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(56) Documents Cited

GB 2261830 A	**GB 2232612 A**	**GB 2063097 A**
GB 2033247 A	**GB 1566264 A**	**GB 1562457 A**
GB 1490270 A	**EP 0042176 A2**	**US 4336043 A**

(58) Field of Search
UK CL (Edition N) **B1D DDNA DDPA DDQA DDRA DDTA DDXB , B1T TDNA TDPA TDQA TDRA TDTA TDXB**
INT CL^6 **B01D 29/15 29/23 29/31 29/33 29/35**
ONLINE DATABASES: WPI,CLAIMS,EDOC,WPIL

(54) Filter assembly and cartridge therefor

(57) A filter element which fits a filter head that is normally arranged for out-to-in gas flow through a filter cartridge has a pipe (32) defining with an upstanding wall of end-cap (16) a gas-tight inlet passage leading to a space (38) within the filter element (10). A return passage for filtered gas is provided by the pipe (32) which extends from an apertured end cap (18) of the filter element through the interior thereof to the first end, said arrangements changing the flow path to in-to-out. In use, in the case of a filter cartridge, it is less prone to give rise to blockages in a drain (55) of the filter housing which is less exposed to contamination with solid matter. In the case of an adsorbent filter, an indicator material can be provided which becomes visible on the exterior surface of the filter element on exposure thereof e.g. to oil droplets.

