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(54) Fuel supply arrangement to at least one combustion chamber of an internal combustion engine

(57) Arrangement for the supply (1) of the fuel provided by a fuel manifold (5) to which are connected a plurality of injectors (8) each of which is able to supply on demand a given quantity of fuel to a respective combustion chamber (2); the supply arrangement (1) also being provided with a pump (7) to transfer fuel from the reservoir (6) to the fuel manifold (5), a recirculation duct (10) each connecting together the output (7a) and the

intake (7b) of the pump (7), a solenoid valve (12) with controlled opening and closing located along the recirculation duct (10), and a piloting unit able to control the solenoid valve (12) to regulate the flow of fuel along the recirculation duct (10) in such a manner as to control the fuel pressure inside the fuel manifold (5).

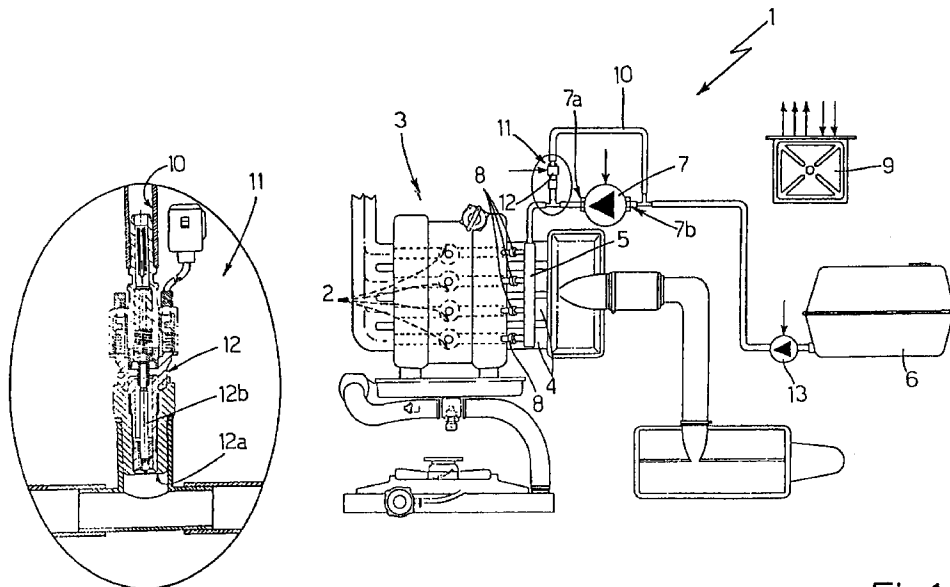


Fig.1

Description

[0001] The invention relates to a fuel supply arrangement and at least a combustion chamber for an internal combustion engine.

[0002] As is known, arrangements for a fuel supply to combustion chambers at present comprise a fuel manifold, inside which is stored the fuel to be supplied to the combustion chamber; one or several injectors connected to the fuel manifold, and able to supply on demand a specific volume of fuel to each combustion chamber of the said engine; a fuel storage reservoir; and a pumping unit able to draw the fuel from the storage reservoir to supply it at high pressure to the inside of the said fuel manifold.

[0003] The supply arrangements also comprise a pressure regulator of the proportional type located on the fuel manifold to prevent the fuel pressure inside the fuel manifold from exceeding a given specific threshold value, and a recirculation duct connecting the pressure regulator with the output of the pumping unit to convey upstream of the pumping unit itself the excess fuel collected from the fuel manifold by the pressure regulator.

[0004] Unfortunately, the pumping unit is normally located at a considerable distance from the fuel manifold, in consequence whereof the recirculation duct is of considerable length which makes it difficult to locate inside the engine compartment. In effect since highly inflammable fuel is passing through it, the recirculation duct must be located in a protected position, away from sources of heat or sharp edged components likely to compromise its structural integrity.

[0005] A second disadvantage of the supply arrangements described above is that the pumping unit must supply on request a pressure such as to guarantee either the flow of fuel to the fuel manifold or the return of the fuel through the recirculation duct.

