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F. CAP

2,983,821

PROTECTIVE DEVICE

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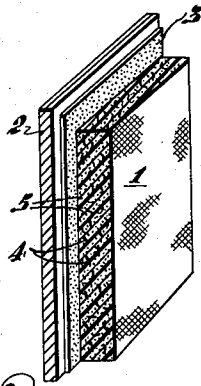


Fig. 1

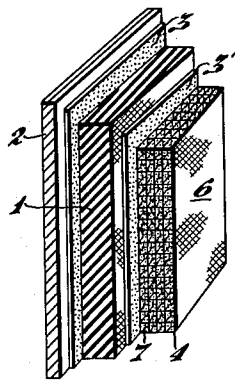


Fig. 2

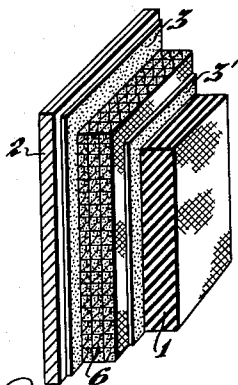


Fig. 3

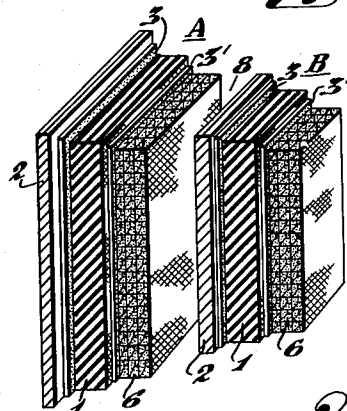


Fig. 4

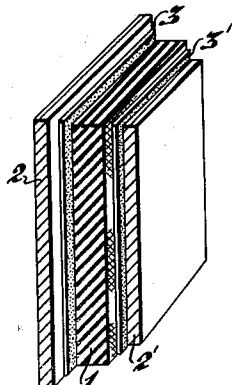


Fig. 5

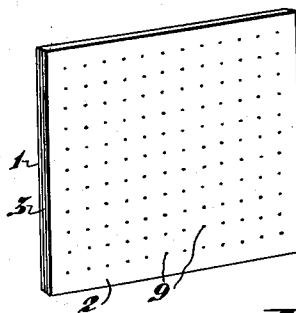


Fig. 6

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PROTECTIVE DEVICE

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8 Claims. (Cl. 250—108)

This invention relates to devices for protecting the human body from injury by the so-called ABC weapons i.e. atomic weapons, bacteria and chemical poisons. In particular, the invention relates to a pliable and flexible material that can be worn by individuals and which is so constructed that it will provide protection against the damaging and injurious effects of these weapons.

Among the factors which are dangerous are the following:

- (1) Alpha rays and other ionized atoms and nuclei;
- (2) Beta rays, both slow and fast;
- (3) Slow neutrons;
- (4) Fast neutrons;
- (5) Solid, liquid, and gaseous biologically poisonous radioactive substances;
- (6) Solid, liquid and gaseous chemical poisons and weapons;
- (7) Solid, liquid and gaseous substances charged with bacteria or viruses;
- (8) Infra red radiation of great intensity;
- (9) Light and ultra-violet radiation of great intensity.

Prior to the invention, no devices were known which were capable of affording protection against the combination of some or all of the above mentioned factors.

An object of this invention is to provide a pliable, flexible material that will provide a protective covering against the above mentioned factors, individually or in a combination of some or all of them.

A further object is to provide a pliable and flexible material having the above qualities that can be fabricated into a protective garment.

A still further object is to provide a material having the above qualities, that comprises a plurality of layers, one of which is the main layer and which is substantially impermeable to gas, yet flexible and pliable, and composed of long chain organic molecules, at least one outer layer which is electrically conductive and capable of reflecting electromagnetic waves having wave lengths in the range from about 14 μ to about 100 μ .

A further object is to provide a flexible composite sheet having a thin outer layer of a metal such as aluminum, that is secured by adhesive to the main layer which is of a plastic composition containing compounds that afford protection against the dangerous ABC factors above mentioned.

