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Inventors: Brown et al.
Serial No.

PATENT APPLICATION
Navy Case No. 78,667

DEVICE FOR TENSIONING SHEET MEMBERS

BACKGROUND OF THE INVENTION

Field of the Invention

This invention pertains generally to tensioning devices and more particularly to a device for tensioning thin-sheet materials so as to prevent wrinkling.

Description of the Related Art

Solar power sources utilized in spacecraft may be comprised of the solar panels and reflectors in the form of a trough, the sun reflecting off the reflector panels onto the solar cells in the solar panel. In some applications, the power sources are stowed in a folded position during launching and unfolded after the satellite is established in orbit The reflectors must be flat in order to provide an even distribution of sunlight across the solar panel since any irregularities decrease the power output of the panel. In the prior art, flatness is achieved by using rigid reflectors which resulted in excessive mass for the system.

SUMMARY OF THE INVENTION

The object of this invention is to provide an apparatus for loading a thin-sheet material with tensioning forces that are perpendicular to the edge of the sheet, and equal in magnitude,

around the entire border of the sheet.

This and other objectives are accomplished by a plurality of tensioning devices that apply a tensioning force around the outer edge of a sheet material to prevent the sheet material from wrinkling. These devices are attached to a supporting member forming the outer frame of a structure upon which the sheet material is to be attached and consist of tape strips or wires attached to or free sliding along the support member, sheet material of a differing material wrapped around the support member and attached to the main sheet material, with or without holes or slots, and extensions of the main sheet material around the support member, with or without heat created depressions along the border to relieve tearing stresses. Another tensioning member is a corner brace between perpendicular segments of the supporting member to remove wrinkles caused by manufacturing irregularities.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a typical installation utilizing a technique for tensioning a sheet matrial.

Figure 2a shows a tensioning device utilizing tape material.

Figure 2b shows a tensioning device utilizing tape material with grommets attaching the material to a support member.

Figure 2c shows a wire tensioning device with loops around the support member and attached to a reflective material with grommets.

Figure 2d shows a tensioning member with a border of continuous, flexible material, having holes or slots of a predetermined dimension punched or cut therein, that is bonded to both the supporting member and the reflective sheet material.

Figure 3a shows a tensioning member integral with the reflector sheet material.

Figure 3b shows a tensioning member with a compliant border created by heating and deforming the parallel tensioning strips of reflector material so that a number of thin, parallel tensioning strips link the tensioning border and the active part of the solar panels.

Figure 3c shows a cross-section A-A of **Figure 3b**.

Figure 4 shows a one-piece solar panel made by casting a plastic material so that it has a thickened border for tensioning and an area of intermediate thickness between the border and active reflector comprised of reflector sheet material for perforations for compliance.

Figure 5 shows a tensioning member comprised of corner braces used in the region

where two supporting members meet, to eliminate wrinkling.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In a typical design utilizing tensioning devices for preventing sheet material from wrinkling, a reflector **12,** as shown in **Figure 1**, comprised of a sheet of thin reflector material **14** is attached to a support member **16**, comprised of catenary-like wires, by a tensioning member **18** to form a reflector. Such an exemplary device is used to reflect solar rays onto an array of solar cells **22** to generate electrical power for a satellite **25**.

In a preferred embodiment **10**, as shown in **Figure 2a**, a sheet of material **14** made of a polymide with a high coefficient of thermal expansion (CTE), and cut in a cantenary or parabolic shape, is attached to a support member **16** made of either Kelvar® or aluminum wire with discrete links such as tape that forms a tensioning member **24**. The support member **16**, having a lower CTE, allows relative thermal expansion motion between the support member **16** and the sheet material **14**, when they are constructed from materials having differing CTE's. The tape, made of Kaptor®, forming the tensioning member **18** is fixed to the support member **16** and reflective sheet material with a glue, such as a phenolic adhesive, made by Fralock 818,709 or 1288. The tensioning members **18** are placed at preselected points along the support member **16**..

In another preferred embodiment **20**, as shown in **Figure 2b**, tape, as described above, forming a tensioning member **18** is bonded to the edge of the reflector material **14** with a glue

as described above, and free to slip along a wire forming the supporting member **16** on a grommet **17** inserted into the material forming the tensioning member **18**. The grommet **17** is preferably made of a plastic material.

