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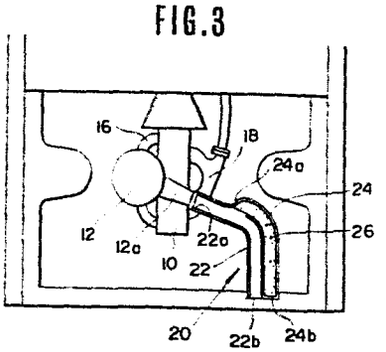
(54) Low-noise air intake arrangement of combustion engine.

(57) An air intake duct (22, 30) and an air inlet pipe (12a) of an air cleaner (12) are combined to form an elongate conduit system through which ambient air to be fed to the combustion engine flows. A branch tube (24, 32) having a length half that of the elongeate conduit system is branched from the longitudinally intermediate portion of the system and closed at its leading end (24b, 32b). A viscous damping material (26), such as, a foamed polyurethane, a glass wool or the like is packed in the branch tube.

FIG.3



EP 0 091 038 A1

LOW-NOISE AIR INTAKE ARRANGEMENT OF COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an air intake arrangement of an automotive combustion engine, and more particularly to an air intake arrangement of an internal combustion engine which is designed to minimize the air intake noise produced therein.

2. Description of the Prior Art

In order to feed the engine with ambient or fresh air, it become usual to fit the inlet pipe of the engine-mounted air cleaner with an elongate air intake duct which leads to a well-ventilated portion of the engine room. However, the provision of the elongate air intake duct tends to cause a noise trouble in air intake due to the resonance which occurs in the duct. This trouble will be outlined hereinafter.

SUMMARY OF THE INVENTION

It is therefore an essential object of the present invention to provide an improved air intake arrangement which can minimize the air intake noise produced therein.

According to the present invention, there is provided an improved air intake arrangement of an automotive combustion engine. The arrangement comprises an air

cleaner mounted to the combustion engine for cleaning air which is to be fed to the engine, an elongate conduit system extending from the air cleaner and terminating at its leading open end, so that upon operation of the engine, ambient air is introduced from the open end into the elongate conduit system and flows therein toward the air cleaner, a branch tube branched from the longitudinally intermediate portion of the elongate conduit system and closed at its leading end, the branch tube having a length half that of the elongate conduit system, and a viscous damping material packed in the branch tube.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the present invention will become clear from the following description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a plan view of an engine room of a motor vehicle, showing a conventional air intake arrangement mounted to an internal combustion engine;

Fig. 2 is a graph showing the characteristics of the air intake noise produced by the conventional air intake arrangement of Fig. 1;

Fig. 3 is a view similar to Fig. 1, but showing an improved air intake arrangement of a first embodiment

of the present invention;

Fig. 4 is a graph showing the characteristics of the air intake noise produced by the air intake arrangement of the first embodiment;

Fig. 5 is a view similar to Fig. 1, but showing an improved air intake arrangement of a second embodiment of the present invention; and

Fig. 6 is a graph showing the characteristics of the air intake noise produced by the air intake arrangement of the second embodiment.

DETAILED DESCRIPTION OF THE INVENTION

Prior to describing the invention, one of the conventional air intake arrangements of an internal combustion engine will be outlined with reference to Figs. 1 and 2 in order to clarify the invention.

Referring to Fig. 1, there is shown an internal combustion engine 10 to which a known air cleaner 12 is mounted, the air cleaner carrying a conventional air intake duct 14. As shown, the air intake duct 14 is of a simply-formed tube, having one end 14a fixed to the air inlet pipe 12a of the air cleaner 12 and the other end 14b located at the front portion of the engine room. Designated by numerals 16 and 18 are intake and exhaust manifolds which are mounted to the engine proper 10 in a known manner.

Thus, in operation of the engine 10, the fresh air taken by the air intake duct 14 flows therein and through the air cleaner inlet pipe 12a, a filter element (not shown) in the air cleaner 12, a carburetor (not shown) and the intake manifold 16 into the engine 10.

