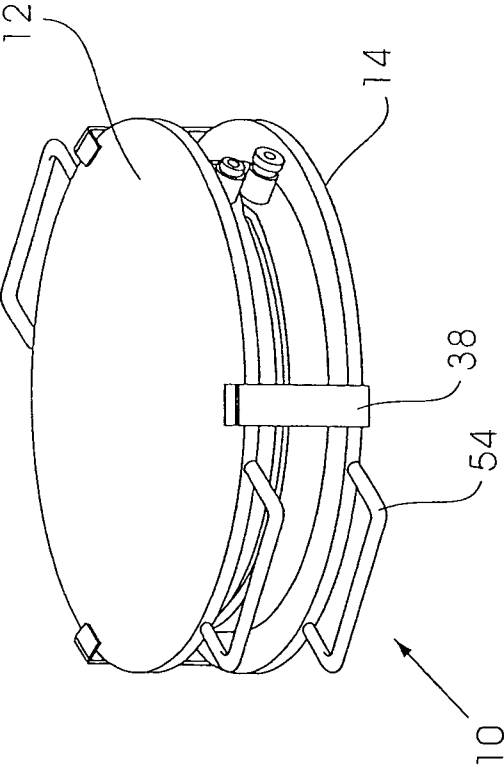


FIGURE 1



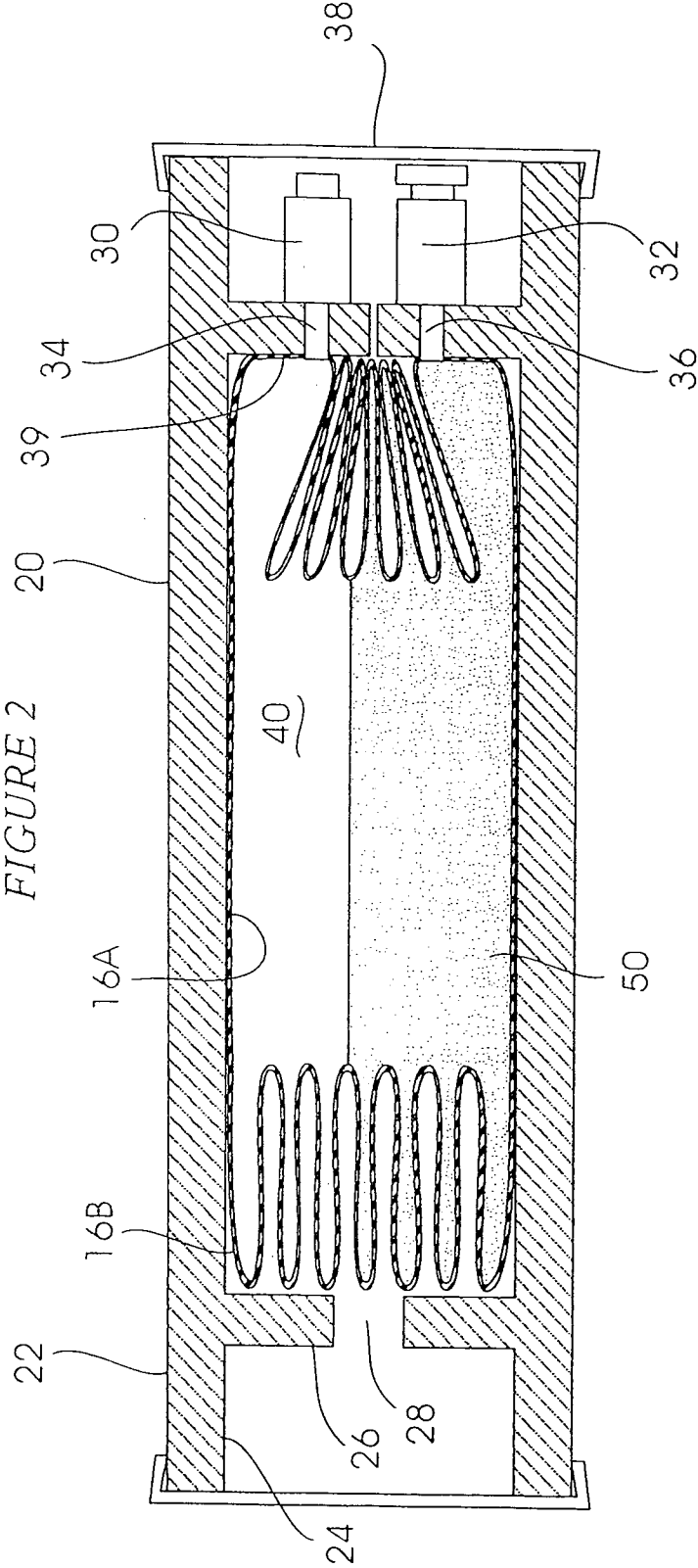


FIGURE 4