[0006] A third disadvantage of the supply arrangements described above is that the pressure regulator does not manage to adequately damp the pressure peaks occurring cyclically during normal operation of the pumping unit of the latest generation. The present tendency on the market is in effect to use as pumping unit high pressure volumetric pumps which supply a pressure variable in time at high frequency, whereas the speed of response of the pressure regulator is notably low.

[0007] The purpose of the present invention is to achieve a fuel supply arrangement free from the disadvantages described above.

[0008] According to the present invention a fuel supply arrangement is achieved with at least one combustion chamber for an internal combustion engine; the supply arrangement comprising a fuel manifold, at least one pumping unit able to supply fuel to the inside of the fuel manifold, and at least one injector group connected to the said fuel manifold to supply on request a specific volume of fuel to the said combustion chamber; the out-

put of the pumping unit being in communication with the fuel manifold, the intake of the pumping unit being in communication with a fuel storage reservoir; the supply arrangement being characterised in that it comprises a recirculation duct, connecting upstream of the fuel manifold, the supply from the pumping unit with the intake of the pumping unit, and means to regulate the fuel flow into the recirculation duct; the said regulating means being able to regulate the pressure of incoming fuel to the fuel manifold.

[0009] The present invention is now described with reference to the appended drawings, which illustrate an example of a non-restrictive operating unit, wherein:

Figure 1 illustrates diagrammatically an internal combustion engine using a fuel supply arrangement designed according to the terms of the present invention; whereas

Figures 2 to 5 each illustrate the timing pattern of a respective magnitude relating to the operation of the supply arrangement in Figure 1.

[0010] With regard to Figure 1, the reference 1 indicates as a whole assembly a fuel supply arrangement to the combustion chambers 2 of an internal combustion engine 3 of known type.

[0011] In particular, the supply arrangement 1 is able to supply on demand a given volume of fuel inside each combustion chamber 2 of the engine 3. The said supply may occur either by atomising the fuel within the intake ducts 4 of the engine 3 which connect the combustion chambers 2 with atmosphere (indirect injection), as illustrated in Figure 1, or atomising the fuel directly inside each combustion chamber 2 of the engine 3 (direct injection).

[0012] The supply arrangement 1 comprises a fuel manifold 5 around which the fuel is stored before being supplied to the combustion chambers 2; a fuel storage reservoir 6, within which is stored the fuel required for the operation of the engine 3; and a pumping unit 7 able to supply the fuel inside the manifold 5 under a pressure, which will preferably, though not necessarily be comprised between 40 and 120 bars. In the example illustrated here the pumping unit 7 is a mechanical pump of the volumetric type which supplies to the intake 7a a flow of fuel at cyclically variable pressure between a minimum value and a maximum value.

[0013] The supply arrangement 1 also comprises one or several injectors 8 of known type interposed between the fuel manifold 5 and the engine 3 to provide on demand a specific volume of fuel into the fuel manifold 5 inside the combustion chambers 2 of the engine 3; and a pilot unit for the injectors able to control the opening and closing of the injectors 8 in accordance with engine operating conditions 3. In the example shown here, in particular, the number of injectors 8 is equal to the number of combustion chambers 2 present in the engine 3, and the piloting unit for the injectors is inte-

grated in the control unit 9 of the engine 3, to which the whole of the management of the engine 3 is delegated.

[0014] The supply arrangement 1 finally comprises a recirculation circuit 10, connecting upstream of the fuel manifold 5, the output 7a of the pumping unit 7 with the intake 7b of the pumping unit 7, and a control means 11 for the fuel flow along the recirculation duct 10. The said control arrangement, regulating the fuel flow along the recirculation duct 10, is able to regulate the pressure of the fuel within the fuel manifold 5. Obviously the recirculation duct 10 can also directly connect the output 7a and the intake 7b of the pumping unit 7 in an indirect manner, for instance bringing in communication the output 7a from the pumping unit 7 with the reservoir 6 which in turn, is connected with the intake 7b of the pumping unit 7 itself.

