

United States Patent

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UNITED STATES PATENTS

405,850	6/1889	Rollins	128/143
1,991,601	2/1935	DeLasaux.....	128/144
2,813,272	11/1957	Hagan	2/82
2,826,758	3/1958	Kahn	128/144
2,994,089	8/1961	Ferguson, Jr. et al.....	
3,058,187	10/1962	Guqen.....	2/82X
3,096,702	7/1963	Malone, Sr. et al.....	2/81X

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- [54] **GARMENT ASSEMBLY**
10 Claims, 7 Drawing Figs.
- [52] U.S. Cl..... **128/142.5,**
2/81
- [51] Int. Cl..... **A62b 7/00**
- [50] Field of Search.....**128/139-141,**
142.5, 142.7; 2/2.1, 79, 81, 82, 205
- [56] **References Cited**

ABSTRACT: A garment assembly useful in clean rooms and similar low contamination areas to prevent personnel carried contamination from entering the room is provided which includes suiting comprising a jacket, pants and a helmet and fitted thereto an air inflow means. An air outflow means occupies the major rear area of the helmet comprising a sub-micron filter means impermeable to wearer-generated contamination, but permeable to air.

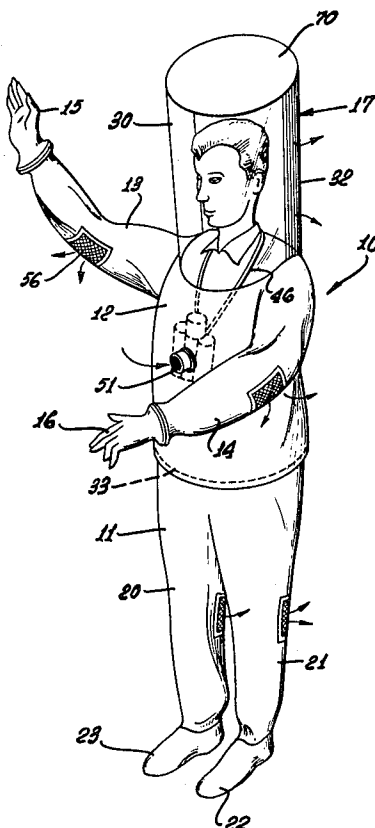


FIG. 1.