A still further object is to provide a material as above set forth in which an intermediate layer is employed that facilitates securement of the outer layer to the main layer, and which is itself so constructed as to enhance the protective qualities of the outer layer.

The foregoing and other objects of the invention will be apparent to those of ordinary skill in the art to which the invention pertains from the following description taken in conjunction with the accompanying drawings.

In the drawings:

Figures 1 to 5, both inclusive, are sectional views in perspective of five different forms of flexible protective covering devices embodying different forms of the invention; and

Fig. 6 is a view in perspective partly in section of a modified form of the invention.

The protective device illustrated in Fig. 1 comprises a main layer 1 composed of a thermoplastic material such as PVC or other materials. The material identified as PVC is a thermoplastic composed of polymerisates

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of vinylchloride. The layer may be composed of a material selected from the group consisting of natural rubber, synthetic rubber and flexible synthetic plastics including PVC. The device also includes an outer layer 2 which is secured to the main layer 1 by means of a layer of adhesive 3. The outer layer 2 may consist of aluminum foil having a thickness of about $\frac{1}{2000}$ inch. The foil layer 2 is for the purpose of reflecting electromagnetic radiation having a wave length in range of 14 μ to 100 μ . An aluminum foil layer is from about 92% to 94% efficient in the reflection of the infra red radiation.

In order to reflect electromagnetic radiation of great wavelength that passes the foil layer 2, the main layer 1 may be impregnated with iron filings 4 having an average length of $\frac{1}{500}$ inch, distributed in a random or non-homogeneous manner throughout the main layer. The quantity of iron filings employed in the main layer may be approximately 60 grams per square meter (60 g./m.²) of surface of the main layer. Furthermore, the main layer may have combined therewith a cadmium compound 5 such as cadmium sulphide (CdS) powder. The cadmium powder is homogeneously or uniformly distributed in the main layer so that neutrons will be absorbed by it. The amount of cadmium sulphide or other compound of cadmium employed may be about 80 g./m.² of surface in the main layer.

The layer 3 may be composed of an acrylate adhesive such as Acronal D500 or Acronal L500, which are trade names of adhesives used in the textile industry in Germany and are composed of polymerisates of acrylic acid esters. Acronal is a term used internationally as an abbreviation for textile adhesives having the above identified chemical composition. D500 or L500 are used to indicate the degree of dispersion of the adhesive in its solvent, in accordance with German practices.

By employing one of a number of different adhesives such as acrylic acid ester, polyvinyl acetate, amyl acetate, synthetic adhesives or latex adhesive, it is possible to adhere the outer foil layer directly to the main layer of the protective device.

The adhesive layer 3 may have admixed therewith compounds for reflecting or absorbing certain components of electromagnetic radiation, especially the radiation within the ultra-violet and the infra red ranges. Materials that may be incorporated in the acrylate adhesive for absorbing the ultra-violet radiation may comprise organic colouring matters such as analine die (colour), ortho-nitroanaline or osazone, 3 amino 6 nitrotoluole and other similar materials. These materials are preferably employed in a suitable solution for example in alcoholic, or aqueous or etheric solution, depending upon the compounds employed, working temperatures and safety regulations of the locality where the product is made.

For the purpose of reflecting radiation in the infra red range, the adhesive of layer 3 may have embodied therein aluminum bronze powder distributed homogeneously or uniformly into the adhesive.

In the manufacture of the protective device of Fig. 1 an embossing operation may be performed on the composite sheet. Preferably, the embossing should be carried out with light pressure at a temperature of about 50° Celsius to obtain a product which is slightly scarred or roughened or crinkled.

In the embodiment of the invention as illustrated in Fig. 2, the adhesive layer 3 is composed of latex, which may contain, if required, aluminum bronze powder and organic colouring matter for the purposes described in connection with Figure 1. The aluminum foil 2, as applied to one surface of the main layer 1, has a thickness of about $\frac{1}{2500}$ inch. A woven fabric 6 is adhered to the opposite side of the main layer 1 by means of an adhesive

layer 3'. It is preferred that the woven fabric 6 be made of yarn threads of about $\frac{1}{60}$ inch in diameter. The openings 7 of the fabric should have a mesh width of about $\frac{1}{8}$ inch to form a honeycomb structure. It is preferred that the weave be impregnated with a solution composed of about 300 g. of borax and 300 g. of latex per square meter of fabric.