[0015] The control arrangement 11 comprises a solenoid valve 12 for controlled opening and closing located along the recirculation duct 10, and a pilot unit for the solenoid valve able to control the opening and closing of the solenoid valve 12 in accordance with the pressure of fuel in the corresponding output 7a of the pumping unit 7, and to the inside of the fuel manifold 5. In the example illustrated here, the pilot unit of the solenoid valve 12 is integrated with the control unit 9 of the engine 3 and can eventually be provided with a pressure sensor (not illustrated) to detect the fuel pressure according to the output 7a of the pumping unit 7; whereas the solenoid valve 12 consists of an injector 12 of known type located with its atomizer jet 12a turned towards the output 7a of the pumping unit 7, and with its closure 12b turned towards the intake 7b of the pumping unit 7.

[0016] In the example shown in Figure 1, the supply arrangement 1 also comprises an intake pumping unit 13 interposed between the reservoir 6 and the pumping unit 7. The said intake pumping unit 13 is designed to provide fuel to the pumping unit 7, the latter not being able to draw fuel directly from the reservoir 6.

[0017] The operation of the arrangement 1 is now described with reference to the case in which the pumping unit 7 is a mechanical pump of the volumetric type supplying to the output a pressure complying with the sinusoidal pattern shown in Figure 2, effecting three outputs for each two engine rotations. It is also assumed that the said mechanical pump, indicated below by number 7, is directly driven by the engine 3, in consequence whereof the pilot unit of the solenoid valve or the control unit 9, is able to follow the pattern in time of fuel pressure at the output 7a knowing the position of the engine shaft 3. Obviously in this case, the pressure sensor detecting the pressure on output 7a from the pump 7 is not necessary.

[0018] In service, when the engine 3 is operative, the solenoid valve pilot unit, or the control unit 9, synchronises opening and closing of the injector 12 with the operation in time of pressure of the output from the pump 7, in such a way as to reduce the propagation of pressure peaks within the fuel manifold 5. In the case in

point the solenoid valve pilot unit or the control unit 9, places in communication the output 7a and the intake 7b of the pump 7 when the fuel pressure to the output 7a has reached its maximum value, in such a manner as to discharge the pressure peak upstream of the pump 7, and obtain inside the fuel manifold 5 the timing pattern of pressure illustrated in Figure 4.

[0019] In particular, the pilot unit of the solenoid valve, or the control unit 9, opens the control unit 9, opens the injector 12 at each maximum pressure value for a timed interval Ta of specific magnitude. As indicated in Figure 3, where the pattern of control current is illustrated for the injector 12 as a function of time, the time interval Ta is preferably, though not necessarily centred upon the moment at which the pressure assumes its maximum value, and its amplitude is varied by the solenoid valve pilot unit, or the control unit 9, in accordance with the pressure required to be maintained in the fuel manifold 6 and/or other operating parameters of the engine 3. The pattern of fuel average pressure in the fuel manifold 5 according to the amplitude of the time interval Ta is illustrated in Figure 5.

[0020] The supply arrangement 1 has the notable advantage of reducing considerably the length of the recirculation duct 10, greatly facilitating the positioning within the engine compartment. The reduced length of the recirculation duct 10 also greatly reduces the overall manufacturing costs of the supply arrangement 1.

[0021] A further advantage of the supply arrangement 1 is that this allows a more accurate regulation of fuel pressure within the fuel manifold 5, thus considerably improving fuel atomising within the combustion chamber 2 or the intake ducts 4.

[0022] Finally, it is clear that the supply arrangement 1 described and illustrated here will allow the introduction modifications or variations without necessarily going beyond the scope of the present invention.

