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(54) Pre-cleaner for use on an internal-combustion engine.

(57) An air cleaning arrangement (22) for use on an agricultural harvesting machine (1), which is operated in surroundings contaminated with airborne impurities and which is provided with an internal-combustion engine (10), comprises a primary cleaner element (24), operable to clean small-size contaminations (e.g. dust particles) from the intake air, and a pre-cleaning element (26) installed upstream of the primary cleaner element (24).

The pre-cleaning element comprises a perforated, outer body portion or screen (42), which is operable to clean larger contaminations (e.g. chaff, straw particles, leaves etc...) from said intake air when passing therethrough, and an outlet conduit (48) in operative communication with the primary cleaner element (24).

The pre-cleaning element (26) further comprises a perforated, inner body (52) in the form of an upwardly extending tube through which the intake air is urged when flowing from said outer body portion (42) towards said outlet conduit (46), in a manner such that the intake air is uniformly aspirated over the total surface of the perforated, outer screen (42).

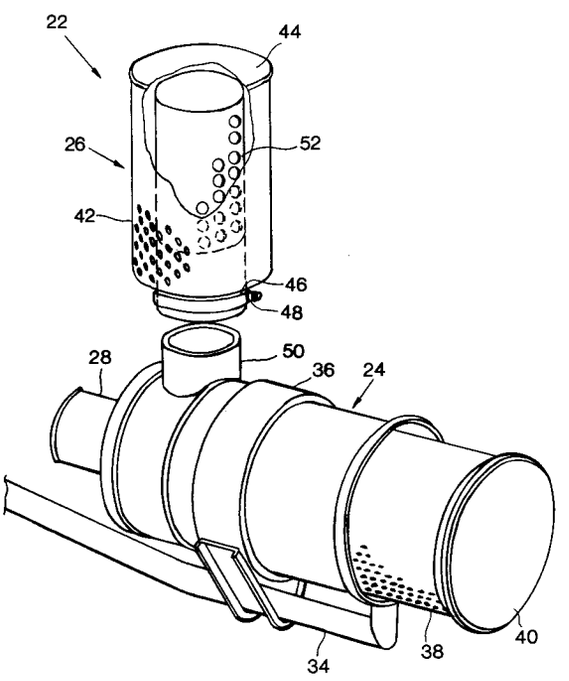

FIG.2

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The present invention generally is directed to an air cleaning arrangement for use on an internal-combustion engine of an agricultural machine which is used in surroundings which are contaminated with airborne impurities. More specifically, although not exclusively, the present invention is particularly useful on combine harvesters which, by their nature, normally are operated in an atmosphere which is loaded with impurities such as chaff, straw particles, dust, leaves etc.

It is generally known in the art to provide an internal-combustion engine with an air cleaning arrangement in order to prevent polluted ambient air from being drawn into the engine. In environments polluted solely with small dust particles, the air cleaning arrangement commonly takes the form of a single dry-type filter element which is capable of removing said dust particles from the intake air before it enters the engine. However, in environments containing larger airborne particles such as chaff for example, the life of a fine-meshed air filter, if used alone, is impractically short, whereby it has become common practice under such conditions to install an additional cleaning element upstream of the conventional primary filter, which is operable to remove the largest particles from the intake air before it can reach the primary filter. Due to its specific location and function, said additional cleaning element is generally referred to as a pre-cleaner.

A pre-cleaner usually comprises an upright, hollow cylindrical body closed at its top by a solid cover and provided with a bottom closure including an outlet conduit which operatively communicates with the primary filter. The cylindrical body consists of a perforated screen which allows ambient air to enter the body meanwhile performing a first, coarse filtering. When installed on a combine harvester, the pre-cleaner advantageously is mounted in the immediate vicinity of the engine to which air is provided in order to keep air conduits as short as possible. Moreover, this location on the harvester may be expected to be best suited with regard to air contamination as the engine normally is positioned on top of the harvester at a considerable height above the ground and therefore relatively remote from the crop treating operations which are an important source of contamination of the environment in which the harvester has to operate.