FIG.2

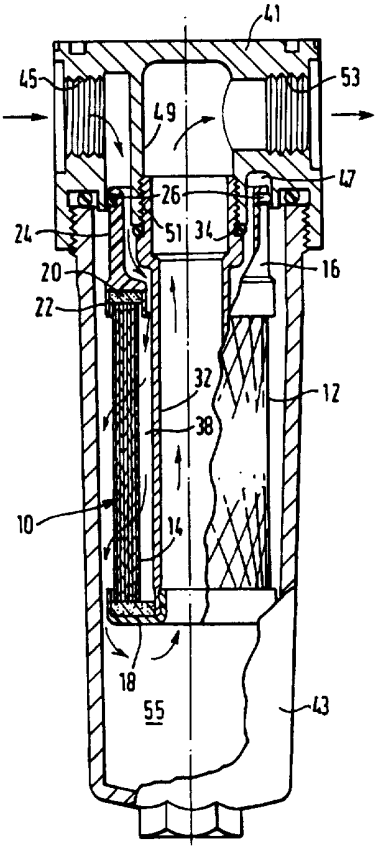

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FIG. 1

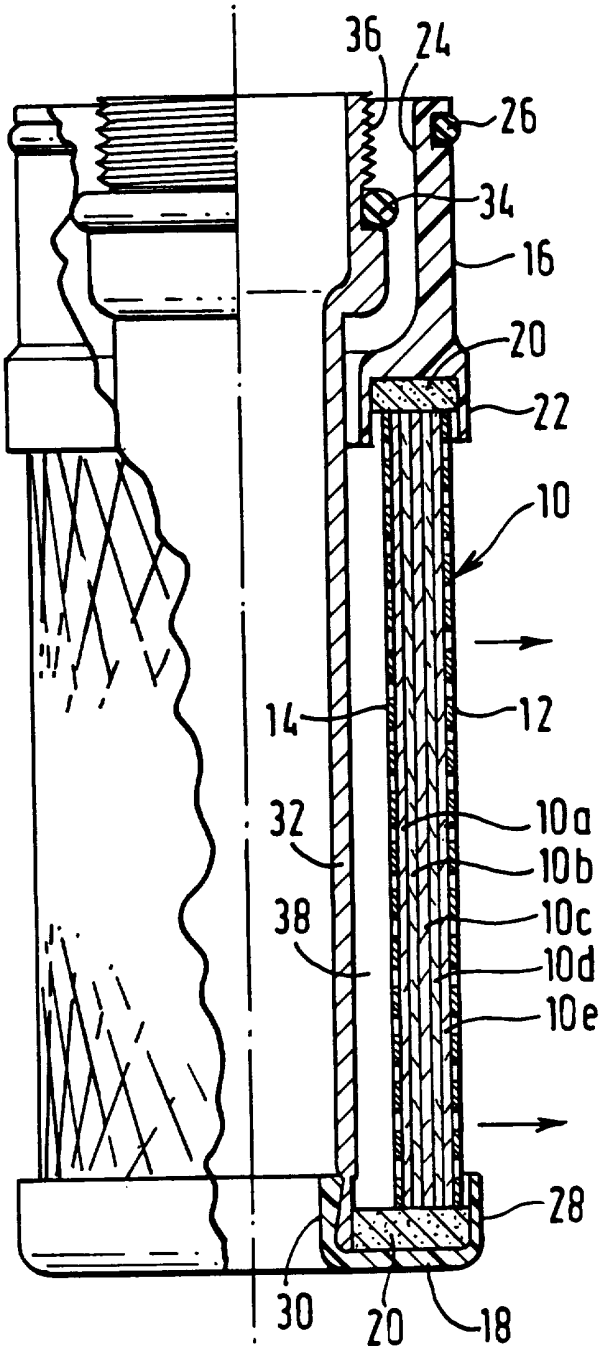


FIG.2