Claims

1. Fuel supply arrangement (1) with at least one combustion chamber (2) in an internal combustion engine (3); the supply arrangement comprising a fuel manifold (5), at least one pumping unit (7) able to supply fuel inside the fuel manifold (5), and at least one injector group (8) connected to the said fuel manifold (5) to supply on demand a specific volume of fuel to the said combustion chamber (2); the output (7a) of the pumping unit (7) being in communication with the fuel manifold (5), the intake (7b) of the pumping unit (7) being in communication with a fuel storage reservoir (6); the supply arrangement being characterised in that it comprises a recirculation duct (10) connecting upstream of the fuel manifold (5), the output (7a) of the pumping unit (7) with the intake (7b) of the pumping unit (7), and regulation means (11) for the fuel flow inside the recirculation duct; the said regulation means (11) being able

to regulate the incoming fuel pressure at the fuel manifold (5).

2. Arrangement according to claim 1, characterised in that the said regulating means (11) comprise a controlled opening and closing valve (12), selectively able to allow the flow of fuel along the said recirculation duct (10), and control means (9) for the said valve. 5
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3. Arrangement according to claim 2, characterised in that the said controlled opening and closing valve (12) is a controlled opening and closing solenoid valve (12). 15
4. Arrangement according to claims 2 or 3, characterised in that the said pumping unit (7) is a pumping unit of the volumetric type which supplies to the output (7a) a flow of fuel showing a pressure with a timed pattern fluctuating between a maximum and a minimum value, and the said control means (9) comprising pilot means (9) to open and close the said valve (12) and synchronisation means (9) to synchronise the operation of the said pilot means (9) with the timed pattern of the pressure. 20
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5. Arrangement according to claim 4, characterised in that the said synchronisation means (9) are able to activate the said pilot means (9) in such a manner as to maintain the said valve (12) open for a specific time interval (Ta) in accordance with each maximum pressure value; the said timed interval (Ta) comprising the moment at which the pressure reaches its maximum value. 30
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6. Arrangement according to claim 5, characterised in that the said synchronisation means (9) are able to vary the amplitude of the timed interval (Ta) as a function of the capacity of the pumping unit (7) and of the running mode of the engine (3). 40
7. Arrangement according to any one of the claims from 3 to 6, characterised in that the said valve (12) opening and closing on demand is an injector (12). 45
8. Arrangement according to claim 7, characterised by the fact that the said injector (12) is located along the said recirculation duct (10) in such a manner as to present its own atomising end (12a) turned towards the output (7a) of the pumping unit (7). 50
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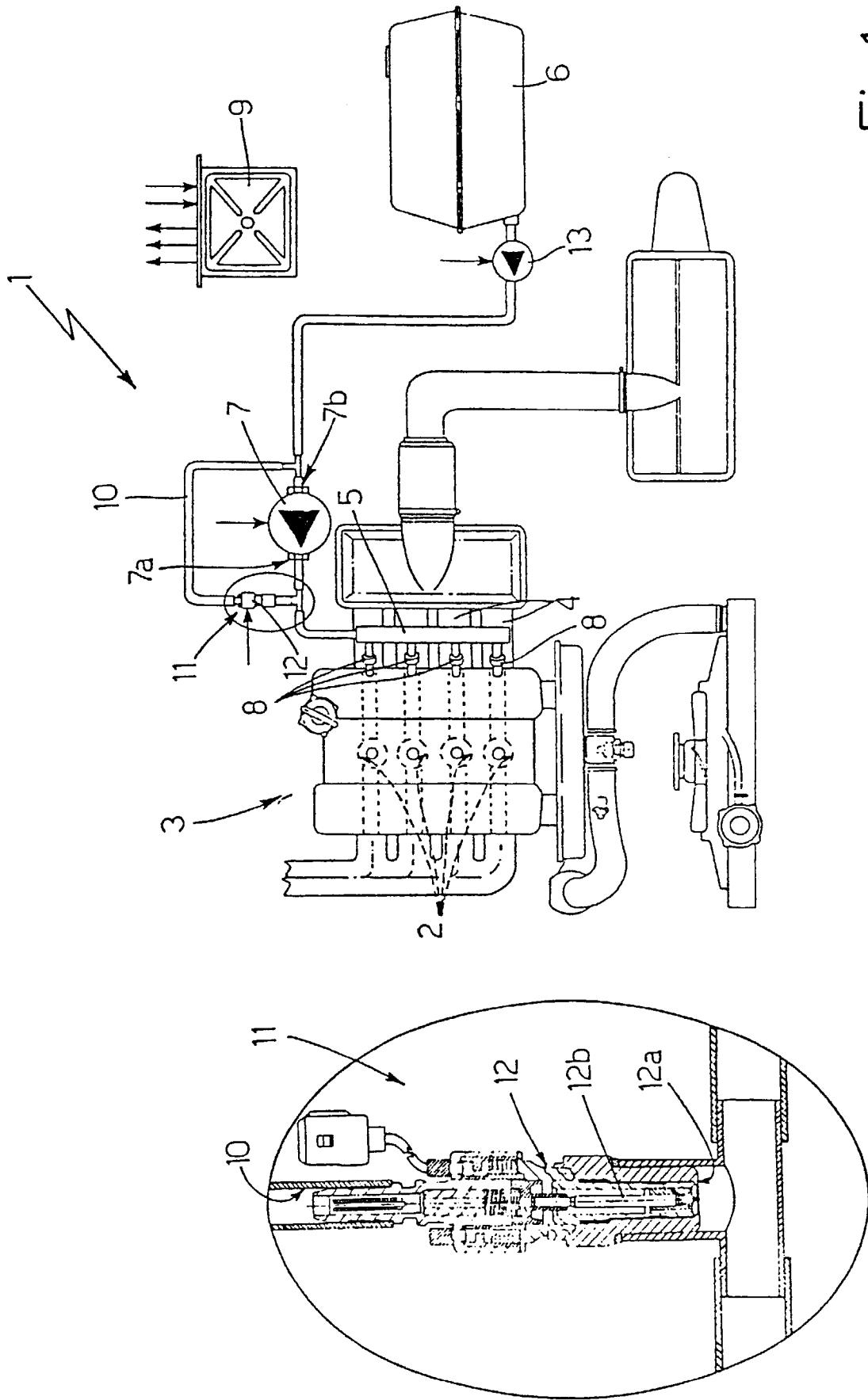


