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## 2.0 Description of the Related Art

Tactical locations, such as naval warships and land based buildings used for command information centers, have  
5 long been pressurized to protect against airborne intrusion therein of chemical, biological and radiological contaminations, such as the system disclosed in U.S. patent 4,962,371, which is herein incorporated by reference. Although the existing systems that provide for  
10 a pressurized environment serve well their intended purpose, it is desired that further improvements be provided thereto.

The filters used in such pressurized systems are commonly placed in relatively small environments, such as  
15 air ducts. It is desired that a compact filtering apparatus be provided wherein all the filtering required to purge the air of contaminants is located in one compact structure.

The pressurized environment provided by the air  
20 filtering systems needs to be maintained at a predetermined positive pressure. It is desired that a system be provided that monitors for the pressure within the enclosed environment and maintains the pressure therein within a desired limit.

## OBJECTS OF THE INVENTION

It is a primary object of the present invention to  
5 provide an air filtering system that is particularly suited  
to filter and remove contaminants created by chemical,  
biological or radiological conditions.

Another object of the present invention is to provide  
an air supply system that has a single air filtering  
10 apparatus which houses all of the necessary filtering  
devices needed to purge the supplied air of contaminants.

It is another object of the present invention to  
provide for a system that monitors the positive pressure  
within an enclosed environment or zone protected by the  
15 system so as to be within a desired range.

## SUMMARY OF THE INVENTION

The invention is directed to an air supply system that  
20 is particularly suited to filter out contaminants created  
by chemical, biological or radiological conditions.

The system comprises a three-stage air filter  
apparatus and a supply fan. The three-stage air filter  
apparatus has an input and an outlet with the input fluidly

coupled to the inlet of the air supply system. The three-stage air filter apparatus has first, second and third coaxially arranged annular filters, with the first filter being disposed within the second filter and the second  
5 filter being disposed within the third filter. The first filter is located closest to the input of the three-stage air filter apparatus and the third filter is located closest to the output of the three-stage air filter apparatus. The first filter filters and removes particles  
10 of at least a first size. The second filter filters and removes aerosols and particles of a size which is less than the first size. The third filter comprises a gas adsorber for removing gases. The air supply system has an input fluidly coupled to the output of a three-stage air filter  
15 apparatus and an output fluidly coupled to the air intake means of the protected zone. The supply fan supplies a sufficient flow of air so as to provide the protected zone with a positive pressure.

## BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention may be realized when considered in view of the following detailed description, taken in conjunction with the accompanying drawings.

Fig. 1 is a block diagram showing the inter-relationship of the elements making up the air supply system of the present invention.

Fig. 2 is a perspective view showing the annular disposed three filters making up the three-stage air filter apparatus of the present invention.

Fig. 3 illustrates the placement of the three-stage air filter apparatus within the air filtering system of the present invention.

Fig. 4 is a functional flow diagram of the air supply system of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, wherein the same reference number indicates the same element throughout, there is shown in Fig. 1 a block diagram showing the interrelationship of the essential elements making up the air supply system 10 of the present invention.

The system 10 supplies an enclosed protected zone 12, having an air intake means 14, with an air supply having an inlet 16 that is coupled to the external environment. The system 10 is particularly suited to provide filtering to  
5 remove contaminants created by chemical, biological or radiological conditions.

The protected zone 12 is defined by enclosed boundaries and is airtight. The practice of this invention frees the personnel in this zone from wearing protective  
10 masks or clothing, otherwise required to prevent the detrimental effects created by the chemical, biological and radiological contamination.

The protected zone 12 is pressurized by supplying air at a sufficient flow and maintaining the positive pressure  
15 by providing air tightness of the protected zone 12 itself and by the use of air locks. Maintaining a positive pressure with the protected zone 12 prevents the infiltration therein of the chemical and biological contaminants. The contaminants are removed from the air  
20 flowing into the pressurized zone 12 by a three-stage air filter apparatus 18.

The three-stage air filter apparatus 18 has a first filter 20, a second filter 22, and a third filter 24, all of which are annular coaxially arranged filters. The first

filter 20 is disposed within the second filter 22, and the second filter 22 is disposed within a third filter 24 in a manner to be further described herein after with reference to Fig. 2. The first filter 20 is physically located  
5 closest to the input of the three-stage air filter apparatus 18, and the third filter 24 is physically located closest to the output of the three-stage air filter apparatus 18.