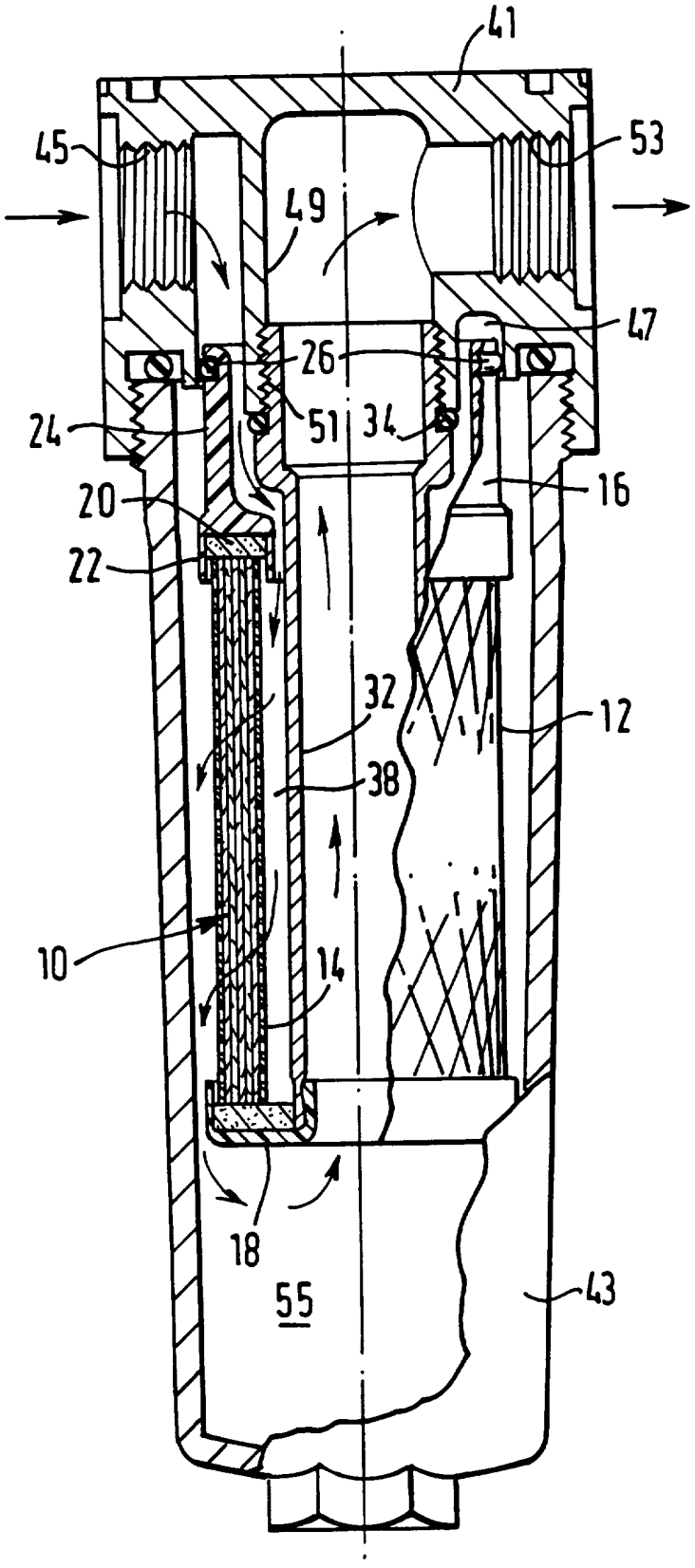


FIG. 3

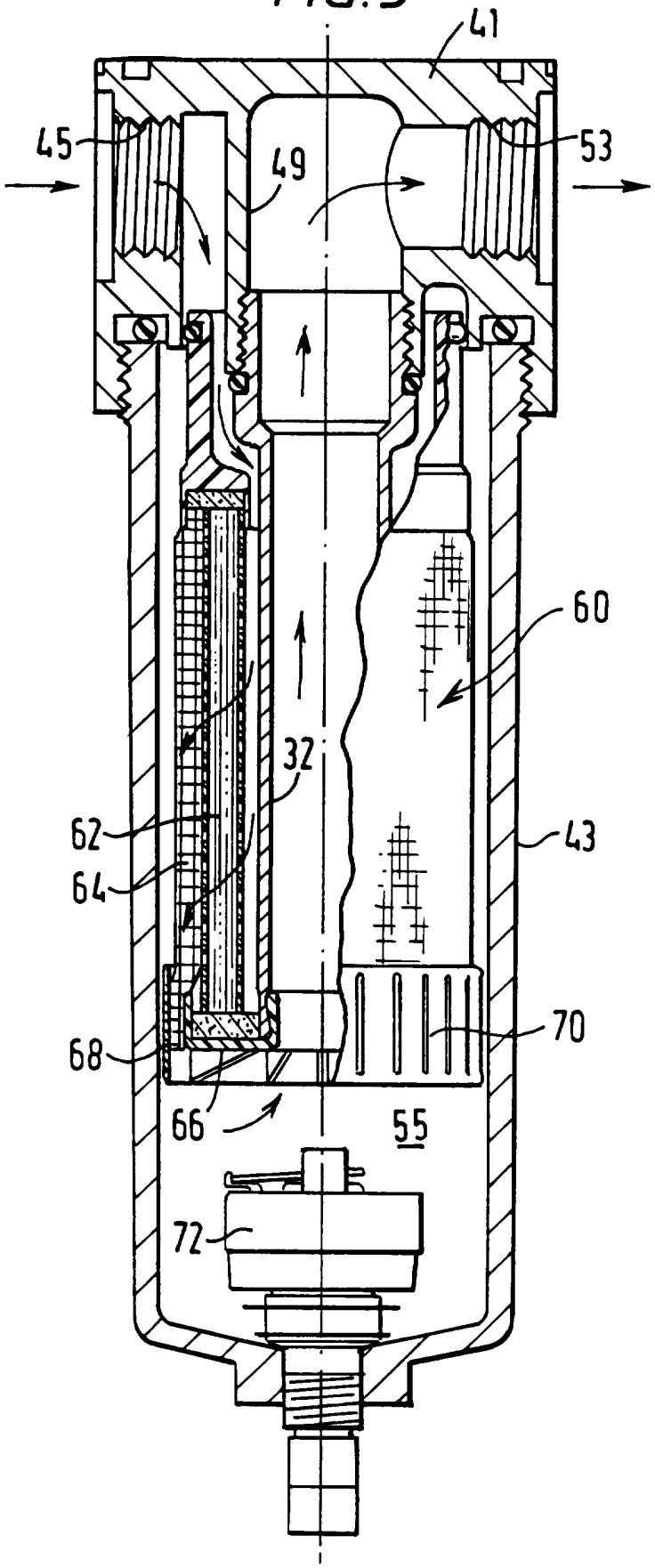


FIG. 4

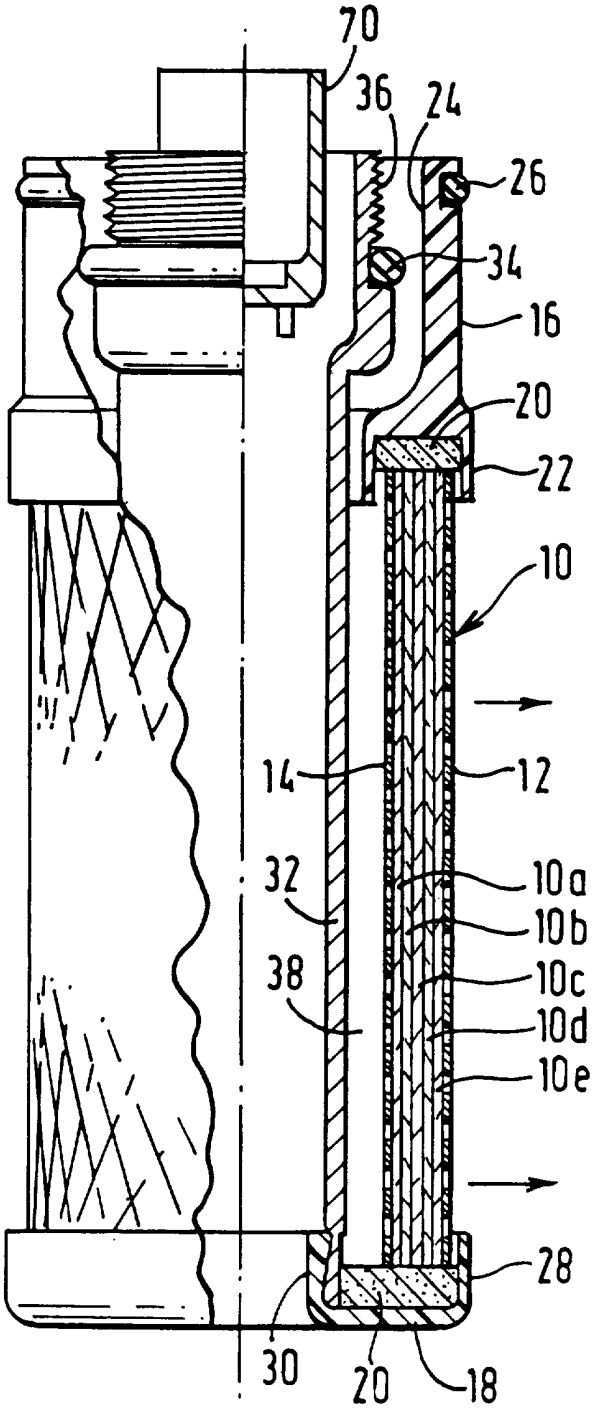
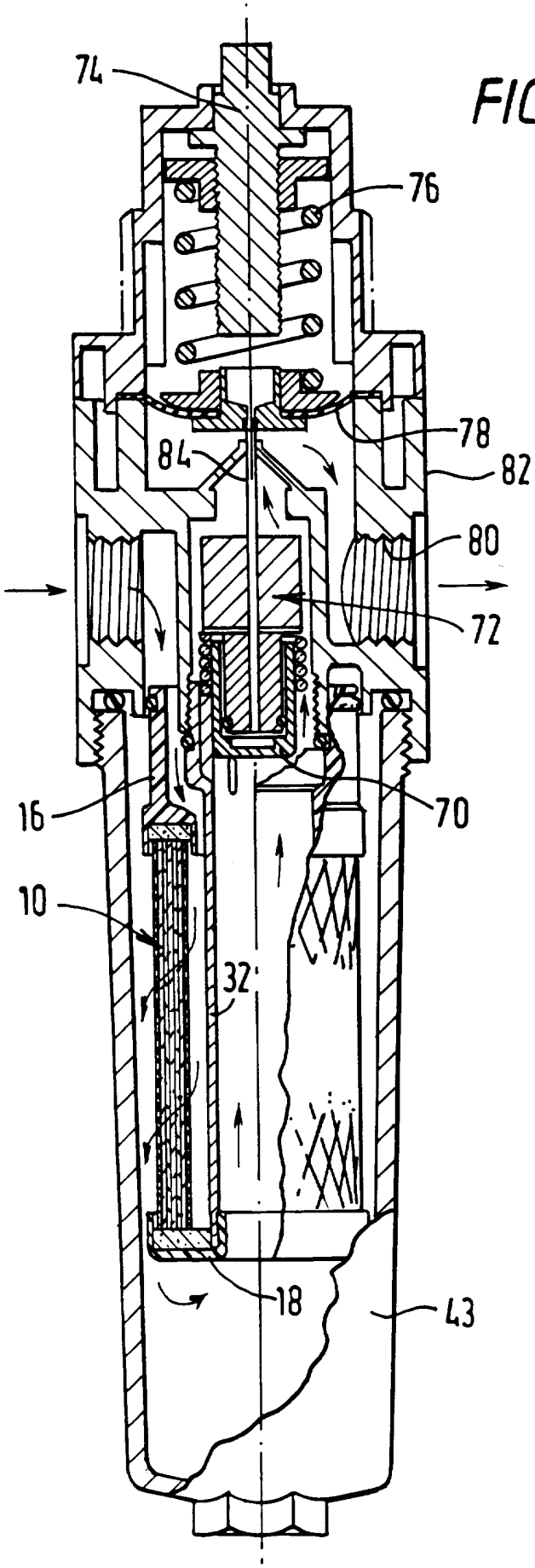


FIG. 5



FILTER ASSEMBLY AND CARTRIDGE THEREFOR

The present invention relates to a filter assembly and to a filter cartridge or canister which can form part of that assembly.