However, the air intake arrangement of the above-mentioned type has suffered from the drawback of emitting unwanted amounts of air intake noise due to the inherent construction of the air intake duct 14. Experiment has revealed that the unwanted air intake noise is caused by the resonance which tends to occur within a conduit system consisting of the air cleaner inlet pipe 12a and the air intake duct 14 at frequencies which may be identified using the equation:

$$f(Hz) = \frac{c}{2\ell} \cdot \underline{n} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

wherein c denotes the accoustic velocity within the conduit system, ℓ the length of the conduit system and $\underline{n}$ a whole number integer. In other words, the pulsation of the intake air in the air cleaner proper 12 is amplified by the resonant function possessed by the conduit system (12a + 14) and thereafter the amplified pulsation is discharged to the atmosphere from the inlet opening 14b of the air intake duct 14.

Fig. 2 shows the characteristics of the air intake noise produced by the above-mentioned air intake arrangement, wherein peaks a_1, a_2, a_3, etc. are attributable to the intake air pulsation per se, and peaks b_1, b_2, b_3, etc. are produced by the resonance in the conduit system (12a + 14).

Therefore, it is an essential object of the present invention to provide an improved air intake system which can minimize the unwanted air intake noise.

Referring to Fig. 3, there is shown an air intake system of a first embodiment of the present invention. In the drawing, identical parts to those of Fig. 1 are designated by the same numerals. As will be understood from this drawing, an improved air intake duct 20 is employed in the invention in place of the afore-mentioned simply-formed air intake duct 14.

The air intake duct 20 comprises a main tube 22 and a branch tube 24 which are integrally attached to each other. The main tube 22 has an end 22a fixed to the inlet pipe 12a of the air cleaner 12 and the other open end 22b located at the front portion of the engine room. The branch tube 24 is connected at its one open end 24a to a given portion of the main tube 24 and extends forward along the main tube and terminates at the leading end 22b of the main tube

22 (that is the air inlet opening of the duct 20). The terminal end 24b of the branch tube 24 is closed, as shown. A viscous damping material 26, such as a foamed polyurethane, a glass wool or the like is packed in the branch tube 24. It is important in this embodiment that the branch tube 24 leads from a point intermediate of the two ends of a conduit system which consists of the main tube 22 and the inlet pipe 12a of the air cleaner 12. Thus, the length of the branch tube 24 is essentially $\frac{1}{2}$ of the length of the conduit system (22 + 12a). Preferably, the branch tube 24 has the same diameter as the main tube 22.

In accordance with the above-stated arrangement of the first embodiment, it is expected that, in the branch tube 24, the progressive accoustic wave from the inlet 24a of the branch tube 24 and the reflected accoustic wave from the closed end 24b of the branch tube 24 interfere and thus cancel or at least weaken each other. Thus, peaks $b_{(2n-1)}$, such as b_1, b_3, b_5, etc. which are produced by the resonance in the conduit system (22 + 12a) can be removed from the air intake noise thereby reducing the accoustic energy of the noise. This advantageous phenomenon will be readily understood from Fig. 4.

It is to be noted that a secondarily occuring

resonant phenomenon which might be caused by the addition of the branch tube 24 is prevented by the sound damping material 26 packed in the branch tube 24. In fact, if the sound damping material 26 is not provided in the tube 24, the secondary resonant phenomenon would not be negligible because of the following reasons. The addition of the branch tube 24 increases the freedom in vibration of the conduit system (22 + 12a) causing the air in the branch the 24 to offer a dynamic damping effect, so that the reflected accoustic wave from the closed end 24b of the branch tube 24 and the progressive accoustic wave from the inlet 24a of the same fail to have a different phases of exact 90 degrees therebetween. In order to achieve the exact 90 degrees different phases between them, the viscous damping material 26 is packed in the branch tube 24.

Referring to Fig. 5, there is shown of a second embodiment of the present invention. In this drawing, identical parts to those of Fig. 1 are also designated by the same numerals. Similar to the first embodiment, an improved air intake duct 28 is employed in this second embodiment in place of the simply-formed air intake duct 14 of Fig. 1.