However, inherent to the open and unprotected positioning of the pre-cleaner on top of the harvester, a disadvantage is recognised in that the cleaner is subjected to all kinds of weather conditions, including rain. It readily will be appreciated that the entrance of water into the engine at all costs should be avoided, what partially is taken care off by providing the pre-cleaner with a solid top closure, as already mentioned. This notwithstanding, oblique driving rain still is able to penetrate through the perforations of the vertically oriented, cylindrical screen, whereafter it runs downwardly along the inner side thereof and collects at the lowermost part of the pre-cleaner and/or is projected towards the core of the pre-cleaner body. To prevent the penetrating water from flowing in one or other way into the outlet conduit, the latter is made reentrant for a considerable distance into the pre-cleaner body so that, together with the outer screen, an annular channel is defined which is solid at the inner side but perforated at the outer side, thereby allowing captured water to leave the pre-cleaner the same way as it entered.

In the just described arrangement, the top portion of the outlet conduit thus considerably surmounts the bottom closure of the pre-cleaner and extends towards the top cover thereof. Consequently, instead of entering the outlet conduit in the region of the pre-cleaner's lowermost part, aspirated air now is received more centrally between the top and bottom closures. As a direct result thereof and since the top portion of the outlet conduit is oriented upwardly, most of the intake air is received through only a small portion of the filter screen, more specifically the upper portion thereof ranging from the horizontal level of the outlet conduit towards the top of the pre-cleaner, whereas the bottom portion of the screen is barely used. Considering now, on the one hand, that an engine under full load conditions may consume up to $30m^3$ of air per minute and, on the other hand, that only part of the filter screen is effectively used, it will be understood that locally around the upper portion of the filter screen considerable air velocities are measured so that larger impurities more easily become aspirated; impurities which all have to be removed by only a slice of the filter screen.

As such, the high concentration of impurities in the aspirated air gradually tends to clog the upper part of the filter screen, the more that large impurities no longer may fall loose from the screen by gravity due to the high air velocities encountered. When this happens, the air pattern around the filter screen gradually is changed and more and more air becomes aspirated through a lower portion of the screen which so far was not yet affected by impurities. As a result, also this area starts to build up and the whole process of clogging continues until finally the complete screen becomes blocked. In the course of events, the free flow of intake air through the screen little by little is hampered whereby the harvester engine has to spend more and more energy to get the required air, but nevertheless becomes choked and ultimately stalls by lack of air.

One possible solution to this problem may be found in increasing the diameter of the outer, perforated body of the pre-cleaner so as to correspondingly increase the surface of the filter screen and thus inversely proportionally decrease the velocity of the aspirated air in the immediate vicinity of the screen. However, this solution is not to be preferred as it incurs considerably higher manufacturing costs and moreover increases the overall dimensions of the pre-cleaner, what is not desirable in view of the already confined space of the engine compartment.

It therefore is the objective of the present invention to provide a compact pre-cleaning arrangement which can be used under all weather conditions but nevertheless is not prone to clog.

According to the present invention, an air cleaning arrangement is provided for use on an agricultural harvesting machine, provided with an internal-combustion engine, and which comprises :

- a primary cleaner element operable to clean small-size contaminations from the intake air; and
- a pre-cleaning element installed upstream of the primary cleaner element and comprising :
  . a perforated, outer body portion which is operable to clean larger contaminations (e.g. chaff, straw particles, leaves etc...) from said intake air when passing therethrough; and
  . an outlet conduit in operative communication with the primary cleaner element; and

  characterized in that

  the pre-cleaning element further comprises a perforated, inner body portion through which the intake air is urged when flowing from said outer body portion towards said outlet conduit, in a manner such that the intake air is generally uniformly aspirated over the total perforated surface of said outer body portion.

As well the outer as the inner body portions are cylindrically shaped and extend upwardly and coaxially with respect to each other. The inner body portion is formed as an open-ended tube, which registers with said outlet conduit, and stops short of a solid top closure of the pre-cleaning element. Preferably, only the upper three quarters of the total length of the inner tube is provided with perforations in order to prevent water from flowing into the outlet conduit.

