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MOBILE SPACE SUIT JOINTS

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FIG. 1.

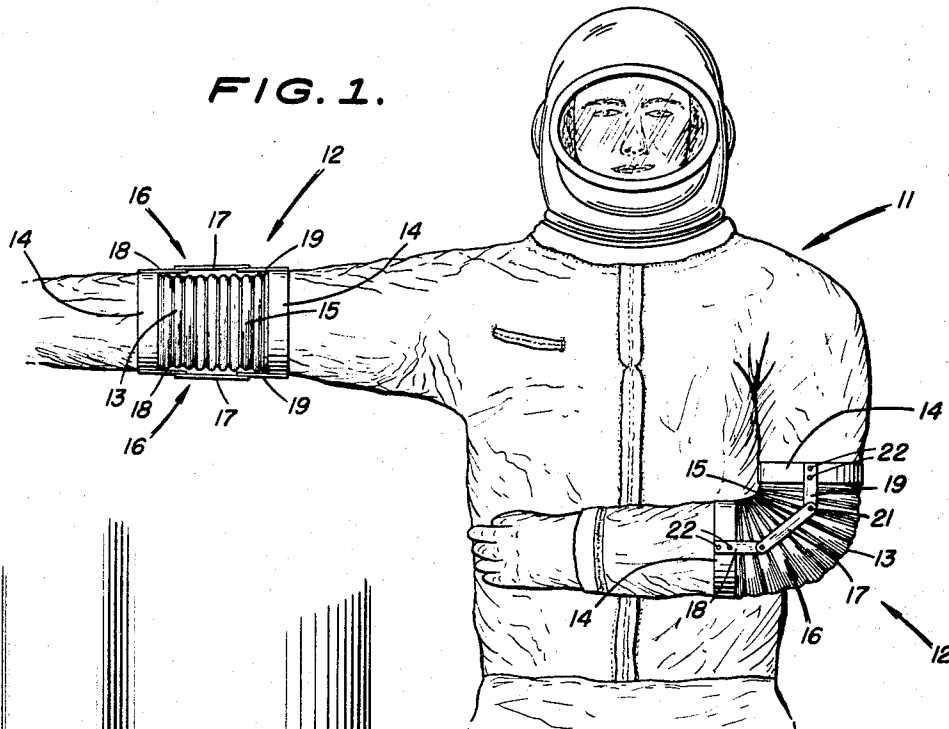
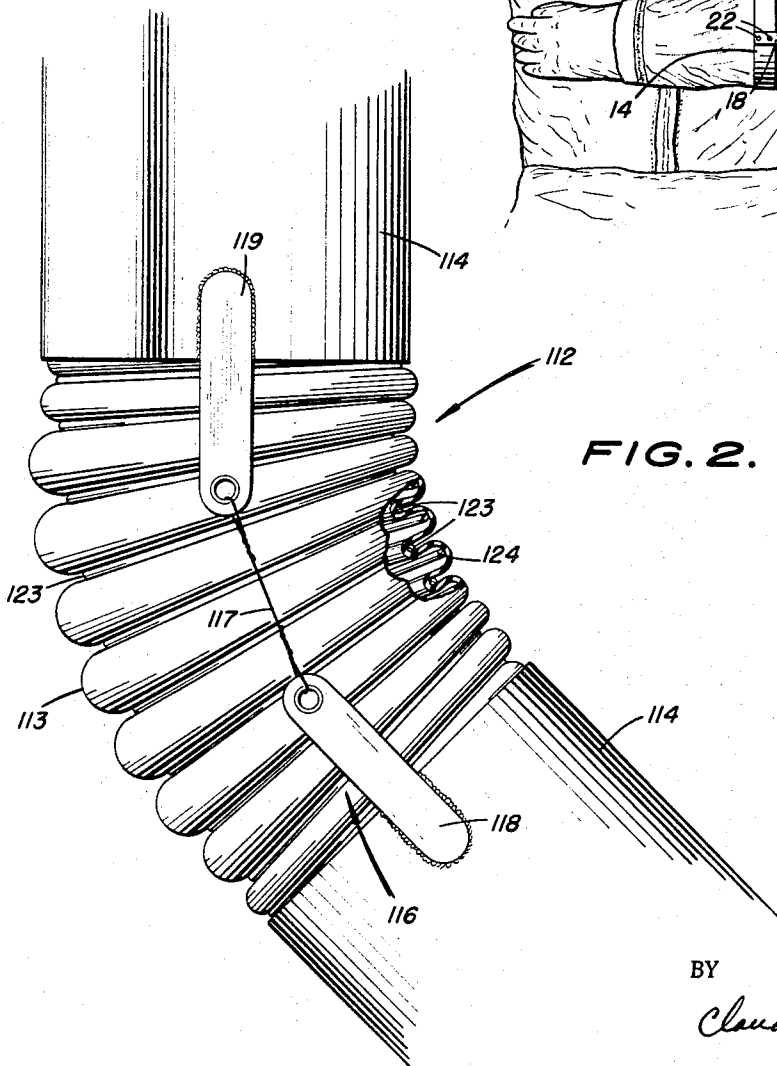