A differential pressure gage 26 is connected between  
10 the input and the output of the three-stage air filter apparatus 18 and develops an output proportional to the differences between the pressure sensed therebetween. The differential pressure gauge 26 may be used as a means for verifying the operation of the three-stage air filter  
15 apparatus 18, that is, a relatively low value indicated by the gauge 26 is representative that the filters therein are not clogged and that the three-stage air filter apparatus 18 is performing correctly.

The air supply system 10 further comprises a supply  
20 fan 28 which preferably is a centrifugal type fan and is also preferably shock-mounted to a structural foundation. The supply fan 28 is selected, in a manner known in the art, so as to supply a sufficient amount of air at a sufficient flow so as to provide the protected zone 12 with

a positive pressure of 1.0 inches wg. The supply fan 28 is located on the downstream side of the three-stage filter apparatus 18 and cooling coils 30.

5 The cooling coils 30 are installed downstream of the three-stage filtering system 18 so as to condition (cool if warm) the supplied air before distributing it to the supply fan 28.

The protected zone 12 further cooperates with air locks 32 known in the art. The air locks 32 are used for  
10 the ingress and egress of personnel to and from the protected zone 12 so as to prevent accidental contamination of the protected zone 12 during periods of chemical and biological threats.

The protected zone 12 further utilizes fan/natural  
15 exhaust equipment 34 known in the art. The exhaust system 34 removes air from the protected zone 12 the amount of which is balanced with the air supplied by system 10 to the protected zone 12 so as to provide and maintain the desired amount of positive pressure within the protected zone 12.

20 The protected zone 12 further utilized zone pressure gages 36 which are monitored to ensure that the protected zone 12 is supplied with a positive pressure within a desired range typically from about 0.5 inches (in) wg to

about 1.5 inches (in) wg. The zone pressure gages 36  
operatively cooperate with an alarm system 38.

The alarm system 38 monitors the pressure in the  
protected zone 12 indicated by the zone pressure gauges 36  
5 and provides an audible alarm to alert personnel of low  
pressure conditions therein. The alarm may be generated  
when the pressure within the protected zone 12 falls below  
0.5 inches wg. Alarm systems are known and one such system  
is described in the previously incorporated by reference  
10 U.S. Patent 4,962,371.

The protected zone 12 further preferably includes an  
opening with an input and an output, wherein a pressure  
control valve (PCV) 40 is installed. The pressure control  
valve (PCV) 40 provides fluid communication between the  
15 input and output of the opening and is dimensioned, in a  
manner known in the art, so as to allow for fluid  
communication therebetween when the positive pressure  
within a protective zone is greater than about 2.0 inches  
wg. Preferably the protected zone 12 includes the use of  
20 one pressure control valves 40 which is used to relieve  
excess air from the protected zone 12 and prevent excessive  
pressure therein from creating undesired air leaks.

The air supplied into the protected zone 12 originates  
from inlet 16, that is preferably directed into a coarse-

filter 42. The coarse-filter 42 typically uses a metal mesh to prevent large particles from entering the air supply system 10. The output of the coarse-filter 42 is directed into a preheater 44.

5           The preheater 44 conditions the air before it enters the three-stage air filter apparatus 18, which may be further described with reference to Fig. 2. As seen in Fig. 2., the three filters 20, 22 and 24 of the three-stage air filter apparatus 18, already discussed with reference  
10 to Fig. 1, are annular in shape and coaxially arranged, with filter 20 being dimensioned to be insertable into filter 22 which, in turn, is dimensioned so as to be insertable into filter 24. The filters 20, 22 and 24 are radial flow types, wherein air enters the inner (filter 20)  
15 diameter area and flows radially outward through the larger (filter 24) diameter surface. The first filter 20 has a typical outer diameter of twelve (12) inches and has a typical length of 10 inches. The first filter is a pleated-medium which filters and removes particles of at  
20 least a first or relatively small size. The second filter 22 filters and removes aerosols and particulates of a size which is less than the first size of the particles being removed by the first filter 20. The second filter 22 is selected of a material, known in the art, for removing

solid and aerosol chemical, biological and radiological  
contaminates. The third filter 24 comprises a gas adsorber  
which removes gases. The third filter 24 contains  
activated charcoal (aszmteda charcoal (chromium  
5 free)selected, in a manner known in the art, for removing  
chemical warfare gases. The placement of the three-stage  
air filter apparatus 18 and further details thereof within  
a system, such as that of system 10, may be further  
described in reference to Fig. 3.