An air cleaning arrangement in accordance with the present invention will now be described in greater detail, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic side elevation of a combine harvester incorporating the pre-cleaning element according to the invention; and
Figure 2 shows, to a larger scale, a perspective, exploded view of the primary filter and the pre-cleaning element.

With reference to the drawings, particularly Figure 1, a combine harvester, generally indicated at 1, comprises a main chassis or frame 2 supported on a front pair of drive wheels 3 and a rear pair of steerable wheels 4. Supported on the main chassis 2 are an operator's platform 5, with operator's cab 6, a grain tank 7, a threshing and separating mechanism 8, a grain cleaning mechanism 9 and a power plant or engine 10. A conventional header 11 and straw elevator 12 extend forwardly of the main chassis 2 and the header 11 is pivotally secured to the chassis 2 for generally vertical movement which is controlled by extensible hydraulic cylinders 13.

As the combine harvester 1 is propelled forwardly over a field with standing crop, the latter is severed from the stubble by a sickle bar on the header 11, whereafter the header 11 and straw elevator 12 supply the cut crop to the threshing and separating mechanism 8. The crop received therein is threshed and separated, that is to say, the crop is rubbed and beaten, whereby the grain, seed or the like, is loosened and separated from the straw, coils or other discardable part of the crop.

The combine harvester illustrated in Figure 1 comprises a conventional threshing mechanism including a threshing cylinder 14, a straw beater 16 and a separator rotor 18. Conventional straw walkers 20 are operable, in use, to discharge a mat of remaining crop material (i.e. mainly straw as the grain is separated therefrom) through the straw hood 21.

It will be appreciated that the discharging of the straw from the machine generates a lot of dust and fine crop parts which become airborne and which contaminate the environment in which the combine has to operate. This is even more explicit in case the harvester is set to chop the straw mat.

Turning now to the cleaning operation, grain which has been separated from the straw falls onto the grain cleaning mechanism 9 which comprises means to separate chaff and other impurities from the grain, and means to separate unthreshed parts, known as tailings. Cleaned grain is then elevated into the grain tank 7 and the tailings are reprocessed in separate tailings rethreshers (not shown) and returned to the cleaning mechanism 9 for repeated cleaning action.

Chaff and other impurities thus separated from the grain in the cleaning mechanism 9 are made airborne and discharged from the machine at the

rear thereof. It again will be appreciated that this equally forms an important source of contamination of the environment in which the combine harvester has to operate.

Another major source of contamination is the header 11, the operation of which also causes lots of dust, chaff and other impurities to become air-borne around the harvester.

Notwithstanding the fact that the engine 10 is installed on top of the combine harvester, generally rearwardly of the graintank 7, and thus quite remote from the crop treating operations which all create a contamination of the ambient air, impurities such as dust, chaff, straw particles, leaves and other foreign particles nevertheless may come into the vicinity of the engine 10. To prevent those impurities from entering the engine 10 during operation, an air cleaning device, generally indicated at 22, is provided which is operable to filter all impurities out of the intake air.

The cleaning device 22 is composed of two major components being a primary cleaner element 24 on the one hand and a pre-cleaning element 26 on the other hand, which are disposed relative to each other in such a manner that air aspirated by the engine 10 is first drawn through the pre-cleaning element 26 before being filtered by the primary cleaner 24, whereafter the clean air is conducted through a conduit 28 towards the entrance of the engine 10. Intermediate between the primary cleaner 24 and the engine 10, a turbocharger 30 is provided for speeding up and propelling the intake air into the engine 10. An ejector unit (not shown), incorporated in the engine exhaust 32, is operable to create an underpressure in a hose 34 which leads towards the primary cleaner 24 for extracting any foreign particles which may accumulate therein. In as much as the turbocharger 30 and the ejector unit arrangement are conventional in the art and form no part of the present invention, they will not be described in any further details.

