Oct. 27, 1970 S. S. SCHWARTZ 3,536,576

SELF-SEALING SPACE SUIT

Filed Aug. 23, 1968

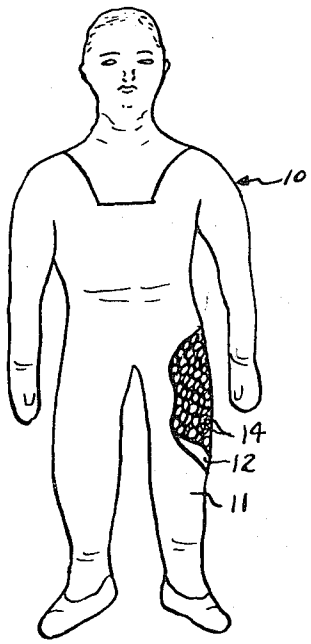


Fig-1

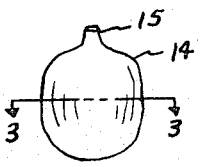


Fig-2

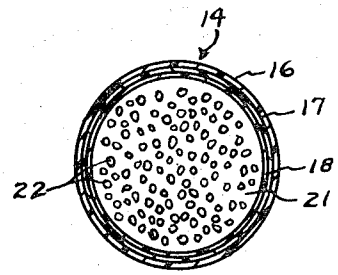


Fig-3

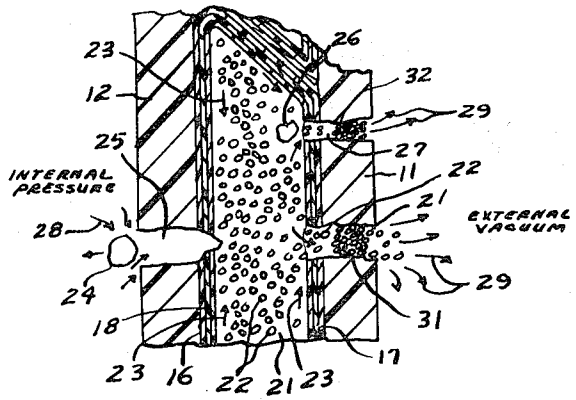


Fig-5

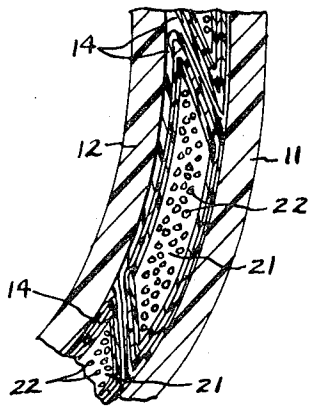


Fig-4

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SELF-SEALING SPACE SUIT

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U.S. Cl. 161—161 4 Claims

ABSTRACT OF THE DISCLOSURE

A space suit having double walls between which there is a layer of overlapping elastomeric packages under tension that contain a mixture of a resinous binder and low density particles as a filler material. When the suit is punctured, the combination of pressure difference between the inside and the outside plus tensile stress of the packages causes the mixture to flow into and eventually seal the hole due to solidification of the resinous binder.

BACKGROUND OF THE INVENTION

Field of the invention

Space suits and, more particularly, self-sealing space suits are the subject of this invention.

Description of the prior art

Heavy felt or flexible plastic foam, now used for micrometeoroid protection in space suits, cannot seal to prevent loss of internal pressurization. Toxic materials of known seal sealantns are hazardous to health of a space suit occupant. Prior art is lacking for any self-sealant system readily applied to space suits.

U.S. Pat. 3,291,333—House issued Dec. 13, 1966 discloses a self-sealing construction for space vehicles but not suitable for space suit use because two component materials are difficult to package.

SUMMARY OF THE INVENTION

According to this invention, a double walled space suit has packages held resiliently under tension between the walls. Each of the packages contains aqueous resin binder and low density filler materials that automatically seal holes caused by micrometeoroid impact with the space suit. Sealant material is nontoxic.

An object of this invention is to provide an automatic sealant system for a space suit.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows a partially sectioned space suit having packages according to the present invention.

FIG. 2 is an enlarged elevational view of one of the packages prior to use in the space suit of FIG. 1.

FIG. 3 is a cross sectional view taken along line 3—3 in FIG. 2

FIG. 4 is an enlarged cross sectional view of a portion of the space suit in FIG. 1.

FIG. 5 is a further enlarged cross sectional view to illustrate the automatic seal that forms to close a hole caused by passage of a particle.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, a space suit **10** is shown having an outer wall **11** and an inner wall **12** of rubberized fabric. A number of packages **14** in an overlapping pattern are between the double walls **11** and **12** throughout the space suit. For maximum flexibility, these packages are no joined to each other. Thus, a space suit occupant has reasonable freedom of movement when wearing the double walled suit provided with the sealant packages. An individual package in original shape is shown by FIG. 2. The package **14** is spherical or egg-shaped, for example, and includes a closable inlet end **15**. More specifically, each package **14** includes small, balloon-like container structure properly made of elastomeric material. Suitable laminate of natural rubber can be used and concentric containers **16, 17** and **18** are shown in the sectional view of FIG. 3. Each of the one or more low modulus, elastomeric containers **16, 17, 18** optionally is concentrically attached or anchored to the other.

The innermost container **18** is filled with a sealant mixture consisting of a water based, resinous binder **21** and particles of a very low density filler **22**. No appreciable tensile stress is induced in the elastomeric containers as they are filled to capacity in the original shape illustrated in FIGS. 2 and 3. When the packages **14** are installed between the space suit walls **11** and **12**, a flattening and distortion of the concentric containers occurs due to pressurization thus inducing a permanent tensile stress in the containers. FIG. 4 is a sectional view illustrating the flattened and distorted containers of packages **14** including the sealant mixture installed between space suit walls **11** and **12**.

