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Henry et al.

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[54] **PROTECTIVE CLOTHING FABRIC**

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[51] **Int. Cl.** **D03d 15/00**

[58] **Field of Search** ..... 139/420 R, 426 R; 2/2, 81; 8/116 R, 116.2; 423/447; 57/140, 140 B, 144; 66/202

[56] **References Cited**

UNITED STATES PATENTS

3,235,323	2/1966	Peters	8/116.2
3,484,183	12/1969	Dickson et al.	8/116 R
3,556,712	1/1971	Yoneshige et al.	423/447
3,527,564	9/1970	Moore et al.	423/447
3,607,672	9/1971	Schmitt	8/116 R
3,572,397	3/1971	Austin	139/426 R
2,252,554	8/1941	Carothers	260/78
3,586,596	6/1971	Ainsworth et al.	2/2

FOREIGN PATENTS OR APPLICATIONS

1,162,110	8/1969	Great Britain	2/81
1,406,529	6/1965	France	139/426 R

OTHER PUBLICATIONS

Nomex: Promising Raw Material for Industrial Knits, Knitted Outerwear Times, Vol. 39 No. 28 July 6, 1970 pages 28, 29, 58 and 59.

Properties of Nomex, High Temperature Resistant Nylon Fiber, Du Pont Technical Information Fibers, Nomex Nylon Bulletin N-236 Oct. 1969.

Graphite Now Produced in Flexible Textile Form–Applications "Limitless," Mechanical Engineering, June 1959 page 121.

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[57] **ABSTRACT**

A flame-resistant and toxic chemical-agent protective clothing fabric woven of aromatic polyamide yarns and carbon yarns having at least 12 mg of carbon yarn per square centimeter of fabric, said carbon yarns having a carbon tetrachloride vapor sorption capacity of at least 15 percent by weight.

10 Claims, No Drawings

PROTECTIVE CLOTHING FABRIC

The invention described herein may be manufactured, used and licensed by or for the Government for governmental purposes without the payment to us of any royalty thereon.

BACKGROUND OF THE INVENTION

This invention is concerned with woven textile fabrics to be used in the fabrication of protective clothing to shield the wearer thereof from certain toxic organic gases or vapors.

Individuals exposed to toxic gases and liquids have, heretofore, protected their bodies by donning certain protective garments which are "impermeable" to both gases and liquids. Clothing that is completely impermeable to gases can be worn for only short periods of time without discomfort or fatigue due to the retention of body heat and moisture within the air space defined by the garment. The buildup of body heat and moisture within the garment results, at a minimum, in discomfort and under certain circumstances can result in excessive and debilitating thermal stress to the individual. Consequently, impermeable garments may only be worn for extremely brief periods of time, a serious drawback, or must be combined with auxiliary ventilating equipment which limits mobility and creates additional logistical and physical burdens. Other forms of protection employed include outer-garments of foam impregnated with activated carbon and clothing liners of woven fabric impregnated with chloramide materials and chlorinated paraffin. These forms of protection have proven to be unsatisfactory because of the physiological stress that they impose on the wearer by virtue of their bulk, weight or insulative properties. Considerable research, however, has been directed toward the development of an air-permeable material that can be worn with comfort and at the same time detoxify or attenuate the effects of toxic gases or liquids in the environment. Until the present invention, there has been no practical permeable sorptive woven clothing fabric that could be worn with comfort and could actually protect the wearer from all toxic gas agents present in the environment.

SUMMARY OF THE INVENTION

This invention relates to woven textile fabrics useful in fabricating permeable, flame-resistant, toxic chemical-agent protective clothing. The fabric is woven from aromatic polyamide yarns and carbon yarns having a carbon tetrachloride vapor sorption capacity of at least 15 percent by weight. The carbon yarns are uniformly distributed throughout the fabric in an amount sufficient to provide at least 12 milligrams of carbon yarn for each square centimeter of fabric.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The objective of this invention, to prepare a woven fabric suitable for use in clothing that is permeable to air and moisture vapor but substantially impermeable to toxic gaseous agents, is accomplished by weaving aromatic polyamide yarns in combination with carbon yarns having certain specific properties.

Carbon yarns are known and are available in many different types having differing physical properties. Carbon yarns, as that expression is used herein, refers

to yarns comprised of fibers having a carbon content of from 50 up to 99+ percent. For purposes of this invention, it is required that the carbon yarns have a carbon tetrachloride sorption capacity of at least 15 percent by weight. The extent of vapor sorption capacity or degree of activation of the carbon material has a finite upper limit which is governed in part by the nature of the carbon precusor as well as the activation conditions or procedures, which are well known to those skilled in the art. Carbon yarns having any significant vapor sorption capacity are known to have extremely poor tensile or breaking strength properties (typically less than 1 gm – denier) as well as poor abrasion resistance and poor flexing properties, all of which make such yarns unsuitable for use in clothing applications. Descriptions of suitable carbon yarns and methods of manufacture are found in U.S. Pat. No. 3,235,323 to E. N. Peters; U.S. Pat. No. 3,484,183 to A. D. Dickson and E. N. Peters and U.S. Pat. No. 3,556,712 to Yoneshige, et al. Examples of commercially available yarns meeting the requirements of this invention are Pluton B–1 and Pluton PX563, both products of 3M Company.

Aromatic polyamides are polymers which exhibit an unusually high degree of stability when exposed to elevated temperatures. High melting points or lack of a melt point before thermal degradation are characteristics of the aromatic polyamides. These polymers are highly resistant to flaming and are extinguished once the flame source is removed. Typically, these polymers are formed by copolymerizing aromatic diamines with dicarboxylic acids, e.g., metaphenylenediamine with isophthalic acid. Nomex, a product of E. I. DuPont deNemours and Co., is but one example of a commercially available aromatic polyamide yarn.