Referring specifically to Figure 2, it is observed that the primary cleaner 24 comprises a cylindrical, horizontally oriented body 36, at the inside of which a dry-type air filter 38 is provided; said filter 38 partially being extracted from the body 36 for ease of reference. A solid cover 40 seals the body 36 at one end whereas the other end thereof receives the clean air conduit 28 already mentioned. The dry-type filter 38 is cylindrical in shape and is composed of fine-meshed material which is able to filter out small-sized particles, such as dust for example, from the intake air.

The pre-cleaning element 26 is mounted upright on top of the primary cleaner 24 and equally comprises a cylindrical outer body 42. However, unlike the body 36 of the primary cleaner 24, said outer body 42 is perforated over its complete cylindrical surface, as such building a screen-like filter, of which the perforations have a diameter of about 1,8 mm. The pre-cleaner 26 further comprises a solid top closure 44 and a bottom closure (not shown) including an outlet conduit 46, which is provided with a fixation brace 48 for removably securing the pre-cleaner 26 onto an inlet flange 50 of the primary cleaner 24. So far, all mentioned components of the pre-cleaner 26 are well known and conventional in the art.

To more clearly visualise the object of the present invention, part of the solid top closure 44 and the outer body or screen 42 is cut away in Figure 2, revealing the interior of the pre-cleaner 26. An inner, cylindrically shaped body 52 is seen which extends coaxially with the outer screen 42 from the bottom closure of the pre-cleaner 26 towards the solid cover 44, stopping short thereof. The inner body 52 is an open-ended tube, registering with the outlet conduit 46 and having an upper circumferential portion which is provided with perforations. In the preferred embodiment shown in Figure 2, the upper three quarters of the tube 52 has perforations with a diameter of approximately 3,5 mm, whereas the lowermost quarter of the tube 52 is kept solid in order to prevent that any water, unintentionally passed through the screen 42, could enter the outlet conduit 46. The disposition of the perforations has been chosen such that the totalled surface thereof amounts to around 50% of the total circumferential surface of the upper three quarters of the tube 52.

During operation of the engine 10, intake air successively is drawn through the screen 42, through the perforated part of the tube 52, via the outlet conduit 46, through the filter element 38 and via the conduit 28 towards the engine 10. The underpressure created in the outlet conduit 46 is felt over the total perforated area of the tube 52 resulting in an evenly distributed supply of intake air therethrough. As a consequence, also the flow of intake air through the screen 42 is generally uniformly distributed over the total height and circumference of the pre-cleaner 26. Hence, although the flow rate of intake air through the air cleaning device 22 may be considerable, the air speed exterially of the screen 42 is kept below an acceptable level, so that, on the one hand, large-sized impurities are less prone of being carried towards the pre-cleaner 26 and, on the other hand, particles which are filtered-out by the screen 42 more easily fall loose therefrom under influence of gravity forces. All this makes the pre-cleaner 26 carefree even during a full-day operation of the combine harvester 1 in a heavy contaminated atmosphere. In addition, energy is saved as an unobstructed flow of intake air is

ensured.

A further compelling reason why clogging of the pre-cleaner 26 at all costs should be avoided is related to the existence of the connection 34 between the primary cleaner 24 and the exhaust 32, in which, under normal operating conditions, air flows from the former towards the latter. However, when an unobstructed flow of air through the pre-cleaner 26 is prevented, the engine 10 tends to aspirate air from the exhaust 32 via the hose 34 into the air filter 38 in order to compensate for the reduced air flow through the pre-cleaner 26. When this happens, a very dangerous situation is created in that hot exhaust gasses are urged through the dry-type air filter 38 which is not resistant to high temperatures and thus easily may ignite, resulting eventually in the engine 10 or even the complete machine catching fire. It readily will be appreciated that running such a risk is unacceptable and therefore should be prevented by safeguarding a free flow of air through the pre-cleaner 26.