In the pre-filtration or filtration of gas, for example gas streams from an air compressor, the filter assembly includes a filter head set up to have an out-to-in flow path, a removable filter bowl that fits onto the filter head and a removable cartridge within the filter bowl that demountably fits onto the filter head. Commonly, a drainage valve is provided at the bottom of the bowl to permit liquid condensate to be removed at intervals as required. In the applicant's experience the most common cause of customer complaint about such filter assemblies is the failure of the manual or automatic drain device, whichever is fitted, due to grit or contamination in the airstream which prevents a seal from being re-established once the condensate has been drained out of the filter housing.

A second problem which exists with an out-to-in flow path is that where an oil indicator incorporated into the filter element of the cartridge to indicate e.g. the presence of oil contaminants in the incoming air stream, a colour change when the contaminants appear is not readily visible because the direction of flow through the filter element is inwards. That problem arises in

particular in relation to adsorbent filter elements for removing traces of oil vapour in an airstream and which commonly have activated carbon as their working medium.

In one aspect the invention provides a filter assembly comprising a filter housing set up to have an out-to-in flow path and a filter cartridge that fits into the housing and has means that cooperates with the filter housing to establish an in-to-out flow path through a tubular filter element forming part of the cartridge.

In a second aspect the invention provides a filter assembly comprising a filter head having a gas inlet annulus surrounding a central gas outlet passage, a filter bowl that fits the head, and a filter cartridge that fits to the filter head within the filter bowl, first means within the cartridge cooperating with the outer annulus to form a passage leading to a gas-tight space in the interior of the cartridge, and second means leading from the exterior of the cartridge gas-tightly to the gas outlet passage, so that the flow path of gas through the cartridge is in an in-to-out direction whilst the housing has been set up to flow out-to-in.

In a third aspect the invention provides a tubular filter cartridge comprising a tubular filter element, a first end cap at a proximal end of the filter element being shaped to fit an intended filter head, and a second end cap at a distal end of the filter element, the second end cap being annular, and a pipe extending from the

second end cap through the filter element to the first end cap, an annular inlet port being defined between the proximal end of the pipe and the surrounding regions of the end cap and leading to a chamber defined between the pipe and the filter element from which in use fluid can flow radially outwards through the filter element, there being a fluid return path through the second end cap to a discharge port at the proximal end of the pipe.

Various embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 is a partly cut away view of a first form of filter cartridge according to the invention;

Fig. 2 is a view in section showing the filter cartridge of Fig. 1 in position in a filter head;

Fig. 3 is a view in section showing a second form of the filter cartridge of the invention in position in a filter head;

Fig. 4 is a partly cut away view of a third form of the filter cartridge which is for use in a filter-regulator; and

Fig. 5 is a view in section showing the filter cartridge of Fig. 4 in position in a filter-regulator.

In Fig. 1 there is shown a first form of filter cartridge according to the invention. It comprises a tubular adsorbent element (10) which is sandwiched between inner and outer foraminous sleeves (12,14) of

e.g. expanded metal or plastics mesh and which is adhered to proximal and distal end caps (16,18) by adhesive (20) in manner known per se. The element (10) comprises an inner fabric wrap (10a) of spunbonded polyamide fibres 25gsm and of thickness 0.12mm, and adsorbent layer (10b) formed of 3-4 wraps of activated carbon (32% by weight) held on a sheet of porous cellulose (Viscose) paper by means of a latex binder, an indicator layer (10c) in the form of a layer of spunbonded polyamide fibres 25gsm and of thickness 0.12mm impregnated with Kenmax Red OS which is an oil-soluble red dye, a dust filter (10d) in the form of a sheet of borosilicate glass microfibre paper, and an outer fabric layer (10e) in the form of spunbonded polyamide fibres 25gsm and 0.12mm thick. The sleeves (12,14) may be of expanded stainless steel and of open area about 60%. The end caps may be moulded in a plastics material which may be filled with a reinforcing filler. For example, they may be made of polybutylene terephthalate filled with glass. The proximal end cap (16) is annular and has a lower portion (22) which is socketed to receive the element (10) and sleeves (12 and 14) and an upstanding annular wall (24) whose external surface is plain except for a groove adjacent to its end in which a sealing member in the form of an O-ring (26) e.g. of nitrile rubber is received. The distal end cap (18) is cup-shaped when viewed in half-section with the element (10) and sleeve (12)

locating against its outer wall (28) and with its inner wall (30) which is of lesser diameter than the internal diameter of the proximal end cap (16) at its lower portion (22) receiving the distal end of a pipe (32) which extends axially therefrom up through the cartridge to the proximal end cap (16). The proximal end of the pipe (32) is enlarged as shown and has on its exterior surface a groove that receives a sealing member in the form of an O-ring (34) above which is a threaded region (36). It will be appreciated that although in this instance the end cap (18) and pipe (32) are separate components, they may instead be formed as a single component.