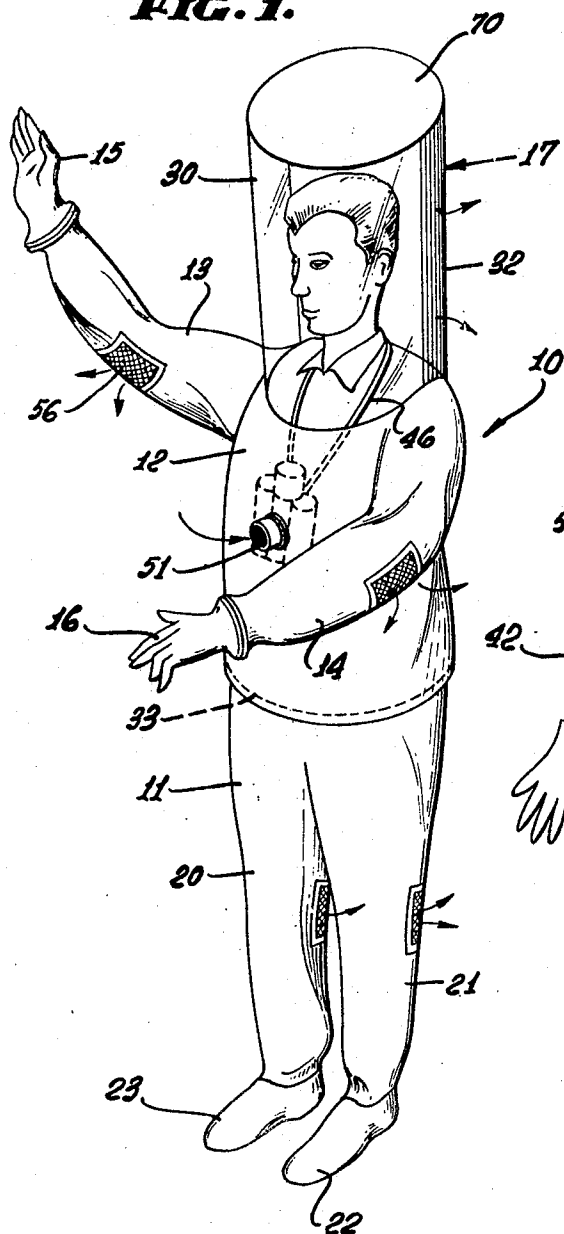
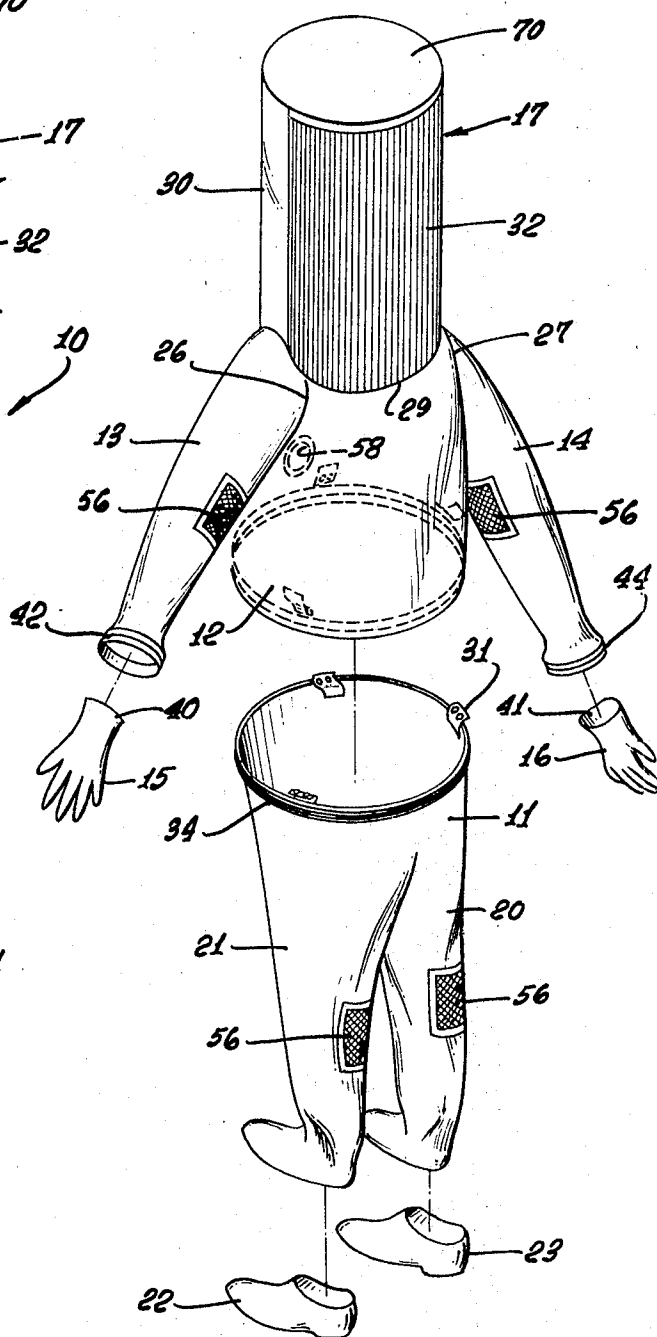


FIG. 2.



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FIG. 3.



FIG. 4.