The air intake duct 28 comprises a main tube 30, a first branch tube 32 and a second branch tube 34

which are integrally attached to the main tube 30. The main tube 30 has an end 30a fixed to the inlet pipe 12a of the air cleaner 12 and the other open end 30b located at the front portion of the engine room. Similar to the first embodiment, the first branch tube 32 is connected at its one end 32a to a given portion of the main tube 30 and extends forward along the main tube and terminates at the leading end 30b of the main tube 30 (that is the air inlet opening of the duct 28). The terminal end 32b of the first branch tube 32 is closed, as shown. The second branch tube 34 is connected at its one open end 34a to another given portion of the main tube 30 and extends forward along the same and terminates at the inlet opening 32a of the first branch tube 32. The terminal end of the second branch tube 34 is also closed, as shown. A sound damping material 26 of the afore-mentioned type is packed in the branch tubes 32 and 34. It is important in this second embodiment that the first branch tube 32 leads from a point intermediate of the two ends of a conduit system which consists of the main tube 30 and the inlet pipe 12a of the air cleaner 12, while, the second branch tube 34 leads from a point at distance 3/4 the length of the conduit system (30 + 12a) from the inlet opening 30b of the main tube 30. Thus, the

length of the first branch tube 32 is essentially $\frac{1}{2}$ of the length of the conduit system (30 + 12a), while, the length of the second branch tube 34 is essentially $\frac{1}{4}$ of the length of the conduit system. Preferably, each branch tube 32 or 34 has the same diameter as the main tube 30.

In this second embodiment, not only peaks $b_{(2n-1)}$, such as b_1, b_3, b_5, etc. can be removed by the first branch tube 32, but also peaks $b_{(4n-2)}$, such as b_2, b_6, b_{10}, etc. can be removed by the second branch tube 34, by substantially the same reason as is mentioned in the first embodiment. Thus, in this second embodiment, much more effective sound damping effect is expected. This advantageous phenomenon will be well understood from the graph of Fig. 6.

If desired, the second branch tube 34 may be connected to a point at distance $\frac{1}{4}$ the length of the conduit system (30 + 12a) from the inlet opening 30b of the main tube 30, as is indicated by a broken line. In this case, substantially the same advantageous phenomenon as that mentioned hereinabove is expected.

WHAT IS CLAIMED IS:

1. An air intake arrangement of an automotive combustion engine (10), comprising:

an air cleaner (12) mounted to said combustion engine for cleaning air which is to be fed to said engine;

an elongate conduit system (22 + 12a), (30 + 12a) extending from said air cleaner and terminating at its leading open end (22b, 30b), so that upon operation of the engine, ambient air is introduced from said open end into said elongate conduit system and flows therethrough toward said air cleaner;

a branch tube (24, 32) branched from the longitudinally intermediate portion of said elongate conduit system and closed at its leading end (24b, 32b), said branch tube having a length half that of said elongate conduit system; and

a viscous damping material (26) packed in said branch tube.

(Figs. 3, 5)

2. An air intake arrangement as claimed in Claim 1, in which said branch tube extends along said elongate conduit system toward the open end of the system.

(Figs. 3, 5)

3. An air intake arrangement as claimed in Claim 1, in which said branch tube has the same diameter as said elongate conduit system.
(Figs. 3, 5)

4. An air intake arrangement as claimed in Claim 1, in which said elongate conduit system comprises an inlet pipe (12a) of said air cleaner and a separate air intake duct (22, 30) which is held by said air inlet pipe of the air cleaner.
(Figs. 3, 5)

5. An air intake arrangement as claimed in Claim 1, further comprising another branch tube (34) branched from a portion of the elongate conduit system at a distance 3/4 the length of said elongate conduit system from said leading open end of said system and closed at its leading end, said another branch tube having a length $\frac{1}{4}$ that of said elongate conduit system, said another branch tube being packed with a viscous damping material.
(Fig. 5)

6. An air intake arrangement as claimed in Claim 5, in which said another branch tube extends along said

elongate conduit system toward the branched portion of said branch tube.
(Fig. 5)

7. An air intake arrangement as claimed in Claim 6, in which said elongate system, said branch tube and said another branch tube are integrated with each other.
(Fig. 5)

8. An air intake arrangement as claimed in Claim 1, further comprising another branch tube (34) branched from a portion of said elongate conduit system at a distance $\frac{1}{4}$ the length of said elongate conduit system from the open leading end of said system and closed at its leading end, said another branch tube having a length $\frac{1}{4}$ that of said elongate conduit system, said another branch the being packed with a viscous damping material.
(Fig. 5)

FIG.1
(PRIOR ART)