As already mentioned above, the inner tube 52 stops short of the solid upper cover 44 in order to allow any foreign matter, which possibly, after considerable time, might accumulate on the lower cover inbetween the outer and inner bodies 42, 52, to be removed in a convenient manner. To this end, the pre-cleaner 26 is detached from its seat 50 and turned upside down whereby any accumulated foreign matter collects on a central portion of the upper cover 44. By rapidly returning the pre-cleaner 26 to its normal orientation, said collected foreign matter is evacuated from the interior of the pre-cleaner through the inner tube 52. Due to the foregoing arrangement, the upper cover 44 immovably may be secured (such as by spot welding for example) to the screen 42, as it is not required to remove the former for cleaning purposes.

It will be appreciated that the arrangement of the preferred embodiment of Figure 2, as to the diameter of the perforations and the ratio of perforated to non-perforated surface of the inner tube 52 for example, in no way should be construed as being limiting, the only requirement being that the flow of engine intake air is uniformly distributed over the outer screen 42, whereby the occurring air velocities are kept below an acceptable level; all this without having to overdimension the pre-cleaner 26.

Claims

1. An air cleaning arrangement (22) for use on an agricultural harvesting machine (1) provided with an internal-combustion engine (10) and comprising :

- a primary cleaner element (24) operable to clean small-size contaminations (e.g. dust particles) from the intake air; and
- a pre-cleaning element (26) installed upstream of the primary cleaner element (24) and comprising
  - . a perforated, outer body portion (42) which is operable to clean larger contaminations (e.g. chaff, straw particles, leaves etc...) from said intake air when passing therethrough; and
  - . an outlet conduit (48) in operative communication with the primary cleaner element (24); and

    characterized in that

    the pre-cleaning element (26) further comprises a perforated, inner body portion (52) through which the intake air is urged when flowing from said outer body portion (42) towards said outlet conduit (46), in a manner such that the intake air is generally uniformly aspirated over the total perforated surface of said outer body portion (42).

2. An air cleaning arrangement (22) according to claim 1 wherein the pre-cleaning element (26) further comprises a solid upper cover (44); and characterized in that as well the outer as the inner body portions (42,52) are cylindrically shaped and extend coaxially with respect to each other.

3. An air cleaning arrangement (22) according to claim 2 characterized in that the inner body portion (52) is formed by an open-ended tube (52) which registers with the outlet conduit (46) and extends upwardly therefrom towards said upper cover (44), stopping short thereof.

4. An air cleaning arrangement (22) according to any of the preceding claims characterized in that the inner body portion (52) is perforated over only a portion of its length.

5. An air cleaning arrangement (22) according to claim 4 when appended to claim 3 characterized in that the open-ended tube (52) is circumferentially perforated over approximately three quarters of its length.

6. An air cleaning arrangement (22) according to claim 4 or 5 characterized in that the perforations have a diameter of approximately 3,5 mm and are provided in the upper portion of said tube (52).

7. An air cleaning arrangement (22) according to any of the preceding claims characterized in that the lowermost portion of the inner body portion (52) is solid in order to prevent any water from flowing into the outlet conduit (46).

8. An air cleaning arrangement (22) according to any of the preceding claims characterized in that the agricultural harvesting machine is a combine harvester (1).