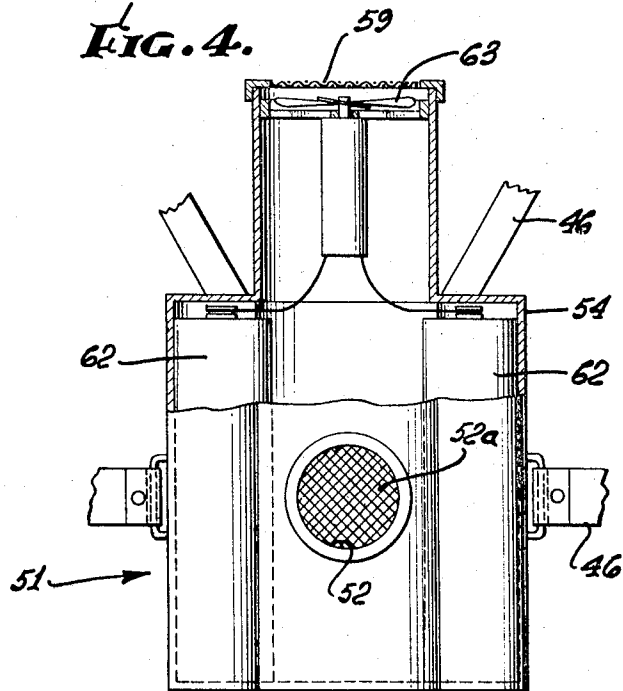


FIG. 5.

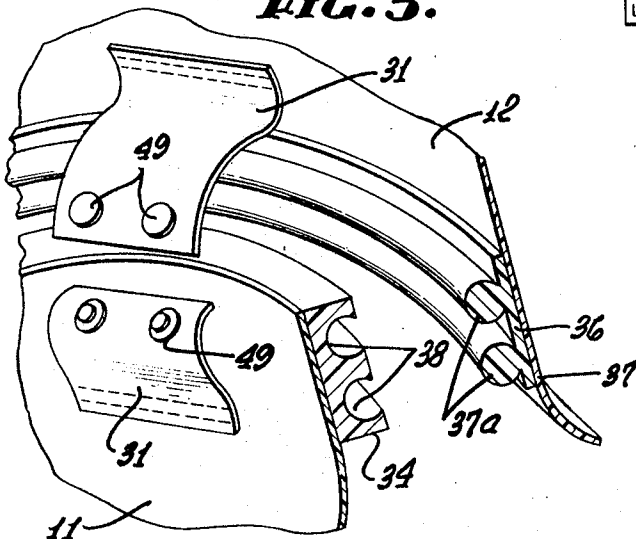


FIG. 6.

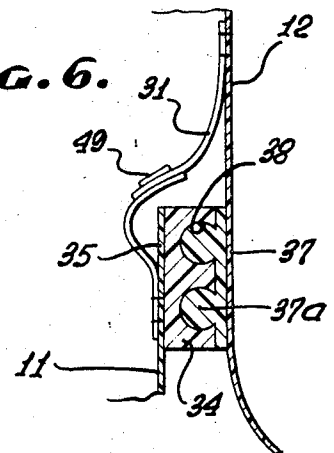
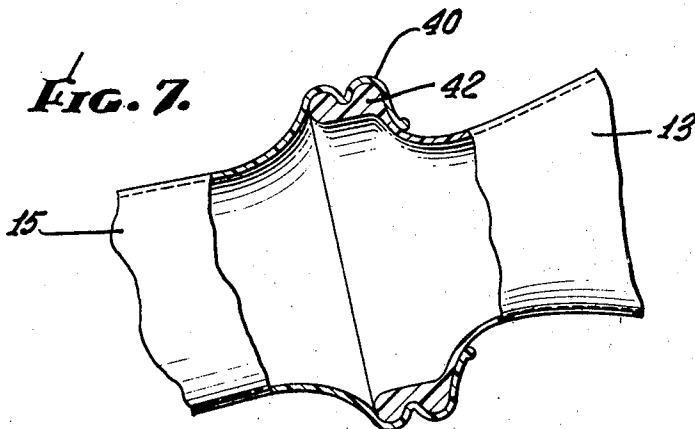


FIG. 7.



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GARMENT ASSEMBLY

This application is a continuation-in-part of our copending application Ser. No. 293,115, filed July 5, 1963, now abandoned.

The present invention relates to a garment assembly for use on a person, and more particularly, to a garment assembly especially adapted for use in low-contamination rooms and other controlled environment localities where the contamination potential of occupants should be reduced.