FIG. 2.



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MOBILE SPACE SUIT JOINTS

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3 Claims. (Cl. 2—2.1)

ABSTRACT OF THE DISCLOSURE

Flexible joints provided in the midportions of protective garment sleeves such as in a space suit each comprising a flexible tube sidewall with convolutions to enable expansion and contraction of the tube along its axis. A pair of linkages each connects the portions of the garment sleeves adjacent the ends of said tube and thereby constrains the tube in a partially collapsed position. Pressure inside the tube will urge it toward expansion against the constraint afforded by the linkages. Thus, upon flexure of the joint by a wearer of the garment, the internal pressure of said tube will expand the tube convolutions in the direction of flexure, thereby permitting easy bending of the joint by the wearer. If the internal pressure of the tube is insufficient to assist in the expansion of the convolutions, a resilient coil spring may be provided for expanding the convolutions.

The present invention relates generally to protective suits of the type worn by astronauts, divers, firemen and the like. More particularly the invention relates to an improved flexible joint for mobile protective suit.

In space suits or other mobile protective suits utilized heretofore the joints, such as elbow and knee joints, have required flexure forces which increase proportionately with the amount of joint flexure desired. Such joints have produced continuous resistive forces acting against each movement of a wearer. In order to overcome this resistance to mobility in the joints of such prior art suits, the wearers have had to exert considerable effort to flex their arms and legs, with consequent expenditure of large amounts of energy. The instant invention seeks to reduce the resistance to mobility inherent in prior art suits and, thereby, to increase the mobility and efficiency of the wearer.

It is, therefore, one object of the present invention to provide a protective suit having flexible joints.

Another object of the instant invention is to provide a protective suit with flexible joints which require minimum flexure forces and do not require increasing flexure forces proportional to increased joint flexure.

Still another object of the invention is to provide a flexible joint which will retain an internal suit pressure proportionately greater than that of the outside atmosphere.

A further object of the present invention is to provide a flexible joint, for use in a mobile protective suit, which is pliable enough to allow the wearer relatively free use of his arms and legs.

A still further object of the invention resides in providing a flexible joint that is safe from failure, and is constructed of materials that are effective in the environment in which they are worn.

Other objects and many of the attendant advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings, wherein:

FIG. 1 is a front elevation of a protective suit incorporating two of the novel flexible joints in the sleeves thereof, and showing one sleeve extended laterally in

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a plane parallel to the shoulder and the other sleeve bent at the elbow;

FIG. 2 is a side elevation showing a modification of the flexible joint in a flexed position;

The flexible joint of the present invention is comprised of a flexible tubular member which, when used with a sleeve or leg of a protective suit, is attached in sealing arrangement at each end to a rigid tubular portion of such sleeve or leg. The flexible tubular member is compressed to a length shorter than its natural length by a plurality of linkages connected to the rigid portions of the protective suit in diametrically oppositely disposed relation to each other. Pressure or spring means urge the compressed flexible tubing toward an extended position against the restraint imposed by the linkages. As the flexible joint is displaced from a central position, the force produced by the urging means reacts against the linkages, thereby forcing the flexing joint toward an increased flexure. However, the resistance of the flexible joint to movement and, primarily the resistance of the material making up the flexible tubular member, increases as the joint flexure increases. The two opposing forces overcome each other and produce a flexible joint requiring a nominal flexure force.