10 Fig. 3 illustrates one three-stage air filter  
apparatus 18 further having a gas cover 46 that is placed  
over the third filter 24 and a NEPA cover 48 which is  
placed over the second filter 22 and a clamp 52, which is  
over the third filter 20. The gas cover 46 and NEPA cover  
15 48 is attached by a nut 50, whereas the third filter 20 is  
attached by way of a clamp 52 and a nut 54.

The system 10 preferably includes five three-stage air  
filter apparatuses 18, but only one is shown in Fig. 3 for  
the sake of clarity. The five three-staged air filter  
20 apparatuses 18 are each housed in an opening 56 with each  
of the filters 20, 22 and 24 disposed inside each opening  
56. The openings 56 open into an outlet plenum 58 which  
has curved upper portions (shown in Fig. 3) that provide an

air flow which is directed toward the air supply 28 (not shown).

The input air originally from inlet 16 of Fig. 1 is indicated in<sup>2</sup> Fig. 3 by directional arrow 62, and a  
5 watertight access door 64, similar to those used for the air locks 32, is generally indicated by reference number 64 and forms part of a bulkhead 66. The support for the openings 56 is provided by the bulkhead 68 and the structural support of the outer plenum 58 is provided by a  
10 deck 70. The operation of the system 10 can be further described with reference to Fig. 4.

Fig. 4 shows a functional flow diagram 72 of the operation of the present invention. Fig. 4 illustrates the elements previously described with reference to Figs. 1, 2  
15 and 3, but in addition thereto illustrates a thermostat 74 that is used to control the cooling coils 30. Fig. 4 further shows a block 76 that represents controlled leaks through doors, hatches etc., that are treated as exhaust generally identified by the use of reference number 78.

20 In general the operation of the system 10 includes supplying an adequate amount of air filtration of the air that is used to pressurize the protected zone 12 and monitoring for and maintaining the protected pressurized

zone 12 so that its positive pressure is within a desired range of between 0.5-1.5 in. wg.

In operation, the air provided from inlet 16 is divided into three elements, identified in Fig. 4 by three different paths 80, 82 and 84 that respectively represent particulates, aerosols, and gases. The three paths are preferably first intercepted by the coarse-filter 42.

The coarse-filter 42 has typical dimensions of 19.5 by 29.5 inches. The coarse-filter 42 filters out large particulates and then directs the paths 80, 82 and 84 onward to the preheater 44.

The preheater 44 elevates the air passing thereover to a temperature of at least 42° F and having a relative humidity of about 70%. The preheater 44 is preferably controlled by a thermostat 86. The preheater 44 directs the three paths 80, 82 and 84 onward to the first filter 20.

The first filter 20 removes relatively large particles and then directs the paths 80, 82 and 84 onward to the second filter 22.

The second filter 22 removes fine particulates and aerosols of 0.3 microns or greater with efficiencies of greater than 99.97 from its received air and delivers an

output which only comprises gases that are directed to the third filter 24.

The third filter 24 removes the gas by an adsorption operation and passes air free, indicated by directional  
5 arrow 88, from the contaminants, especially those created by unwanted chemical, biological and radiological conditions, that is directed to the outlet plenum 58 which, in turn, direct the air 88, free from contaminants, onward to the cooling coils 30.

10 The cooling coils 30, in response to the thermostat 74, supplies the same air 88 free from contaminants to the supply fan 28 which, in turn, provides filtered air 88 free of contaminants into the protected zone 12.

The protected zone 12 is maintained by means of the  
15 pressure transducers 36 and its related alarm system 38 as well as the pressure control valves 40 and is supplied with a continuous flow air 88 free from contaminants.

It should now be appreciated that the practice of the present invention provides for an air supply system that is  
20 particularly suited to filter out contaminants created by chemical, biological or radiological conditions.

It should be further appreciated that the air supply system utilizes a three-stage air filter apparatus that contains all of the necessary filtering element, and

because of its single structure, is conveniently mounted into bulkheads related to the system 10 of the present invention.