In another preferred embodiment **30**, as shown in **Figure 2c**, the tensioning member **18** is a wire, preferably Kevlar®, or a similar material, that is free to rotate in a washer **32** attached to the reflector sheet material **14** and a loop **44** that is free to slip along the supporting member **16**. The washer **32** preferably is of a plastic material, however any other similar material or metal may be used.

In another preferred embodiment **40**, as shown in **Figure 2d**, a reflective sheet material **14** may also be joined to the supporting member **16** with a border **34** of continuous, flexible material, having holes or slots **19** of a predetermined dimension punched or cut therein, that is bonded to both the supporting member **16** and the reflective sheet material **14** with a glue as previously described. This design provides a means to absorb strains in the supporting member **16** so they are not transferred to the reflective sheet material **14**. This border material may be the same material as that found in the reflective sheet **14**.

All of the foregoing embodiments **10** through **40** the tensioning members are called compliant borders in that they prevent strain in the supporting member **16** from being transferred to the reflective sheet material **14**, and allow the supporting member **16** and sheet **14** to expand and contract relative to each other without wrinkling the sheet **14**. To avoid severing of the supporting member **16** by micrometeorites, the tensioning device **16** and a wire **36** joining the

corners of the reflectors **12** to a boom **38**, may be made of a braided cable, of several cables separated by a spacer, or of solid elements such as strips of metal or tubes.

In another preferred embodiment **50**, as shown in **Figure 3a**, shows a tensioning member **18** integral with the reflector sheet material **14**. In this embodiment **50**, the tensioning member **18** has a CTE closer to that of the reflector sheet material **14**. This may be a plastic tubing bonded to the reflector material **14**, or strips of reflector material **14** bonded together, to a preferred thickness of 0.005 inches, and then bonded to the reflector sheet material **14**. The bonding agent preferably is a glue of the type described above.

In another preferred embodiment **60**, as shown in **Figure 3b**, to decrease the danger of wrinkling at the edge of the reflective material **14**, a compliant border **48** is created by heating and deforming selective portions of the strip of reflective material **14** so that a number of thin, parallel tensioning strips **62** link the compliant border **48** and the active part of the reflective material **14**, as shown in **Figure 3c**. The parallel tensioning strips **62** being comprised of a plurality of heat deformed depressions formed in the sheet material **14** by a heat process well known to those skilled in the art. The reflective material **14** is wrapped around a member made of layers of the thin strips of reflective material (approximately 0.0005 inches thick) to a thickness of 0.005 inches glued together, as discussed above, or the reflective material **14** may be rolled to form a circular support member **64** and glued together between layers, as described previously. The reflective material **14** is precut to a cantenary or parabolic shape prior to assembly and maintained in that configuration, without wrinkles, by the stresses set up in the

material by the support member **64**.

In another preferred embodiment, as shown in **Figure 4**, a one-piece solar panel **70** is made by casting a plastic material so that it has a thickened border **46** for tensioning and an area of intermediate thickness **48** between the border and active reflector comprised of reflector sheet material **44** for perforations for compliance. The edge support members **52** have curves that are either parabolic or a constant radius, and while they are generally referred to as "catenary-like", they are not true catenaries. Parabolic curves are used where the links between the supporting member **52** and the reflector sheet material **44** are fixed at either end, while constant radius curves can be used where the joining member is free to slip along the supporting member **16**.

In another preferred embodiment **80**, as shown in **Figure 5,** corner braces **54** may be used in the region where two supporting members **16** meet, to eliminate wrinkling in this region caused by manufacturing imperfections. The braces **54** are rigid rods that link two adjacent edge supporting members **16**, outside the area of active reflector, to prevent wrinkling in the corners of the reflector sheet material **14**. These braces are preferably made of graphite epoxy.

Although this invention has been described in relation to exemplary embodiments directed to application in a spacecraft environment, it is equally applicable to other applications where it is desirable to tension flexible sheets of material so as to prevent wrinkling of the sheet material, therefore, it will be understood by those skilled in the art that other variations and modifications can be affected in the preferred embodiments without detracting from the scope of the invention.