It is well known that many modern manufacturing, assembly or testing activities have to be carried out in low-contamination rooms or so-called "clean rooms," the air and inside of which are carefully cleansed of dust and other deleterious particles. It is also well known that the bodies of the persons occupying these rooms constitute a major source of contamination. In the past, various garments or suits have been proposed and employed in an attempt to reduce contamination to a permissible minimum. As the effectiveness requirements of these suits increased, difficulties were experienced with the prior art garments or "clean suits" which were unable to contain the contamination to the required extent. Prior art garments were generally constructed of a material that allowed air to pass therethrough so that the wearer could breathe. The people working in these clean rooms have also more and more been required to refrain from the use of cosmetics and to observe many generally inconvenient measures which have not yet led to the desired result.

The present invention provides a clean suit garment assembly which overcomes these disadvantages to an extent not heretofore realized through the provision of a garment assembly that effectively isolates wearer-generated contamination from the clean room environment.

Garment assemblies of various types are well-known, ranging from underwater diving rigs to spacesuits. Each has its peculiar requirements dictated by the use environment. Almost all garment assemblies, heretofore known, however, have sought to protect the person from the environment. Clean room technology on the other hand requires protection of the environment from the person. Accordingly, previous garment design wherein air inflow to the suit is closely controlled but air outflow is uncontrolled is not useful. The control of air outflow to the extent necessary to filter dust and other wearer-generated contamination requires the use of sub-micron, even absolute, filters. The outflow restriction resulting from interposition of such filters in conventional outflow apertures causes reduced air flow over the wearer's body and discomfort due to resulting moisture accumulation in the suiting. In addition, positive air displacement into the suiting with insufficient outflow provision may cause a rupturing of the suiting material. In U.S. Pat. 405,850 to Rollins, a conventional wearer protecting garment is disclosed provided with positive air displacement means and quite small, but relatively unrestricted air outflow apertures (cotton filled). Other garment assemblies cover only a portion of the wearer's body leaving contaminant sources exposed.

It is an object, therefore, of the present invention to provide a garment assembly adapted to protect clean room environments from wearer-generated contamination wherein by a novel arrangement and extension of air outflow apertures highly effective, submicron filters can be employed and adequate insuit air flow and complete room integrity both be maintained.

According to the invention, the garment assembly is of suiting material impermeable to air and wearer-generated contamination and includes, jacket, pants and a helmet having a visor to enclose and cover the wearer's body. The garment assembly includes air inflow means, such as a blower supported on the wearer having a motor within the suiting and provided with an air intake outside the suiting and an air exhaust within the suiting. Air outflow is provided through submicron filter means disposed in the suiting and occupying the major rear area of the helmet. Additional submicron filter means can be disposed in the jacket and pants as will be described.

These and other objects and advantages of the invention, as well as the details of illustrative embodiments, will be more fully understood from the following detailed description of the drawings, in which:

FIG. 1 is a front elevation of the garment assembly of the present invention on a wearer;

FIG. 2 is an exploded rear elevation of the garment assembly showing the filter means occupying the major rear area of the helmet;

FIG. 3 is a front elevation of the blower supported on a wearer prior to donning the garment assembly;

FIG. 4 is an enlarged front elevation of the blower partly broken away to show underlying parts;

FIG. 5 is a detail view in elevation of the waistband seal and support means for the garment assembly;

FIG. 6 is a cross-sectional view of the waistband seal and support means; and

FIG. 7 is a cross-sectional view of the seal between the glove and sleeve of the garment assembly.

As used herein the term "submicron filter" refers to a filtering medium having an effective porosity such that particles of material greater than a micron in any dimension are trapped as by mechanical engagement in the air paths within the filter, such as the interstices of matted fibers. The interstices and other paths need not in themselves be less than a micron in every dimension, provided the particles of desired fineness are entrapped within the filter medium. Such filters provide a pressure drop across them of from 0.1 to 1 inch of water and preferably from 0.1 to 0.3 inch of water. A typical filter material is a mass of compressed inorganic fibers such as glass and asbestos fibers, but other materials including finely perforate films can be used, instead of or in addition to fiber masses, where the capability of mechanically engaging particles of one micron or more in any dimension is afforded. Where use environment tolerances are greater or less the filter medium can be varied accordingly.