5 Still further it should be appreciated that the pressure transducer in cooperation with the alarm circuits allows for the monitoring of the protected zone so as to maintain its filtered air within a desired limit, such as 0.5-1.5 inches wg.

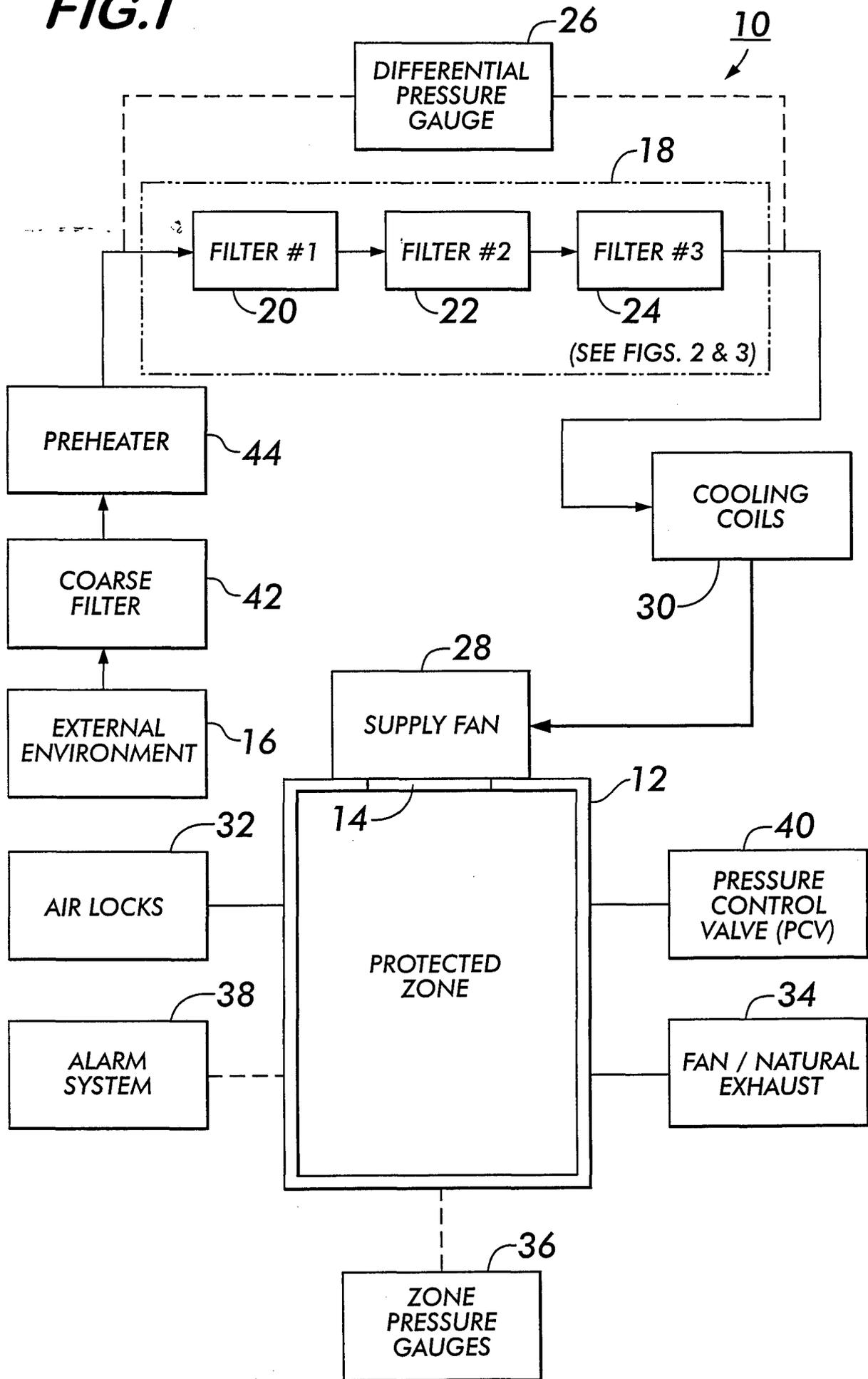
10 While the invention has been described with reference to the specific embodiments, this description is illustrative and is not to be construed as limiting the scope of the invention.