ABSTRACT

The device for tensioning sheet material applies a tensioning force around the outer edge of a sheet material to prevent the sheet material from wrinkling. These devices are attached to a supporting member forming the outer frame of a structure upon which the sheet material is to be attached and consist of tape strips or wires attached to or free sliding along the support member, sheet material of a differing material wrapped around the support member and attached to the main sheet material, with or without holes or slots, and extensions of the main sheet material around the support member, with or without heat created depressions along the border to relieve tearing stresses. Another tensioning member is a corner brace between perpendicular segments of the supporting member to remove wrinkles caused by manufacturing irregularities.

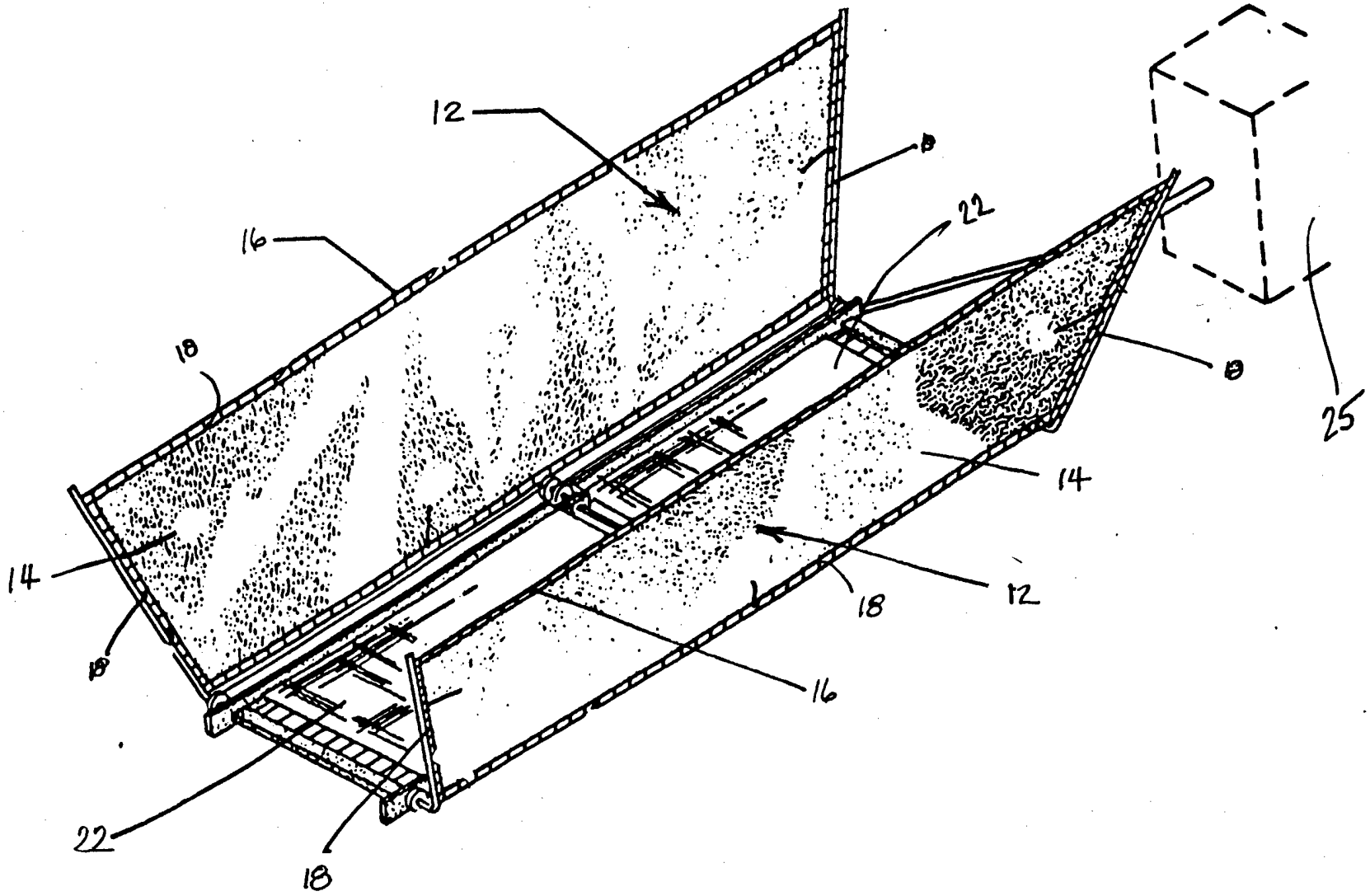