The term "impermeable" herein refers to the quality of not permitting passage. Thus "impermeable to air" refers to a quality of not permitting passage of air. "Impermeable to contamination" refers to a quality of not permitting passage of contamination where "contamination" refers to unwanted solid particulate, elongate or otherwise configured elements, such as dust particles in clean rooms and the like.

Referring now to the drawings in detail, there is provided as shown in FIG. 1, a garment assembly 10 comprising suiting including pants 11, jacket 12, sleeves 13 and 14, gloves 15 and 16 and helmet 17. In this embodiment, and as best shown in FIG. 2, pants 11 include pants legs 20 and 21 which extend to and enclose the feet of the wearer. A pair of slippers 22 and 23 (FIG. 2) are desirably worn over the ends of pants legs 20 and 21 to reduce abrasion on these portions. The slippers are made of abrasion-resistant contamination-free material and can be injection molded or sewn sheets of plastic, such as vinyl chloride polymer.

Jacket 12 has the sleeves 13 and 14 sealably connected thereto at seams 26 and 27 respectively. If a suitable material is used, the seams 26 and 27 can be heat seal formed, optionally reinforced with stitching tape or otherwise.

The helmet 17 is secured to jacket 12 at seam 29 suitably by heat sealing, taping, sewing or solvent or sonic welding, as may be appropriate. The helmet 17 has a viewing window, visor 30, arranged opposite the wearer's eyes. The visor 30 is a clear plastic material such as vinyl chloride, nylon, acrylic or styrene polymer. Preferably, the helmet 17 is generally cylindrical for ease of fabrication and comprises cylinder segments, visor 30 and filter means 32, either contiguous or joined by tape or other means to an intervening common material.

The pants 11 are sealably and releasably connected to jacket 12 at waistband 33. For this purpose, a resilient annular female member 34 having grooves 38 and of natural or synthetic material is incorporated in pants 11. A resilient annular male member 36 having tongues 37a of similar material and sized to be insertable and releasably retainable in grooves

38 of member 34, is incorporated in edge margin 37 of jacket 12. As seen in FIGS. 5 and 6, a releasable seal can be accomplished by drawing the upper edge margin 35 of pants 11 over edge margin 37 of jacket 12 and pressing tongues 37a of member 36 into grooves 38 of member 34. As shown, the edge margins 35 and 37 are pressed together without being folded over, but other arrangements can be used. To mechanically strengthen the seal between edge margins 35 and 37, straps 31 are provided in registry on adjacent jacket and pants edge margins. The mating parts of snap fasteners 49 are attached respectively to these straps 31 and to the pants 11, so that the wearer of the suit can attach the straps 31 to the pants 11 before establishing the seal at waistband 33. In this manner, accidental breaking of the seal is avoided.

The gloves 15 and 16 are of air and contamination impermeable material such as polyethylene, vinyl chloride polymer, natural or synthetic rubber or other suitable material. Each of gloves 15 and 16 has an elastic annular cuff 40 and 41, respectively, incorporated therein. Each sleeve 13 and 14 has O-rings 42 and 44, respectively sealed to the free end thereof. The configuration of O-rings 42 and 44 is shown in FIG. 7. Elastic annular cuffs 40 and 41 cooperate with O-rings 42 and 44 to sealably secure gloves 15 and 16 to sleeve 13 and 14 respectively.

In general, preferred materials of construction for jacket, pants, boots and gloves are air impermeable plastic materials. Sheets or heavy gauge films of thermoplastics such as polymers and copolymers of vinyl chloride, vinylidene chloride, ethylene, acrylic acids and esters, methacrylic acid and ester, propylene, amines such as polyamides and other polymerizable monomers are desirably employed. Combinations of these materials with other similar or different materials for increasing comfort, strength, appearance or any other property of the suiting are within the scope of the present invention. For example, combinations of plastic film with non-woven materials such as massed material and synthetic fibers, e.g. flocked cotton and silk, compressed nylon, polyester, spandex and modacrylic fibers can improve wearer's comfort. Relatively thin films can be strengthened by combination with fibers such as mentioned above, non-woven or woven into materials of various types or coatings or laminates of films such as polyester or polyamide, thermoplastic or thermosetting resins, e.g. polyurethanes can also be employed.