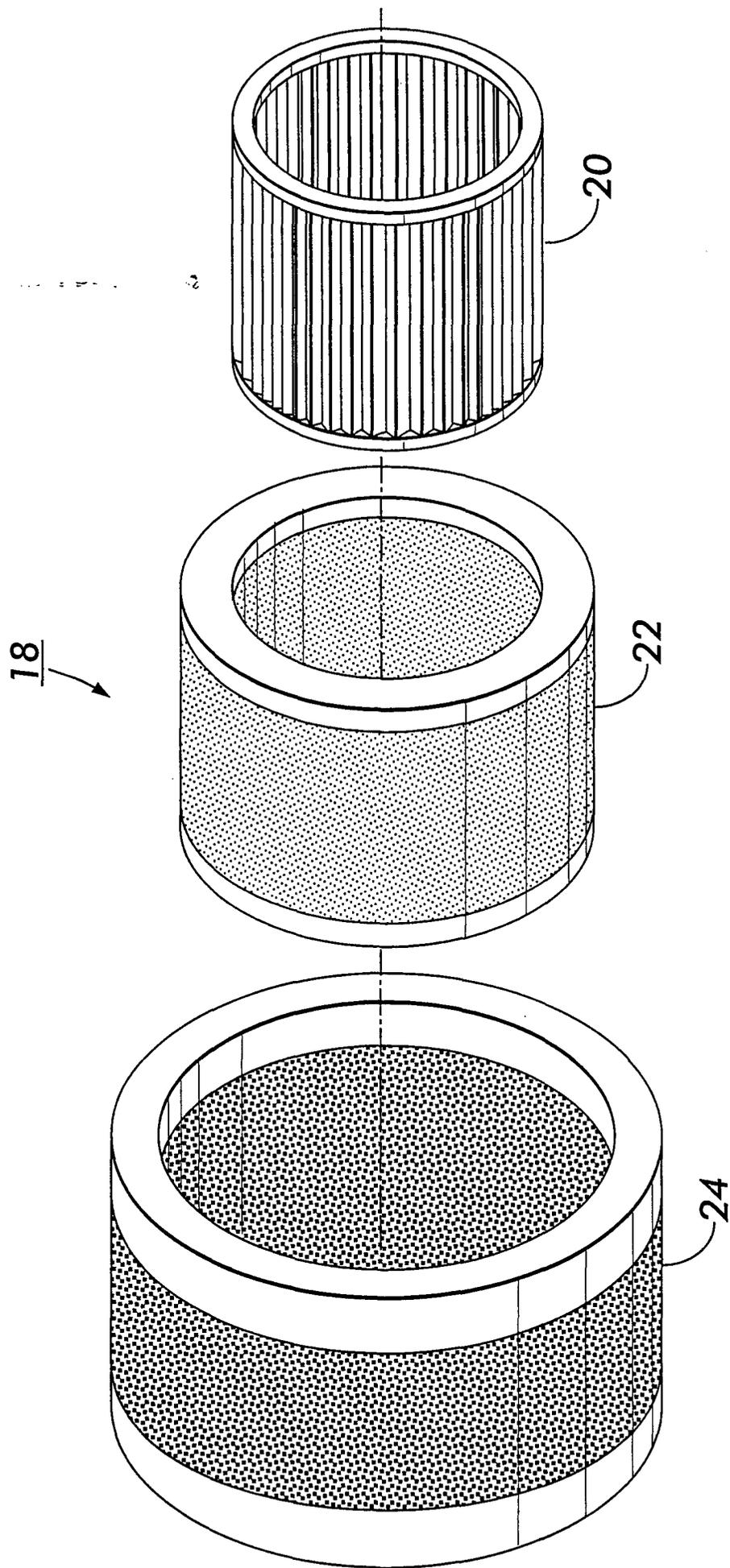
15 Various modifications will occur to those skilled in the art without departing from the spirit and scope of the invention.

ABSTRACT OF THE DISCLOSURE

Disclosed is an air supply system that provides filtered ventilation to a protected zone which is  
5 maintained at a positive pressure so as to prevent contaminants from infiltrating therein. The system further discloses a three-stage air filter apparatus that provides all the necessary filtering to remove contaminants from the air that may be created by chemical, biological and  
10 radiological conditions.

**FIG. 1**





**FIG. 2**



**FIG. 4**