In use, air or gas contaminated with hydrocarbon vapour enters the cartridge through the annular port between end cap (16) and pipe (32) and enters a chamber (38) which is defined between the pipe (32) and the element (10). It then passes radially outwards through element (10) with any hydrocarbon vapour contaminants remaining trapped within the element (10). Return air re-enters the cartridge through end cap (18) and travels up through the pipe (32) to a discharge port at the proximal end thereof. The present cartridge construction has the advantage that if the air or gas passing through the adsorbent element (10) is contaminated with droplets of liquid oil, the indicator dye present in layer (10c) is dissolved and colour appears at the exterior visible

surface of the cartridge by reason of the in-to-out flow direction of the air or gas.

It will be appreciated that the adsorbent element (10) may be replaced by a filtering element e.g. a coalescing element. In this form of the filter cartridge there is the advantage that air appearing outside the filter must have passed through the filtering element and any solids contaminant must have been retained within the filter element.

In Fig. 2 the tubular filter cartridge of Fig. 1 is shown fitted into a filter housing set up to have an out-to-in flow path and when so fitted establishes an in-to-out flow path through the tubular element (10) forming part of the cartridge. The filter housing comprises a filter head (41) and a filter bowl (43) which fit removably together by a threaded or bayonet connection. In this instance the filter bowl (43) is of a transparent plastics material. As set up in Fig. 2 the filter head has an inlet port (45) leading to a downwardly facing annular space (47). A depending tubular wall (49) of the filter head is internally threaded at (51) to mate with the threaded region (36) of the pipe (32) and hold the filter cartridge in place on the filter head (41). The depending tubular wall (49) leads to exit port (53) of the filter head. When the cartridge is in place, a gas-tight connection between the annular space (47) and the inlet port to the cartridge is established by O-rings

(26,34), and simultaneously the O-ring (34) seals off the outlet port at the proximal end of the pipe (32). Gas entering the inlet port of the filter head (45) which is typically compressed air contaminated with oil vapour passes into the chamber (38). Gas filtration is radial and the gas stream freed from oil vapour passes outwardly and downwardly to a quiet zone (55) in the filter bowl below the filter cartridge. In the event that the stream or gas becomes contaminated with oil a colour appears at the exterior of the cartridge and is visible through the bowl (43).

The material of the filtering or adsorbent element (10) may, instead of the particular construction set out above, be any conventional material in the filtration art and will depend upon the duty which the cartridge is to perform. The cartridge is particularly suited for the filtration of compressed air e.g. in an air line leading from an air compressor and having a typical pressure of from 1 to 10 bar, or it may be fitted in a line leading from the discharge side of a vacuum pump. Examples of suitable materials for the element are set out below:

(a) For pre-filtration of suspended water and oil droplets and a small amount of suspended solids from an air stream, the element (10) may comprise wrapped layers of micron-sized polyester or nylon fibres in a non-woven spunbonded or needlebonded construction and may have a nominal cut-off of 20-25 μ. Advantageously these are

fluorocarbon impregnated to assist removal or drainage of filtered condensate. A sintered tubular element may also be used but is less preferred.

(b) For high efficiency filtration the element may be of microfibres of inorganic material. Glass microfibres having low water affinity such as borosilicate glass microfibres are particularly suitable. The element should have a structure and pore size such that it will retain particles and droplets having a size from 0.01 to 10 microns, and in particular particles of size less than 1.5 microns which form a major component of the entrained oil from a compressor or vacuum pump. Desirably the efficiency of particle entrapment is between 99.97 and 99.9999% when subjected to a dioctylphthalate test to ASTM D 1986-1971 (Military Standard 282). The filtration or coalescing element may be formed from layers of sheet wrapped one around the other, it may be formed from pleated sheet or it may be made by moulding or vacuum forming. It may be unimpregnated with binder, in which case it is normally supported by a fabric which prevents migration of the medium. Alternatively, it may be impregnated with a resin binder which imparts hydrophobic and oleophilic properties and a degree of mechanical strength. Suitable media for a coalescing filter include microfibrous filter materials as described in Patent Specification Nos. GB-A-1014882 (Domnick Hunter) and GB-A-1544822 and GB-A-

1603519 (both of Process Scientific Innovations). In the case of a coalescing filter, a drainage sleeve of coarser-porosity material may be provided outside the microfibrous filter element, and such a drainage sleeve may be of an open-celled foam material or may be a fabric treated with a fluorocarbon resin, as disclosed in US Patent 5129923 (Process Scientific Innovations), in order to reduce oil carry-over.