In FIG. 5, arrows **23** represent direction of force due to permanent tensile stress in the containers. Puncturing of the space suit wall and containers by a micrometeoroid particle **24** results in a hole **25**. Resilience of the elastomeric containers resists excessive tearing and assures minimum size of the opening caused by micrometeoroid particle **24**. This control of hole size by the low modulus elastomeric containers prevails both for puncturing caused by a particle **24** traversing both inner and outer space suit walls as well as for a smaller micrometeoroid particle **26** that forms an opening **27** in only one wall and the containers immediately adjacent to this wall. Such a smaller particle **26** is hindered by filler material **22** that at times is able to prevent passage of micrometeoroid particles entirely through both walls. The sealant material serves to attenuate shock wave force due to impace of the particles against the space suit.

On impact, and perforation by a particle, the combination of the differential pressures between internal pressurization and external vacuum supplements the tensile stress in the elastomeric containers to force the sealant mixture to the holes. Arrows **28** in FIG. 5 represent internal pressure and arrows **29** represent effect of external vacuum upon sealant mixture as subsequently described.

Sealing of each hole occurs progressively. First, the low density filler **22** flows to the hole in the outer wall **11** and partially plugs the hole. The resinous binder **21** also flows to the hole. This resinous binder upon encountering the vacuum is rapidly stripped of the liquid in action represented by arrows **29**. Remainder of the resinous binder solidifies and forms a permanent seal with the low density filler **22** in formation of plugs **31** and **32** in FIG. 5.

Typical water based binders usable for the sealant material include natural and synthetic rubber latex emulsions and suspension. Also, similar emulsions, suspensions and solution of resins that are water dispersed are usable. Examples of the latter include polyvinyl/alcohol, polyvinyl acetate, acrylics, and gelatin. Preferably, liquid binders have a solid content in a range between 40 and 60% by weight and viscosities range between 80 and 250 centipoises. Suitable low density fillers include expanded styrene beads, cork particles, ground plastic foam particles and other material compatible for bonding with the water based binders. The liquid binder to filler ratio preferably ranges between 10:1 and 50:1 by weight.

Each of the ingredients of the sealant package **14** has multiple functions. The liquid binder **21** acts as a carrying agent for the low density filler **22** and acts as a sealant that "dries" around the periphery of the hole and eventually over the hole. Water is used as the liquid media and assures nontoxicity of resulting vapors. The low density filler **22** reduces weight of the overall system and acts as the initial "plug" in the sealing operation. The low modulus elastomeric containers serve both to hold the sealant material and to control hole size. Effects of an impact are confined to a relatively small area due to low modulus elastomeric containers compared with high modulus materials such as metal that result in much larger holes after contact with a high speed particle.

Automatic sealing action is particularly useful because it occurs even in many areas of the suit where holes would be extremely difficult or impossible to reach. Due to the self-sealing action and maintenance of internal pressure, several particle penetrations may occur in the same containers as represented in FIG. 5. The automatic self-sealing action utilizes the amount of binder and filler needed to plug a particular hole. Remaining binder and filler materials in each package are available automatically to seal subsequent punctures. Systems that employ reactive ingredients can only be perforated once in any particular container. Chemical reaction once having occurred between reactive ingredients will preclude repair of any further damage for an entire package location. Leakage of sealant materials can occur now to a limited extent inside the space suit and possibility of toxic fumes is precluded because only water based materials are used for the binder.

The present invention serves in a life saving manner. Less likely to occur are injuries that are due to high velocity particles penetrating the suit and due to loss of pressurization. Any particles that do penetrate both inner and outer walls are slowed considerably and the puncture is sealed automatically. Light weight filler material and flexibility of the space suit permits as much freedom of movement as possible for the occupant. Catastrophic damage due to contact with small micrometeoroids is minimized. The subject space suit is useful for a manned orbiting laboratory as well as for lunar exploration work.

While the invention has been described for a space suit, the automatic sealant system also is applicable for spacecraft and other dual walled pressurized enclosures for use in space, the operation being exactly the same as for a space suit.

I claim:

1. An automatic sealant system for pressurized enclosures susceptible to puncture by particles encountered in space comprising, inner and outer walls spaced from each other, and packages held tightly between said walls, each of said packages including at least one low modulus elastomeric container under tensile stress between said walls and including a sealant mixture in said container, said sealant mixture being made up of both resinous binder and low density filler materials that automatically seal wall puncture points due to particle impact.

2. The sealant system as claimed in claim **1** wherein said resinous binder is water based to safeguard against toxic hazard inside the pressurized enclosure whenever internal leakage of sealant mixture results from particle impact.

3. The sealant system as claimed in claim **2**, wherein said binder has between 40% and 60% by weight solid content and viscosity in a range between 80 and 250 centipoises, said binder material being one from a group consisting of natural and synthetic rubber latex emulsions and suspensions, and similar emulsions, suspensions and solutions of resins that are water dispersed including polyvinyl alcohol, polyvinyl acetate, acrylics and gelatin.

4. The sealant system as claimed in claim **3** wherein binder to filler ratio ranges between 10:1 and 50:1 by weight, said filler material being one from a group consisting of expanded styrene beads, cork particles and ground plastic foam particles that attenuate shock wave due to micrometeoroid particle impact with the pressurized enclosure.

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U.S. Cl. X.R.

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