One embodiment of the present invention is shown in FIG. 1, wherein a protective suit 11, such as a pressurized mobile space suit, is equipped with flexible joints 12, one on each sleeve which are capable of axial bending movements. The flexible joint 12 is shown in an unflexed position on the right sleeve of the space suit 11 and in a flexed position on the suit's left sleeve. A flexible tubular member 13 forms the heart of each flexible joint. This flexible tubular member 13, or bellows, may be constructed of an elastomeric material, such as silicone rubber, and is convoluted uniformly around its central axis to permit axial bending. The flexible member 13 is attached at each of its ends to nonconvoluted rigid tubular members 14 secured to the sleeve of the space suit 11, above and below the elbow thereof. Each rigid member 14 is attached to the flexible tubing as by bonding or an internal clamping means, not shown, for providing a pressure tight sealing arrangement therebetween. Means comprising springs 15, within and without each member 13 and in the convolutions thereof, increase the resistance of said member to lateral expansive forces caused by the internal suit pressure. A pair of linkages 16 are mounted, in diametrically oppositely disposed relation to each other, on the rigid members 14, thereby compressing the flexible tubing 13. Each linkage consists of three link elements 17, 18, and 19 having a first link element 17 pivotally connected at each of its ends, as by pins 21, to second and third link elements 18 and 19, respectively. The second and third link elements 18 and 19 are secured to the rigid tubular members by rivets 22 and constitute opposed extensions of said rigid tubular members.

During operation of the flexible joint 12, the flexible tubular member 13 is urged toward an axially extended position, against the restraint of the linkages 16, by the internal suit pressure. As the joint is flexed, by movement of the arm, the force exerted by the suit pressure is directed by the linkages 16 toward increasing the joint flexure. In this manner the resistance of the flexible joint to flexure is overcome and the resultant flexure force is minimized. More specifically, because of restraint by the linkages 16, the internally pressurized tubular member 13, when bent, acts as a linear spring and tends to increase its bending. However, expansion of the spring, i.e. the tubular member, is controlled by the suit pressure, with the result that it balances the tendency of the tubular member to resist bending. Essentially, the tubular member and linkages operate as an over-center device.

Another embodiment of the flexible joint capable of axial bending is shown in FIG. 2. In this embodiment one of the flexible joints 112 has a flexible tubular member 113 which may be constructed from an asbestos material for protection against heat, rather than retention of pressure. The flexible tubular member is convoluted in a helix about its central axis in order to enhance its bending motion. A pair of helical compression springs 123 and 124 encompass and engage the flexible tubing. The first spring 123 is mounted within the groove, or apices, formed between adjacent convolutions around the external surface of the flexible tubing 113. The second spring 124 mounts concentrically within the first spring on the internal surface of the tube 113. The flexible tube 113 is attached in sealing arrangement to rigid members 114 as in the embodiment of FIG. 1. A pair of linkages 116 mounted in diametrically oppositely disposed relation compresses the flexible tubular member 113 against the urging of the springs 123 and 124, in the manner of the first embodiment. Each linkage 116 is comprised of three link elements 117, 118, and 119. The first link element 117 consists of a cable pivotally connected by suitable means to a second and third link element 118 and 119; while the second and third link elements comprise opposed extensions of said rigid tubular member and are permanently secured to diametrically opposed surfaces of the rigid members 114. The operation of the embodiment shown in FIG. 2 is substantially the same as the operation described hereinabove for the embodiment of FIG. 1.

The embodiments of the flexible joints described hereinabove may be utilized in many types of protective suits including, among others, those for space and ordinary flights, deep-sea diving, and fire fighting.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In a protective suit having a sleeve, a flexible joint in the elbow of each of the sleeves, each said joint comprising a flexible tubular member, rigid tubular members secured to the sleeve above and below the elbow, said rigid tubular members having opposed extensions, diametrically oppositely disposed linkages extending along said flexible tubular member, means pivotally connecting said linkages to said extensions, and

means engaging said flexible tubular member and urging it toward an extended position, said last-mentioned means comprising a spring engaging said flexible tubular member.

2. In a protective suit having sleeves, a flexible joint in the elbow of each of the sleeves, each said joint comprising a flexible tubular member of bellows configuration capable of axial bending, means engaging said flexible tubular member urging it toward and extended position, said means comprising helical springs engaging the convolutions of the bellows of said flexible tubular member, rigid tubular members secured to the sleeve above and below the elbow, a pair of linkages mounted in diametrically oppositely disposed relation to each other and connecting said rigid tubular members above and below the flexible tubular member, said linkages each including second and third link elements connected to the rigid tubular members and secured to the sleeve above and below the elbow and a first link element extending along the flexible tubular member and pivotally connected at its opposite corresponding ends to said second and third link elements.
3. A protective suit as recited in claim 2, wherein said linkage includes a cable as one of its elements.

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