(c) For adsorption the element may, as indicated above, comprise 3-4 wraps of activated carbon or other adsorbent material held by latex or other binder onto a porous cellulose paper or other support. These are followed on the downstream side by a layer of microfibrous filter material to prevent particulate material being carried downstream, and optionally by an indicator layer impregnated into an oil-soluble dye.

The filter assembly of Fig. 3 is generally similar to that of Fig. 2 except that the filter generally indicated by the reference numeral 60 is of the type described in our International Publication No. WO 93/10881 (Process Scientific Innovations), the disclosure of which is incorporated herein by reference. The cartridge has a pleated borosilicate glass filter element (62) and a macroporous foam drainage layer (64) or a polyester needlefelt layer which may be fluorocarbon treated. The drainage layer (64) is typically a PVC impregnated reticulated polyether or polyurethane foam

having typically 60 pores per inch. The drainage layer fits into the lower end cap (66) but is uncompressed and unobstructed. The end cap (66) is slotted to permit oil from the drainage layer (64) to pass dropwise down through it and has a guard (68) which defines a relatively quiet zone in which the oil droplets can form so that in use air flow through a wet band forming at the lower end of the cartridge (60) is minimised. Finger grips (70) on the outside of the guard (68) enable the filter element to be offered to and removed from the filter head (41) without risk of damage to the drainage layer (64). It has been found that a filter having the above-mentioned structure can provide a significant reduction in pressure drop at high air flow rates, and that the amount of oil mist appearing on the clean side of the filter is less than half the amount of oil mist present using a coalescing filter in which the drainage sleeve (64) is tightly fitted into a channel in the distal end cap.

At the lower end of the filter cartridge the lower end cap (66) approaches closely to the inner surface of the filter bowl (43) leaving only a small annulus between them. Preferably, the area of that annulus is less than the area of the pipe (32). Coalesced droplets of water are entrained in a relatively high velocity downwardly travelling airstream as they pass the end cap (66) so that the droplets of water are propelled towards the

lower end of the filter bowl (43). After it has passed the end cap (66), the airstream is in the quiet region (55) where its velocity is reduced, and as it returns up the pipe (32) the tendency for droplets of water to be re-entrained in the rising airstream to be carried in the air leaving the discharge port (53) is reduced.

It will be apparent that no significant change is needed in the structure of the filter head (41) or the filter bowl (43) in order to achieve the present conversion from an out-to-in to an in-to-out flow path through the tubular filter element, and the present cartridge is compatible with existing designs of filter head and bowl. However, solids are caught within the filter element (10) and an automatically operating drain valve (72) at the lower end of the filter bowl (43) is exposed only to water or other liquid condensate but not to solid contaminants which are retained within the filter element (10). The drain valve (72) may, if desired, be simply a manually operated poppet valve.

A cartridge for use in a filter chamber forming part of a combined filter and pressure regulator is shown in Figure 4 and the filter regulator assembly is shown in Figure 5. In this instance the cartridge used is the same as in Figure 2 except that the pipe (32) has at its proximal end an integrally moulded upwardly facing cup (70) that as seen in Figure 5 provides support for parts of a pressure-reducing and regulating valve mechanism

generally indicated by the reference numeral (72) and of a type known per se. Rotation of a shaft (74) applies or removes load from an adjustment spring (76), and when no load is applied the valve (72) is closed. When the spring (76) is loaded, the load is transmitted through a flexible diaphragm (78) to the valve (72), opening the valve. The diaphragm (78) is exposed to air or gas at the outlet side (80) of the filter head (82) so that as the outlet pressure rises the force on the diaphragm (78) is increased, compressing the adjusting spring (76) the load exerted by the spring is equal to the load exerted on diaphragm (78) by the air or gas leaving the filter head (82). Movement of the diaphragm (78) is transmitted to the valve (72) by means of a link (84) so that the valve (72) is opened or closed as the diaphragm (78) moves up or down. Again the use of a cartridge of the present kind does not require significant alteration of the filter head (82) (which has to be set up in the out-to-in flow direction shown) and associated regulator valve mechanism. Although the use of an adsorbent cartridge has been illustrated, other kinds of cartridge such as a pre- or coarse-filter cartridge or coalescing filter cartridge could be used instead.