The garment assembly is provided with a blower 51. As shown in FIG. 3, a harness comprising straps 46 encircling the waist and neck of the wearer supports blower 51 at the middle of the wearer's body. The blower 51 has an inflow means, inlet 52, adapted to project fluid tightly from the blower through aperture 58 in jacket 12. Inlet 52 can be provided with a grille or inlet filter 52a if desired. Blower 51 comprises a housing 54 suspended by straps 46 and a fan 63, powered by batteries 62, arranged to exhaust through outlet 59. Generally, the blower capacity should be sufficient to draw air into the suiting and force it out of the suiting filters at a rate permitting normal respiration against the static head within the suiting. An air flow of 5 to 15 cubic feet per minute (c.f.m.) is satisfactory as are somewhat lower and higher flows. It will be noted, the blower 51 is entirely enclosed by the jacket 12, except for inlet 52. In this manner, contamination generated by the blower motor mechanism (not shown) is retained within the suiting and not released into the use environment. Inlet 52 is receivable into aperture 58 of elasticized material and is fluid tightly retainable therein, as shown in FIG. 1 with the housing 54 shown in dotted outline. The air outlet 59 is also shown in dotted outline in FIG. 1 to illustrate that it is generally arranged to issue air in the direction of helmet 17. Lateral or downward air flow is not as desirable but can be used. The blower 51 can be any conventional self-powered fan mechanism, and is preferably a nickel/cadmium battery-powered rotating fan blade assembly, such as are well-known, so further detailed description will not be included here. Actuation of the motor of blower 51 is by a conventional switch, not shown.

Importantly with the present invention, adequate air flow through the garment over the wearer's body is realized and yet micron and larger particles are filtered from the garment air outflow. This is possible only because sufficient filter area has been provided to permit adequate outflow. Sufficient filter area is obtained by the occupation of the major rear area of the helmet 17 by filter 32. Only by virtue of such occupation can the conflicting requirements of low filter porosity and high air flow need be resolved.

As best shown in FIGS. 1 and 2, the helmet 17 includes visor 30 and filter 32 occupying the major rear area of helmet 17. In the embodiment shown, visor 30 and filter 32 are cylinder segments and the helmet 17 is cylindrical. Other configurations are equally satisfactory, e.g. a conical or square configuration. Filter 32 in a preferred embodiment comprises compressed glass and asbestos fibers arranged in a mat having plastic material around the mat periphery and traversed by a supporting mesh, generally 5 to 50 mils in thickness. Disc 70 closes the end of the cylinder-shaped helmet 17. The visor 30 and filter 32 materials in helmet 17 are preferably fabricated of relatively lightweight materials so as to be less cumbersome and irksome after long periods of wear. In a preferred embodiment, the helmet 17 is air floatable as will be explained hereinafter.

In addition to the filter 32 provided in the helmet 17, other filter areas can be provided. These are desirably arranged to draw air flow into the extremities of the assembly, thus filters 56 in the sleeves 13 and 14 and pants legs 20 and 21 can be provided. The maximum gross area of the filters 56 will generally be less than one half the total area A of filter provided, or A/2, and preferably filters 56 will provide only .25 A and less of total filter area; the remainder, .75 A and greater will be provided by helmet 17. The reason for this distribution of filter area is to (1) ensure adequate fresh air supply for breathing, and (2) for convenience in fabrication of suiting, and (3) for durability in use since sleeve and pants leg filters 56 are more subject to flexing and other unavoidable and accidental mechanical abuse. In a typical garment total filter area will be 30 to 40 R square inches, where R is the air flow in cubic feet per minute provided by the blowers 51. If R is 10, A is 300 to 400 square inches, and is desirably divided, thus, filter 32, 275 to 336 square inches; filter 56, 25 to 64 square inches, preferably but not necessarily equally apportioned among the several suiting extremities, e.g. 16 square inches each to sleeves 26 and 27 and pants legs 20 and 21, and desirably no less than 10 square inches of filter 56 per sleeve or pants leg.