Instead of placing the neutron absorbing substance 4 in the main layer of Fig. 1, they may be incorporated in a cement that fills the openings 7 or honeycombs formed by the fabric.

The protective device shown in Fig. 3 comprises an outer layer of aluminum foil 2, a weave 6 joined to the foil with a layer of adhesive 3, a main layer 1 bonded to the weave layer with adhesive 3'. The weave 6 may be of cotton batiste having a mesh of approximately 80/80. It is preferred that the shrinkage of the particular weave employed shall not be in excess of 2%. The weave 6 may be impregnated with a flame-killing compound such as akaustan. Akaustan is an aqueous solution of alum and is widely used by the German textile industry for the purpose of fire or flame proofing fabric.

The amount of flame-killing or fire proofing compound employed should be such as not to increase the weight of the weave layer 6 by more than 20%. By employing a fabric having an 80/80 mesh, the amount of adhesive used should be about 120 g. to 150 g. as Acronal D500 supra, per square meter of the main layer 1.

In Figure 4 a twin type protective device is shown. It comprises two composite layers A and B, that are separated by an air space 8. Group A comprises the outer foil layer 2, main layer 1, the bonding adhesive layer 3, the fabric layer 6 and the adhesive layer 3' by which it is bonded to the main layer.

Group B is similar, hence similar layers are identified by the same reference characters.

In Figure 5 a still further modification of the invention is shown. It comprises an outer foil layer 2, a main layer 1, joined to the former by a layer of adhesive 3 and another outer foil layer 2' joined to the main layer 1 by a layer 3' of adhesive. Thus a protective device is provided having two outer layers of foil 2—2' with an intermediate main layer 1 to which the foil layers 2—2' are adhered with layers of adhesive 3 and 3', respectively. The main layer 1 may be composed of the same plastic composition as is provided in the main layer 1 of Figs. 1, 2, 3 and 4.

In order to provide for easy escape of the solvent, if a solvent type adhesive is used to secure the foil layer to the main layer, the foil layer 3 may be provided with fine, closely spaced perforations 9 as shown in Fig. 6. The relatively small amount of radiation that would enter the inner layers of the device through these perforations would be absorbed by the absorption components described in connection with Figs. 1 to 5.

It is preferred that adhesives be of the non-thermo-setting or thermoplastic type. The preferred adhesives are those in which solvents are utilized because it is quite easy to incorporate metal powders, such as bronze powder for example, into them. When a solvent adhesive and a foil of the construction shown in Fig. 6 are used, excess solvent escapes through the perforations, causing the metal powder to be dispersed homogeneously or uniformly throughout the adhesive when it has solidified; therefore, the adhesive layer containing such metal powder is rendered increasingly resistant to heat and infra red radiation.

If the foil layer 2' is employed on the inner surface of the composite protective device also, so that there will be two exposed or outer foil layers, one layer provides protection against electromagnetic radiation while the other gives protection to the wearer by insulating the body against the cold and reflecting body heat towards the same and conserving it.

Protective devices heretofore devised were effective primarily against X-rays and gamma rays. But such devices

were not sufficient for the purposes of this invention because they were not sufficiently heat resistant. A protective device for the purpose of this invention must be effective with relation to the conditions to which it would be subjected. For example, when an atomic bomb is exploded, the heat flow at a distance of 2 km. is about 10 cal./cm.², this heat flow being caused by radiation. At a heat flow intensity of this order synthetic resin would be utterly insufficient because it begins to melt at a heat input of 3 cal./cm.² and upward.

The decided thermal instability of synthetic materials or rubber, both, as regards infra red radiation and heat makes such materials quite useless for the purpose of my invention. The reason for this is that in the case of A bomb explosions, A war or atomic reactor accidents, alpha rays, radioactive substances etc., as a rule are accompanied by heat radiation. My invention gives protection against such heat radiation. The synthetic materials as well as rubber are, for practical purposes, also quite useless as protection against alpha rays, radioactive substances, chemical poisons and bacteria. For other purposes, however, they possess valuable and well-known protective qualities.