The woven fabrics of this invention have aromatic polyamide yarns in the filling and warp directions with carbon yarns also woven in either or both directions. The strength of the fabric in the warp and fill directions is at least 90 lbs per inch as measured by Method 5102 of the Federal Test Method Standard 191. To be effective, the carbon yarn must be substantially uniformly distributed through the woven fabric, i.e., a component of either or both the filling and warp yarns. It is essential, for the purposes of this invention, that there be at least 12 mg of the above defined carbon yarn in each square centimeter of woven fabric. The fabric should also be woven so as to have an air permeability of at least 50 cubic feet/minute/square foot of fabric.

Clothing or garments constructed with the fabric of this invention provide a high degree of protection against the passage of toxic, organic gases. Toxic, organic chemical gases, or liquids which readily volatize to produce such gases, are selectively adsorbed by the carbon yarns of the fabric and thus prevented from passing through the fabric to the body of the wearer. For example, vesicant military gases, such as mustard or lewisite, which are capable of producing painful and incapacitating blisters when allowed to contact the skin, can be effectively held back by preferential adsorption in the carbon yarns of the clothing fabric of this invention. The expression toxic chemical agent-protective fabric, refers to fabric which can absorb relatively large quantities of toxic organic gases. A satisfactory sorptivity in this context is 95.5 micrograms of mustard sorbed out of a total of 100 micrograms. While effective in retaining or absorbing toxic chemical gases, the same garment, by virtue of its high air-permeability

(over 50 cubic feet per minute per square foot) and reduced thickness may be worn with reduced physical stress being placed on the wearer. In addition to the foregoing desirable properties, this fabric exhibits a high degree of flame resistance due to the unique combination of properties of the 2 yarn components. Flame resistance refers to the ability of the fabric to self extinguish when the flame source is withdrawn.

EXAMPLE 1

A fabric according to the invention is constructed by waving Pluton PX 563 yarn with Nomex yarn. The Pluton carbon yarn has a surface area of 240 square meters per gram, a strength of 2.8 lbs per yarn, denier (g per 9,000 meters) of 1152, and a twist having 2.8 turns per inch. The Nomex yarns are 3 ply (200 denier) and 2 ply (200 denier). A plain weave fabric was constructed having the 3 ply Nomex in the warp and the 2 ply Nomex and the carbon yarn woven together in the fill direction. The resulting fabric had a yarn count of 34 ends per inch and 34 picks per inch, a thickness of 26–27 mils, a weight of 10.5 ounces per square yarn, air-permeability (Federal Test Method Standard 191, Method 5450) of 82 cubic feet per minute per square foot and strength (Federal Test Method Standard 191, Method 5102) in the warp of 150 lbs per inch of sample and in the fill of 92 lbs per inch of sample. The flame resistance of the fabric, as determined by the Federal Test Method Standard 191, Method 5902, was as follows:

Warp, after flame, seconds	0
Warp, after glow, seconds	7
Warp, char length, inches	0
Fill, after flame, seconds	0
Fill, after glow, seconds	4
Fill, char length, inches	1.4

The fabric was tested for distilled mustard gas retention on the Dawson apparatus under standard testing conditions described in "Laboratory Methods for Evaluating the Protection of Permeable Protective Clothing Against Chemical Agents" by B. P. Dawson and N. F. Gilchrist, EATM 311–3, Edgewood Arsenal, Maryland, A.D. 824901 (December 1967). Under the standard conditions set forth therein, exposure to a concentration of 500 micrograms per square centimeter of distilled mustard resulted in less than 1 microgram of penetration per centimeter of fabric, and exposure to a concentration of 800 micrograms per square centimeter resulted in less than 5 micrograms penetration per centimeter of square fabric. These results indicate a high level of protection against mustard vapor.

We claim:

1. A woven, flame-resistant, toxic chemical agent-protective clothing fabric comprising flame resistant aromatic polyamide yarns interwoven with carbon yarns, said carbon yarns having a carbon tetrachloride vapor sorption capacity of at least 15 percent by weight, and the minimum weight of said carbon yarn in said fabric being at least 12 milligrams per square centimeter.

2. A clothing fabric, according to claim **1**, wherein said carbon yarns are uniformly distributed throughout the fabric.

3. A clothing fabric, according to claim **2**, wherein said polyamide yarns of said fabric are woven in the fill and in the warp directions.

4. A clothing fabric, according to claim **3**, wherein the air permeability of said fabric is at least 50 cubic feet per minute per square foot of fabric.

5. A clothing fabric, according to claim **4**, wherein the strength of said fabric in the warp and fill directions have at least 90 lbs per inch.

6. A clothing fabric, according to claim **5**, wherein the warp of said fabric consists of a 3 ply (200 denier) aromatic polyamide yarn and the fill is a combination of a 2 ply (200 denier) aromatic polyamide yarn and the carbon yarn.

7. A clothing fabric, according to claim **6**, wherein the weave is a plain weave.

8. A method of protecting a wearer from a toxic chemical gas agent which comprises enclosing said wearer in a clothing garment constructed of a fabric comprising flame resistant aromatic polyamide yarns interwoven with carbon yarns, said carbon yarns having a carbon tetrachloride vapor sorption capacity of at least 15 percent by weight, and the minimum weight of said carbon yarn in said fabric being at least 12 milligrams per square centimeter.

9. A method according to claim **8** wherein said carbon yarns are woven uniformly throughout said fabric.

10. A method according to claim **9** wherein said aromatic polyamide yarns are woven in the fill and warp directions.