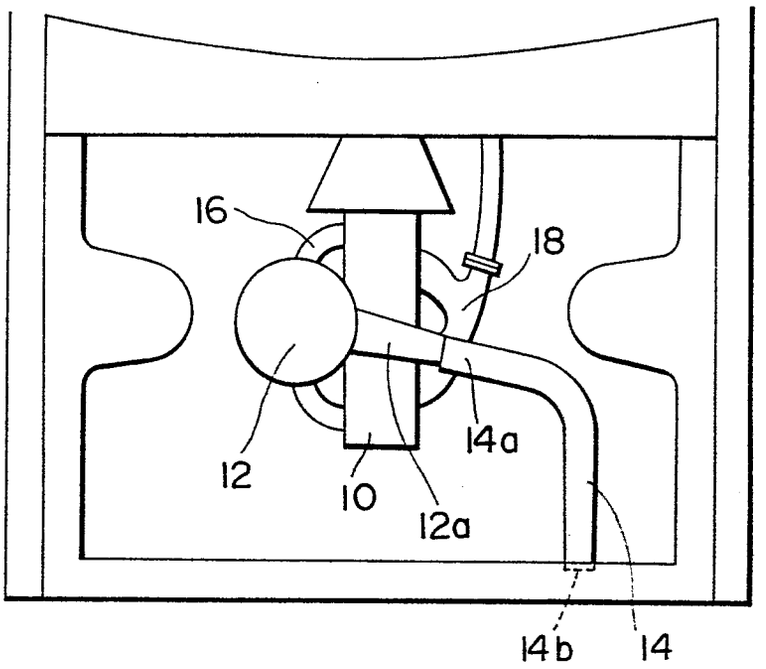


FIG.2
(PRIOR ART)