FIGURE 1

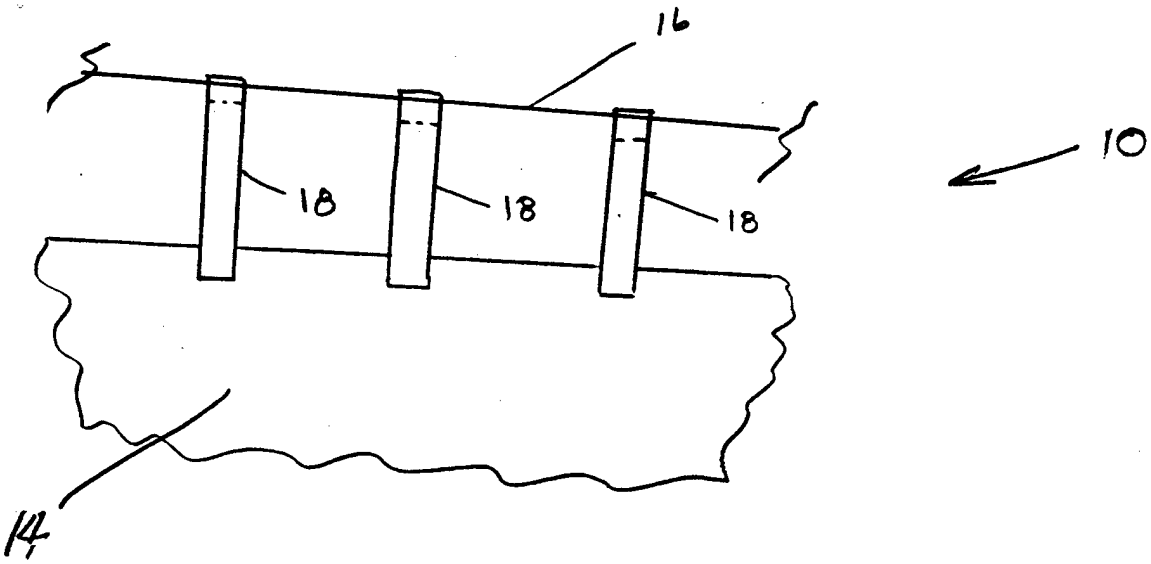

FIGURE 2a

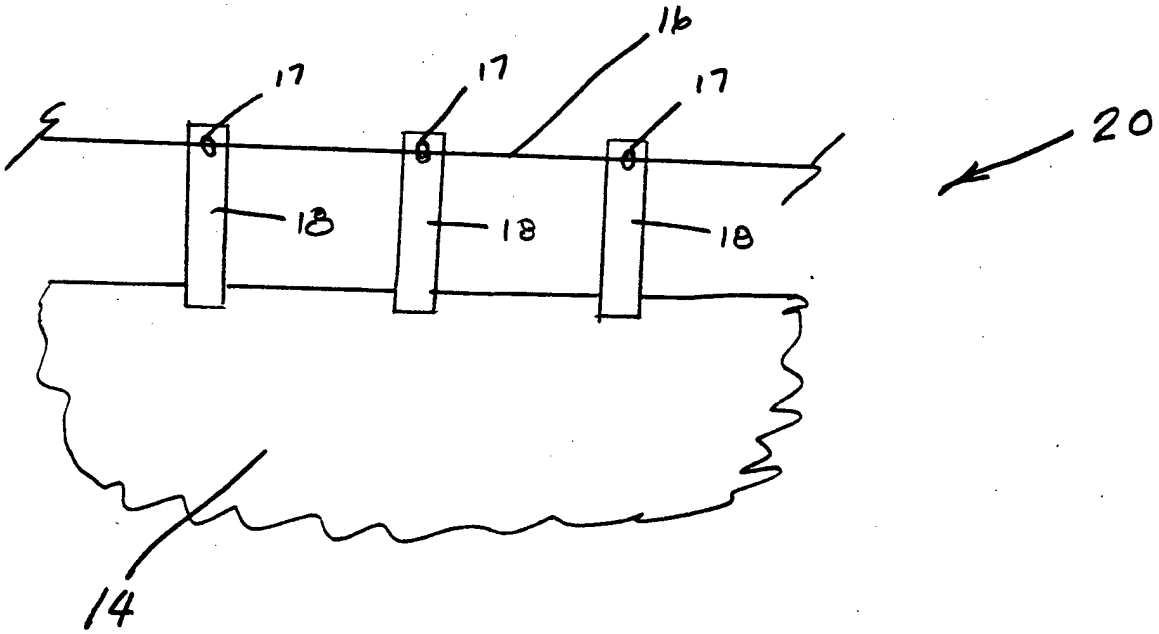

FIGURE 2b

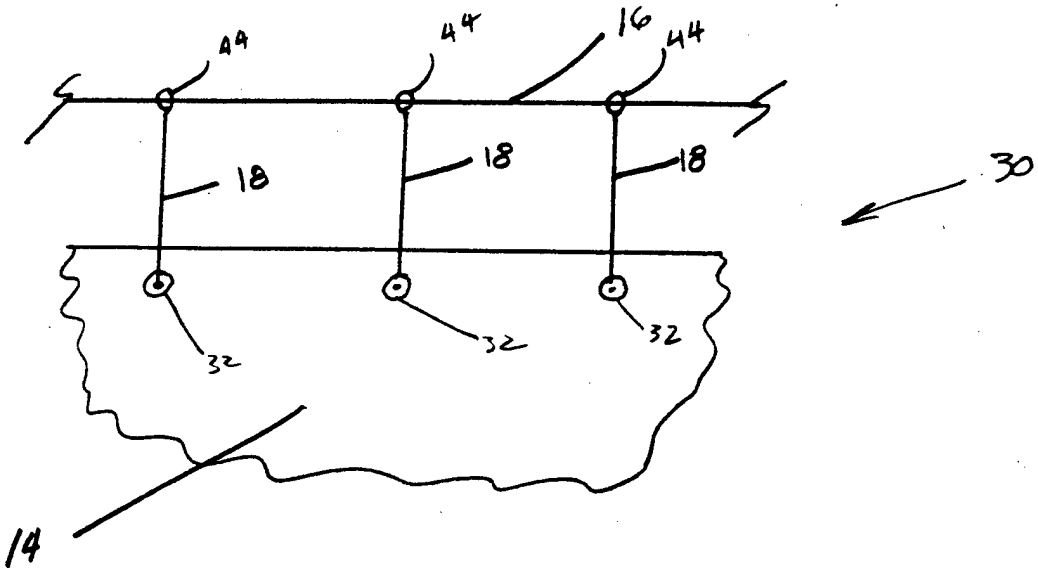

FIGURE 2c

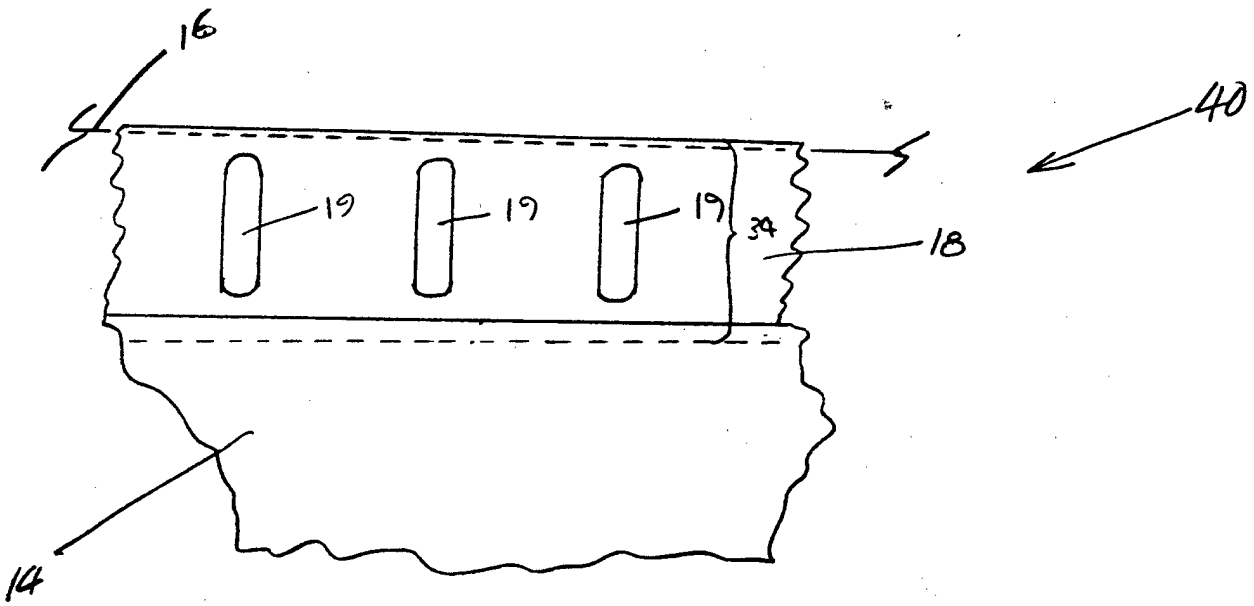

FIGURE 2d