As is clear from the foregoing, the materials of choice in fabricating the various parts of the present garment assembly are synthetic organic plastic materials, and/or fibers combined with plastics. Since plastic materials lend themselves to a great variety of joining techniques, seams between adjacent pieces, e.g. helmet 17 and jacket 12, or jacket 12 and sleeves 13 and 14, or visor 30 and filter means 32 can be air tightly sealed together in many ways, some of which have been disclosed above. In summary heat sealing, solvent and ultrasonic welding, adhesive, sewing and like techniques can be used. The combination of sewing for seal strength and heat sealing for seal integrity is particularly effective.

In use, the wearer first puts on blower 51 with straps 46. Jacket 10 with integral helmet 17 is then donned and inlet 52 is press fitted into aperture 58 in jacket 12. Pants 11 are then donned and sealably joined to jacket 12 by connecting snap fasteners 49. Annular members 34 and 36 are press fitted together to complete the sealing together of jacket 12 and pants 11.

Blower 51 is actuated and air flows into the suiting. Inflation results where the air inflow rate generally 5 — 15 c.f.m. exceeds the air outflow rate of the filters 32 and 56 at existing interior pressure. As interior pressure increases outflow rate, varying directly with pressure, increases until a pressure balance is achieved. Similarly, inflow rate which varies inversely with interior pressure will decrease as interior pressure increases as the fan must operate against higher pressures. With submicron

filters of the type herein described, the static head or interior pressure differential over ambient or exterior pressure when air inflow and outflow are equal will be in the range of 0.1 to 0.3 inch of water. At such a differential, it is desirable that the suit be generally out of contact with the wearer's body and that the helmet be light enough to be lifted or floated off the wearer's shoulders. In this manner, maximum flow of air over the skin and minimum garment weight are experienced by the wearer, and the garment assembly can be worn comfortably for longer periods.

We claim:

1. Garment assembly adapted to protect clean room environments from wearer-generated contamination comprising:
 - suiting to loosely fit the wearer's body including a jacket having sleeves and pants having pants legs and a helmet having a transparent visor arranged opposite the wearer's eyes, said suiting being fabricated of material and assembled to be impermeable to air and wearer-generated contamination;
 - air inflow means in said suiting including a blower supported adjacent the wearer having a motor within the suiting and provided with an air intake means outside the suiting and an air exhaust means within the suiting; and
 - air outflow means in said suiting occupying the major rear area of the helmet comprising a submicron filter means impermeable to wearer- and motor-generated contamination and permeable to air to provide air outflow from the suiting, said inflow means having a greater flow rate than said outflow means thereby producing a positive interior pressure.
2. Garment assembly claimed in claim 1, wherein said filter means is substantially contiguous with the visor and air tightly attached to the suiting below.

3. Garment assembly claimed in claim 2, wherein said visor and filter means are cylinder segments.

4. Garment assembly claimed in claim 2, wherein the helmet includes means for retaining air pressure and is floatable above the wearer at a positive interior pressure differential within the suiting of between 0.1 and 0.3 inch of water.

5. Garment assembly claimed in claim 4, wherein the suiting material is a synthetic organic plastic material.

6. Garment assembly claimed in claim 4, wherein sub-micron filter means are provided in both sleeves and pants legs.

7. Garment assembly claimed in claim 6, wherein said air inflow means provides an air inflow in the suiting at a rate of R cubic feet per minute and R is a number between 5 and 15 inclusive inversely varying with the interior pressure differential and wherein total filter means area A is within the range of $30R$ to $40R$ square inches and is divided into a major portion occupying the major rear area of the helmet and a minor portion distributed among the sleeves and pants legs of the suiting.

8. Garment assembly claimed in claim 7, wherein the filter means in the helmet has an area equal to $0.75A$ and greater and the remaining $0.25A$ and less filter means area is uniformly distributed among the sleeves and pants legs.

9. Garment assembly claimed in claim 8, wherein the filter means is a compressed mass of inorganic fibers and each separate filter means has an area of at least 10 square inches.

10. Garment assembly claimed in claim 7, wherein the blower is provided with an air intake means fluid-tightly extending through the front of the jacket portion of the suiting and is supported by a harness including straps around the waist and neck of the wearer.

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