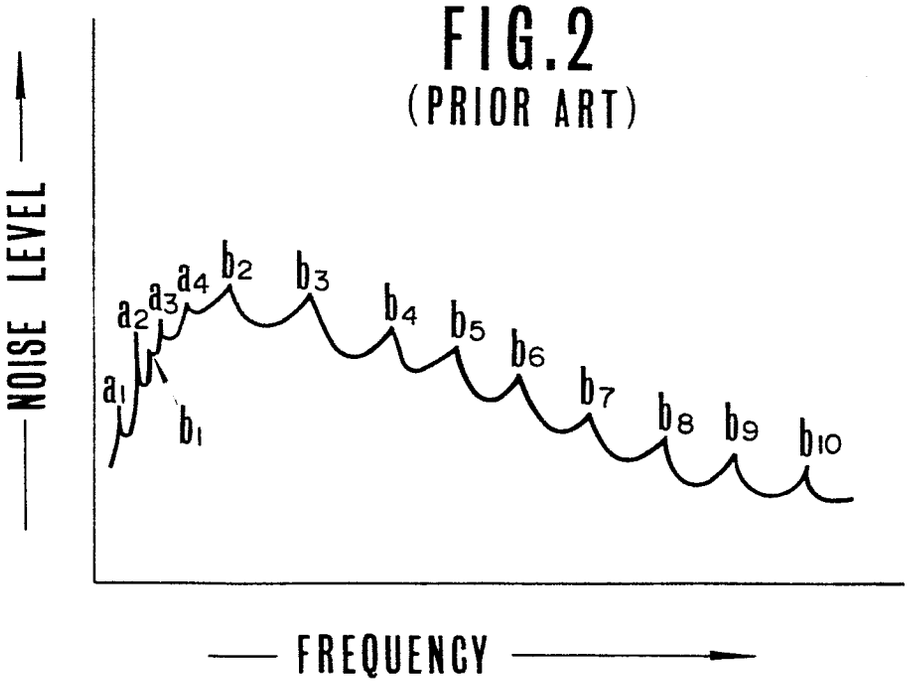


FIG.3

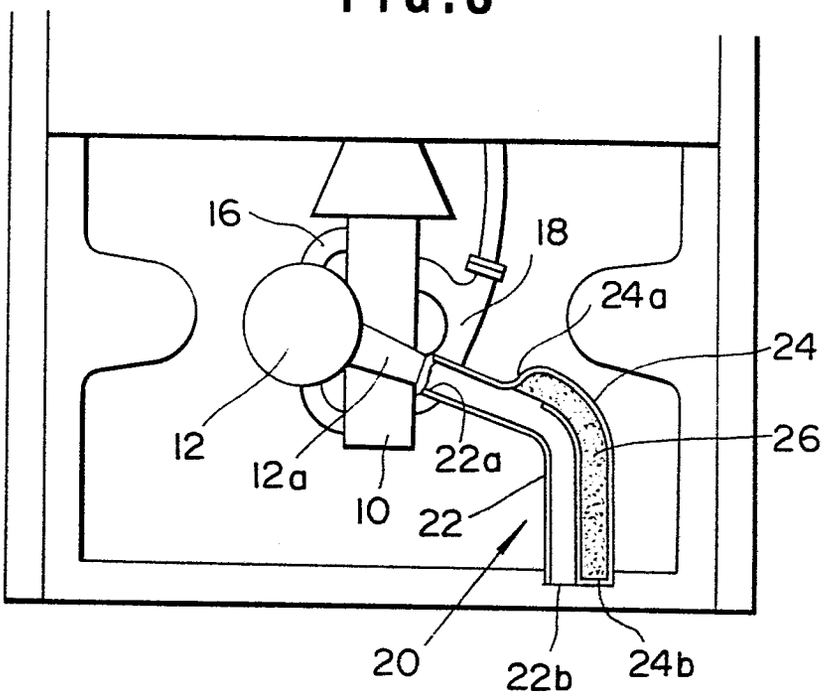

16
18
24a
24
12
12a
22a
26
10
22
20
22b
24b

FIG.4

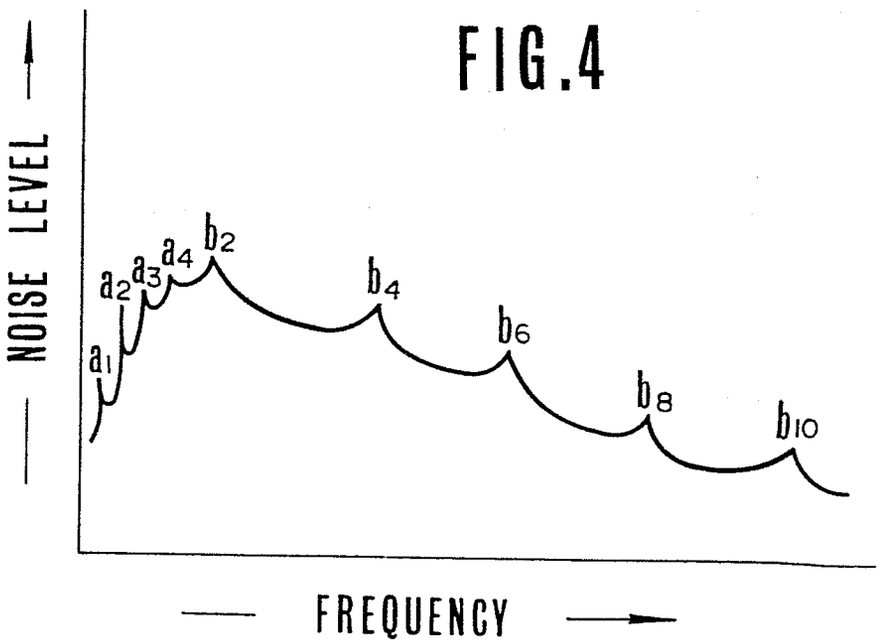

NOISE LEVEL
a1
a2
a3
a4
b2
b4
b6
b8
b10
FREQUENCY

FIG.5

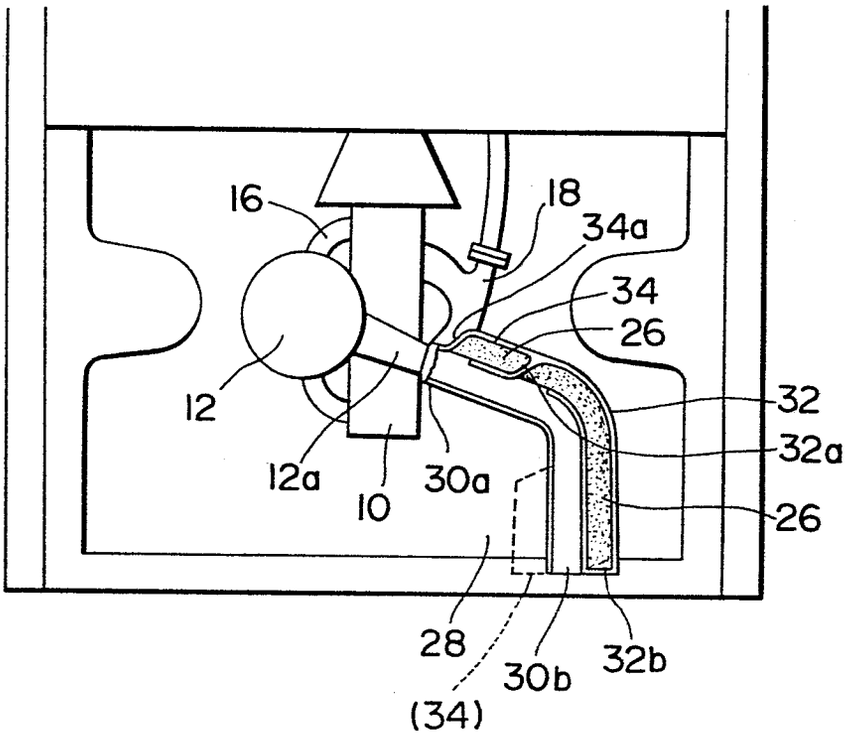
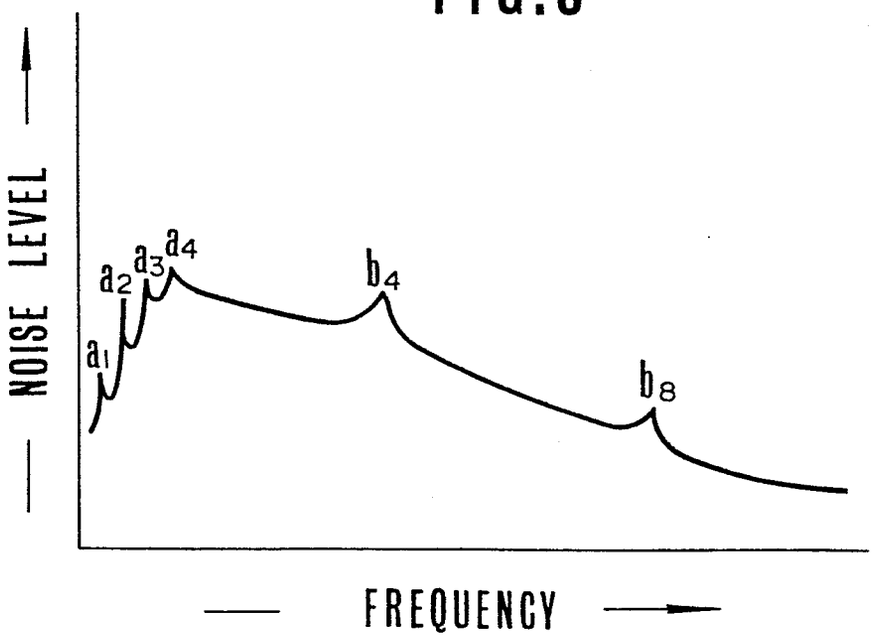

16
18
34a
34
26
12
32
32a
12a
10
30a
26
28
30b
32b
(34)

FIG.6


NOISE LEVEL
a1
a2
a3
a4
b4
b8
FREQUENCY

European Patent Office

EUROPEAN SEARCH REPORT

0091038
Application number

EP 83 10 3004

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. ³)
A	US-A-2 297 046 (BOURNE) * Page 1, left-hand column, lines 1-3; page 2, right-hand column, line 44 - page 3, left-hand column, line 26; figures 5,11,31,32 *	1,2,5, 6,8	F 02 M 35/12
A	US-A-2 468 454 (MASON) * Column 1, lines 1-3; column 3, line 23 - column 4, line 24; figures 1,2 *	1,2	
A	DE-C- 891 343 (GÖSLE) * Page 1, line 1 - page 2, line 39; page 2, lines 82-100 *	1,2	
A	FR-A-2 163 938 (LAURETTE) * Page 1, lines 1-2; page 6, lines 1-14; figure 1 *	1	TECHNICAL FIELDS SEARCHED (Int. Cl. ³) F 02 M F 01 N
A	FR-A-1 217 190 (BOET) * Abstract *	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	28-06-1983	TATUS W.D.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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