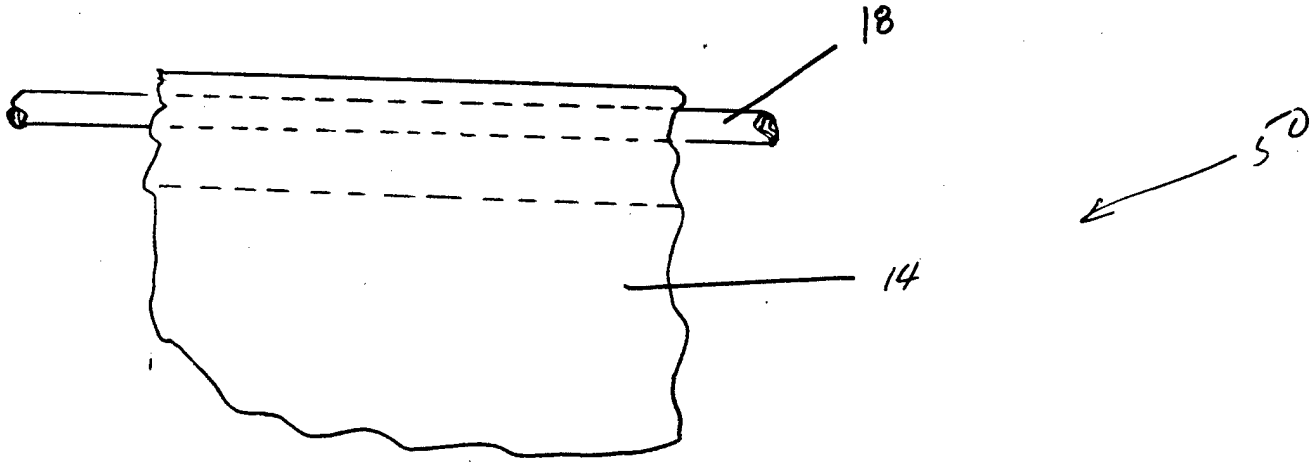

FIGURE 3a

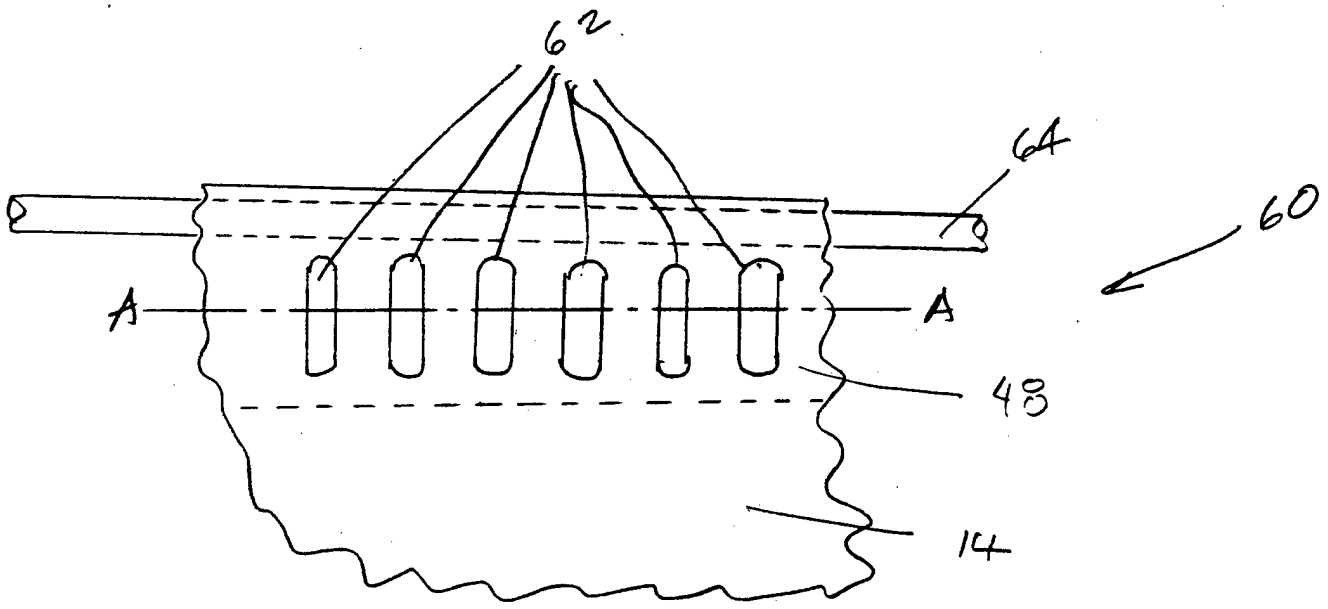

FIGURE 3b

FIGURE 3c

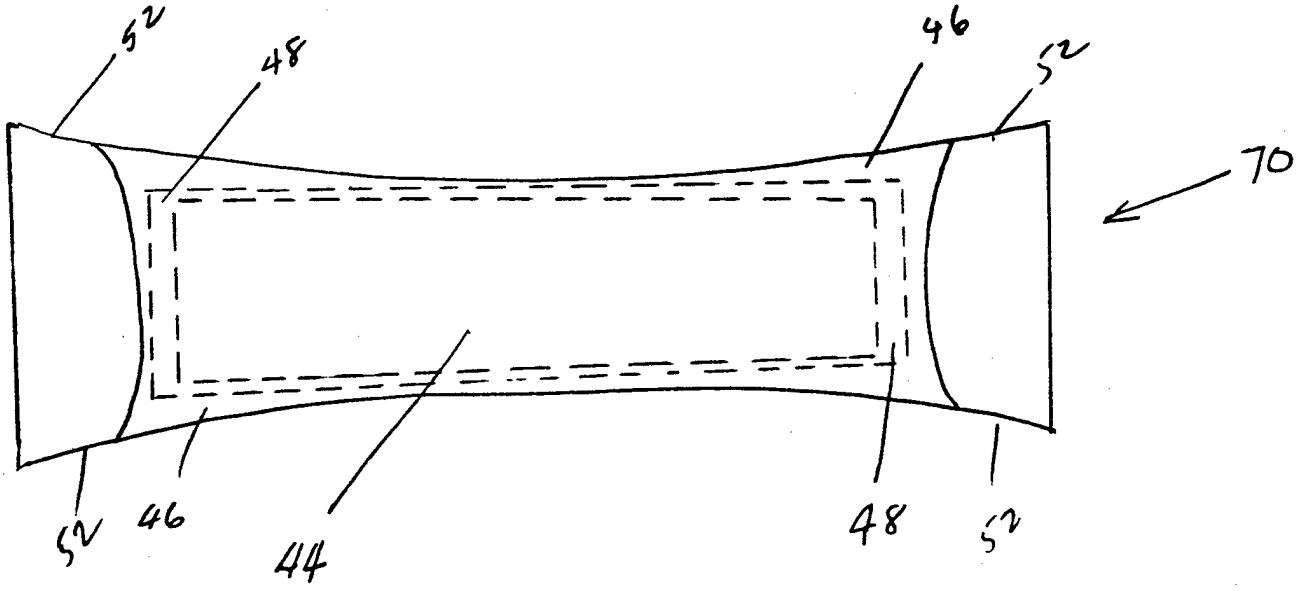

FIGURE 4

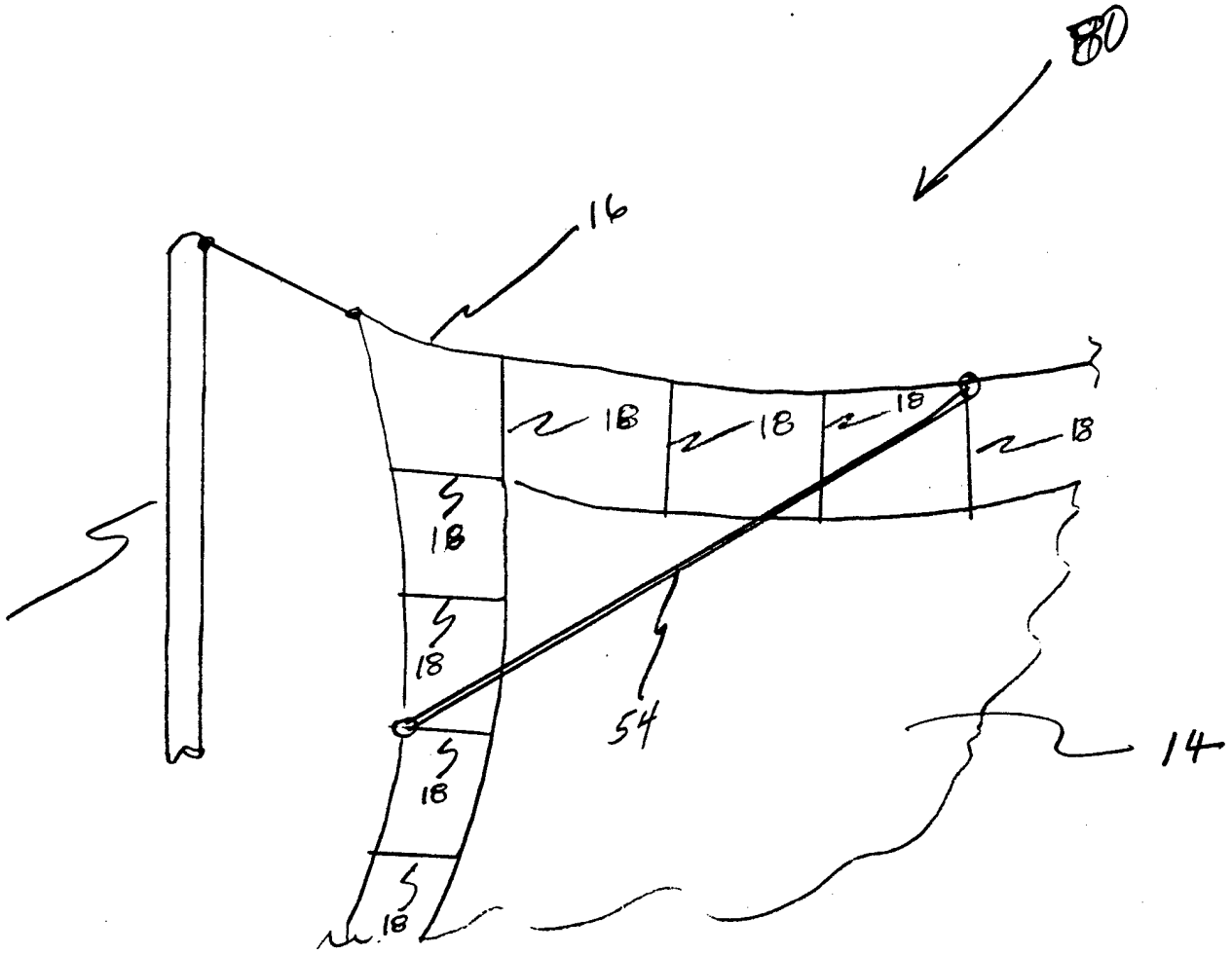

FIGURE 5