The protective device of this invention is effective and efficient against heat radiation because of the reflective properties of the outer foil layer 2 and 2' of the several views. Furthermore, the protective device of this invention is flexible and gas-proof by virtue of the properties of the plastic or rubber main layers 1 or 1'. The material of the main layer is a composition composed of long chain organic molecules, and is protected by the outer foil layer because the latter is electrically conducting and reflects electromagnetic wave radiation within the range of 14 mμ to 100μ.

The outer foil layer not only reflects to a high degree the incident infra red radiation, but also, because of its good heat conductivity, distributes the heat resulting from such radiation over a large surface. Because of the large surface, the foil layer protects the main layer from the damaging effects of contact heat (flames pointed at the device) that appear for a short time and within certain limits of distance after an atomic explosion.

Furthermore, the protective device of this invention is capable of providing protection against neutrons in that it includes neutron absorbing substances which are worked into the fabric layer or embodied in the main layer 1. Substances that absorb neutrons by nuclear reactions are included in the group comprising cadmium, boron, gadolinium.

The loss of reflective power in the foil layer because of the small perforations 9 and because of tears resulting from accidental mechanical damage, is compensated by the reflective power of a material such as bronze powder, for example, aluminum bronze, which is worked directly into the adhesive before the foil layer is secured by it to the main layer.

It is also of advantage to so arrange the layer groups of the protective device that a thin air space will occur between the respective layers (see Fig. 6). Such an arrangement offers the advantages that the air space acts as a heat insulator, and as a resistor to the electromagnetic radiation penetrating the first layer. Therefore, there is better total reflection than if the foil layer of the second layer group B were connected directly to the weave 6 of the first layer group A.

The neutron absorbing properties of the protective device are increased by means of the woven fabric layer having in the open spaces a latex containing neutron absorbing substances. The neutron absorbing substances have been described supra, and include all elements and their chemical compounds undergoing neutron absorbing nuclear reactions, especially cadmium, boron and gadolinium and their chemical compounds.

It is known that protection against alpha rays and ionized nuclei can be obtained by any homogeneous ma-

material provided it is thick enough to screen off fast beta rays. The protection in that case is complete.

Homogeneous layers such as the layers 1 or 1' having a weight or density of the order of 60 mg./m.² and sufficient to completely screen off electrons containing energy of many mev. The homogeneous main layer 1 which may be composed of gas-tight rubber, plastic or similar material and having a weight of from 20-120 mg./cm.². The covering or outer layer of aluminum foil, provides protection against beta rays, alpha rays, other nuclei and ionized atoms.

In most cases, substances that absorb slow neutrons also weaken the energy of fast neutrons; thus a layer that weakens slow neutrons also offers partial protection against the fast neutrons.

The intensity of the incident slow neutrons is decreased to the fraction $f = (1 - dN\sigma)$.

Thus the thickness (d) of a sheet of material 1 required to reduce the intensity of the incident slow neutrons to the quantity of fraction f may be expressed as follows:

$$d = \frac{(1-f)}{N\sigma}$$

where σ is the total cross section of the sheet material, N is the number of nuclei/cm.³.

Substances capable of decreasing the intensity of slow neutrons to the fraction f may be incorporated in an intermediate layer in the protective device or worked into a layer thereof. The protection under consideration against neutrons is effectuated by substances which undergo neutron absorbing nuclear reactions. Such substances are for instance the chemical elements cadmium, boron, gadolinium and others and the compounds of those elements. These substances may be worked into the main layer of the protective device, whether it be of synthetic material, rubber, plastic or the like, during the manufacture thereof. The thickness d represents the distribution density of the absorbing substances and is computed by the formula supra.

Protection against radioactive substances which are obviously biologically poisonous chemical weapons, and carriers of bacteria of various kinds can be kept off the body by the protective device of the invention by means of protective layers of definite thicknesses which contain chemical substances that are chemically resistant and both air and gas-tight. These substances being substantially homogeneous, or consisting of several layers may be manufactured from synthetic materials and rubber.