CLAIMS:

1. A filter assembly comprising a filter housing set up to have an out-to-in flow path and a filter cartridge that fits into the housing and has means that cooperates with the filter housing to establish an in-to-out flow path through a tubular filter element forming part of the cartridge.

2. An assembly according to claim 1, wherein the filter cartridge provides a pre-filter for removing liquid and solid contaminants in bulk or aerosol form from a stream of compressed gas in which they are carried.

3. An assembly according to claim 2, wherein the filter has a 5 to 25 μ cut-off

4. An assembly according to claim 1, wherein the filter cartridge provides a high efficiency filter having a cut-off less than or equal to 1 μm.

5. An assembly according to claim 4, wherein the filter element of the cartridge is of borosilicate glass microfibres.

6. An assembly according to claim 4 or 5, wherein the filter element is pleated.

7. An assembly according to claim 4 or 5, wherein the filter element is moulded.

8. An assembly according to claim 4 or 5, wherein the filter element is a wrapped sheet.

9. An assembly according to claim 1, wherein the filter cartridge provides an adsorbent material for removing contaminants from a stream of compressed gas in which they are carried.

10. An assembly according to claim 9, wherein the adsorbent material forms part of a tubular element through which flow is radial.

11. An assembly as claimed in any preceding claim, in which the filter housing has a drain valve which can be opened to permit the housing to be emptied of condensate.

12. A filter assembly substantially as hereinbefore described with reference to and as illustrated in Figure 2 or 3 of the accompanying drawings.

13. A filter assembly comprising a filter head having a gas inlet annulus surrounding a central gas outlet passage, a filter bowl that fits the head, and a filter cartridge that fits to the filter head within the filter

bowl, first means within the cartridge cooperating with the outer annulus to form a passage leading to a gas-tight space in the interior of the cartridge, and second means leading from the exterior of the cartridge gas-tightly to the gas outlet passage, so that the flow path of gas through the cartridge is in an in-to-out direction whilst the housing has been set up to flow out-to-in.

14. A tubular filter cartridge comprising a tubular filter element, a first end cap at a proximal end of the filter element being shaped to fit an intended filter head, and a second end cap at a distal end of the filter element, the second end cap being annular, and a pipe extending from the second end cap through the filter element to the first end cap, an annular inlet port being defined between the proximal end of the pipe and the surrounding regions of the end cap and leading to a chamber defined between the pipe and the filter element from which in use fluid can flow radially outwards through the filter element, there being a fluid return path through the second end cap to a discharge port at the proximal end of the pipe.

15. The cartridge of claim 14, wherein the first end cap carries a sealing member on its external surface which in use makes a seal with an outer port of the intended filter head.

16. The cartridge of claim 14 or 15, wherein the proximal end of the pipe carries a sealing member which in use makes a seal with an inner port of the filter head.

17. The cartridge of claim 14, 15 or 16, wherein the proximal end of the pipe has a fastening formation which in use mates with a corresponding formation of the filter head to hold the cartridge in place.

18. The cartridge of claim 17, wherein the proximal end of the pipe is threaded.

19. A filter cartridge substantially as hereinbefore described with reference to and as illustrated in Figure 1 or 3 of the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

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Relevant Technical Fields

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(ii) Int Cl (Ed.6) B01D; F04B; F04D

Search Examiner
A J RUDGE

Date of completion of Search
27 FEBRUARY 1995

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE DATABASES: WPI, CLAIMS, EDOC, WPIL

Documents considered relevant following a search in respect of Claims :-
1 - 19

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2261830 A	(PROCEN SCIENTIFIC) see whole document	1 - 3 at least
X	GB 2232612 A	(SARTORIUS) see whole document	1 - 3 at least
X	GB 2063097 A	(ORION) see whole document	1 - 3 at least
X	GB 2033247 A	(PROCEN SCIENFIFIC) see Figure 1 at least	1 - 3 at least
X	GB 1566264	(WHATMAN) see examples	1 - 3 at least
X	GB 1562457	(A B LECTROSTATIC) see whole document	1 - 3 at least
X	GB 1490270	(PALL) see Figure 1	1 - 3 at least
X	US 4336043	(ORION) see Figure and Abstract	1 - 3 at least
X	EP 0042176 A2	(MEISSNER) see Figure and Abstract	

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).