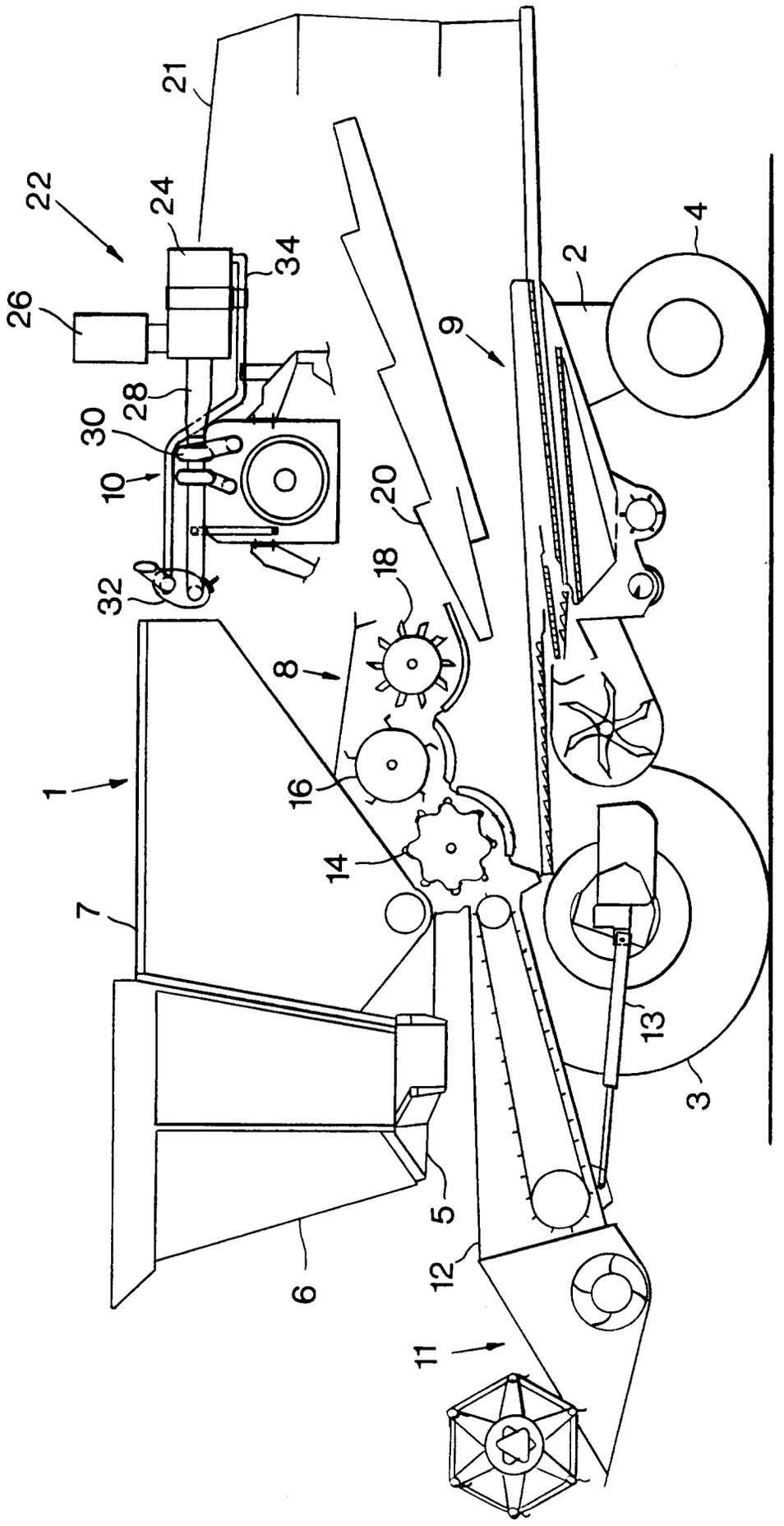

FIG.1

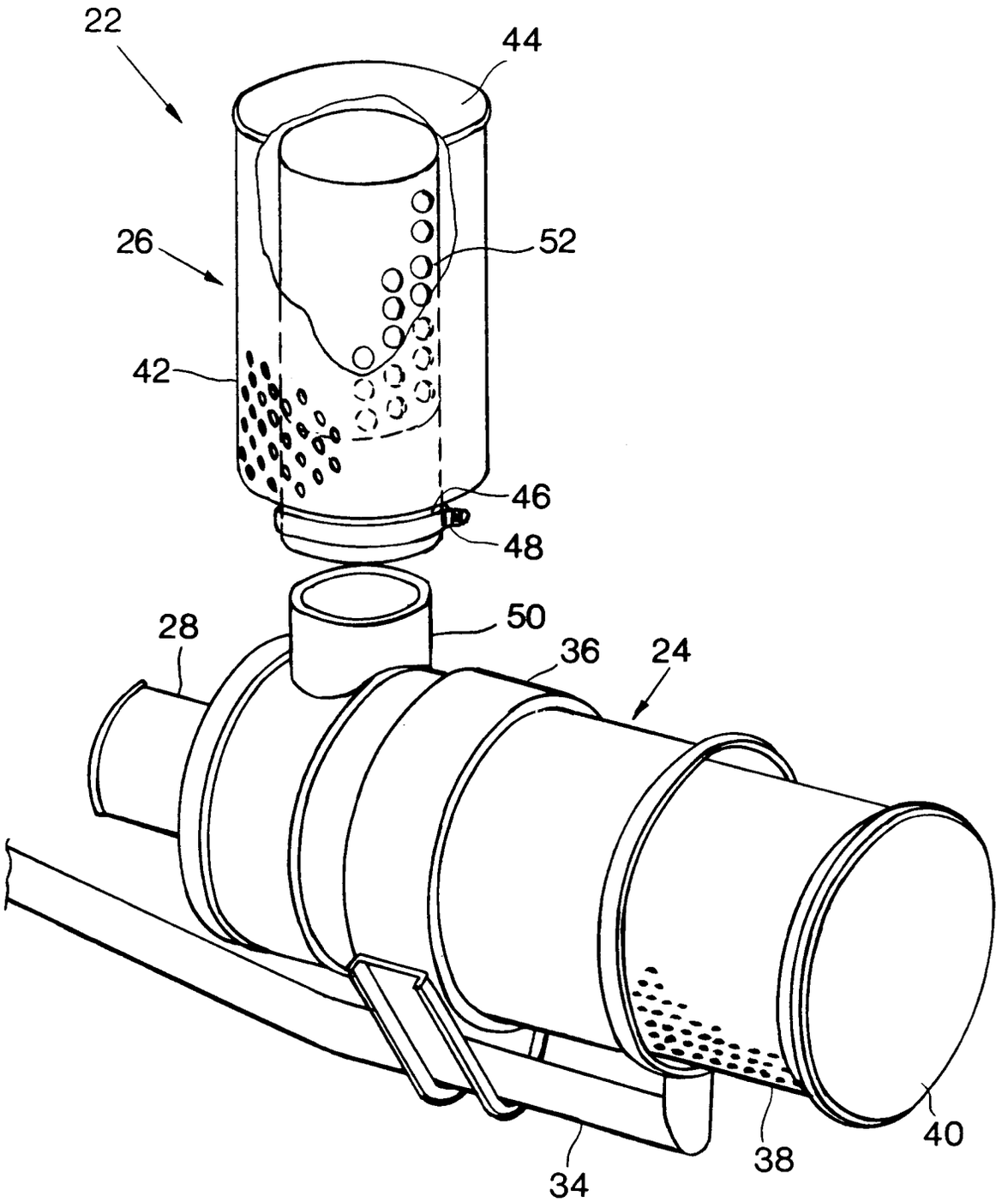

FIG. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 20 2918

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-2 062 548 (WILSON) 1 December 1936 * column 2, line 31 - line 55; figure 1 *	1,2	F02M35/024
Y		7	
Y	US-A-3 791 112 (LIDSTONE) 12 February 1974 * abstract * * column 2, line 61 - column 3, line 3; figure 1 *	7	
X	US-A-3 972 700 (GLEOCKLER) 3 August 1976 * column 1, line 59 - column 2, line 62; figures 2,3 *	1,2	
A	FR-A-1 526 460 (FARR COMPANY) 24 May 1968 * page 2, right column, paragraph 4 * * page 3, left column, paragraph 1 * * page 4, right column, paragraph 2 *	1	
A	US-A-1 875 427 (DONALDSON) 6 September 1932 * page 1, line 1 - line 6 * * page 1, line 64 - line 71 * * page 2, line 80 - line 83; figure 2 *	3,7	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	US-A-3 123 456 (BOLTZ) 3 March 1964 * column 3, line 26 - line 33 * * column 3, line 71 - column 4, line 12; figure 1 *	1	F02M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16 JUNE 1992	JORIS J.C.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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