Electromagnetic radiation in the wave length range of from about 100 μ to about 14 $m\mu$ can be effectively screened off by absorption and reflection. Mainly this reflection is obtained by a metallic layer such as aluminum. Protection against electromagnetic waves can be effectuated on the following bases:

(1) Pure absorption—as for example selective absorption (by band-spectra) accomplished by organic coloring compounds as for instance the aniline-compounds;

(2) Pure reflection as obtained by the reflection produced by thin aluminum foil or foils which should constitute the outermost layer or layers of the protective device;

(3) By absorption and reflection through the employment of layers having variable complex refractive indices, i.e. a sheet of material composed for example of rubber and metallic filings such as iron or aluminum distributed at random (non-homogeneously) throughout the rubber. In such a material the dielectric constant and the electrical conductivity are not constant as they are dependent on the distribution of the metallic filings.

(4) By absorption through the use of layers consisting of a mixture of graphite, platine-black and the like, with glue or latex.

The multi layer device of this invention is capable of

conversion into protective clothing and devices for protecting the ears, mouth and eyes. The protective device may also be used as a protective covering for buildings, packaging material, for shelters etc.

Having thus described the invention, it will be apparent to those of ordinary skill in the art to which the invention pertains, that various modifications and changes may be made in the illustrated and disclosed embodiments without departing from either the spirit or the scope of the invention.

Therefore, what is claimed as new and desired to be secured by Letters Patent is:

1. A protective device which acts as a barrier to radiation produced by alpha-, beta-, neutron-, and infrared radiation, bacteria and gases, comprising a flexible base member composed of a material selected from the group consisting of rubber and synthetic plastics, and having on one face thereof a layer of reflective metal foil, and a layer of adhesive for securing the foil to the base member, said adhesive being a member selected from the group consisting of synthetic adhesives consisting of acrylic acid ester, polyvinyl acetate, amyl acetate, including latex, which adhesive contains uniformly dispersed metallic particles selected from the group including aluminum powder and bronze.

2. A protective device which acts as a barrier to radiation produced by alpha-, beta-, neutron-, and infrared radiation, bacteria and gases, that comprises a plurality of multi-layer units having an air space between them, each unit comprising a metal foil layer, a main layer of rubber and a fabric layer, the foil layer of one unit lying face to face with the fabric layer of the other and said foil layers being the outer layers of the unit, characterized by the fact that the main layers contain an element selected from the group consisting of cadmium, boron and gadolinium, including a compound of any such element, and that the adhesive layers have admixed therewith organic compounds selected from the group consisting of aniline, orthonitroaniline, osazone and 3 amino 6 nitrotoluole.

3. A protective device as in claim 1 in which the density of the main layer is of the order of 20-120 mg./cm.².

4. A protective device as in claim 1 in which the base member contains an element selected from the group consisting of cadmium, boron, and gadolinium, including a compound of an element of said group.

5. A protective device as in claim 1 in which the adhesive layer has admixed therewith an organic compound selected from the group consisting of aniline, ortho-nitroaniline, osazone, and 3 amino 6 nitrotoluole.

6. A protective device as in claim 5 in which the adhesive layer also includes metallic particles selected from powdered aluminum and metallic bronze.

7. A device as in claim 2 in which the units are secured to each other at the air space interface.

8. A protective device as in claim 4 in which the selected element is homogeneously distributed in the main layer.

References Cited in the file of this patent

UNITED STATES PATENTS

2,404,225	Green	July 16, 1946
2,627,072	Frommelt et al.	Feb. 3, 1953
2,642,542	Weinberg	June 16, 1953
2,773,459	Sechy	Dec. 11, 1956
2,796,411	Zirkle	June 18, 1957
2,858,451	Silversher	Oct. 28, 1958

FOREIGN PATENTS

547,223	Great Britain	Aug. 19, 1942
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OTHER REFERENCES

Levey: Abstract of application Serial No. 49,649, published December 23, 1952, 665 O.G. 1314-15.