Fig.1

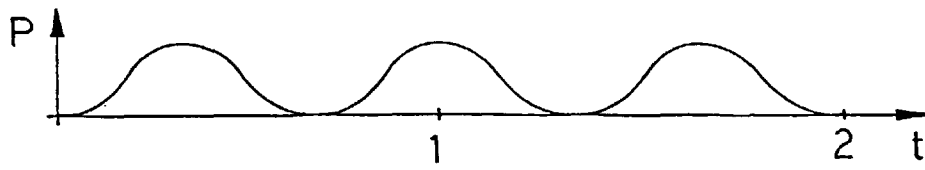


Fig.2

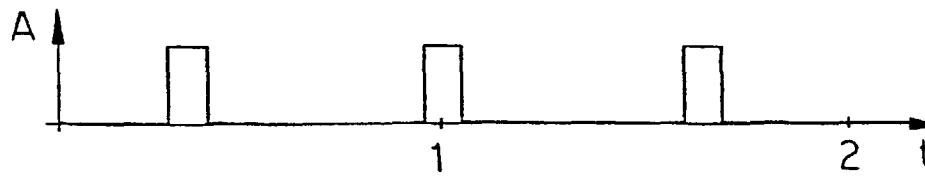


Fig.3

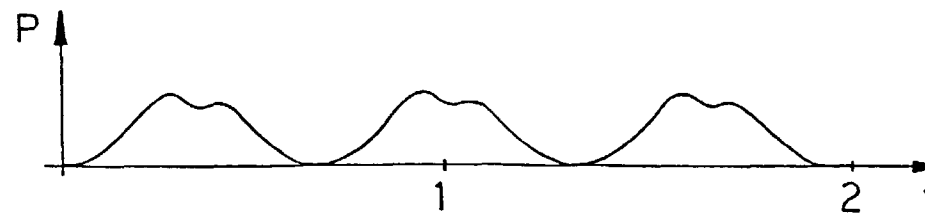


Fig.4

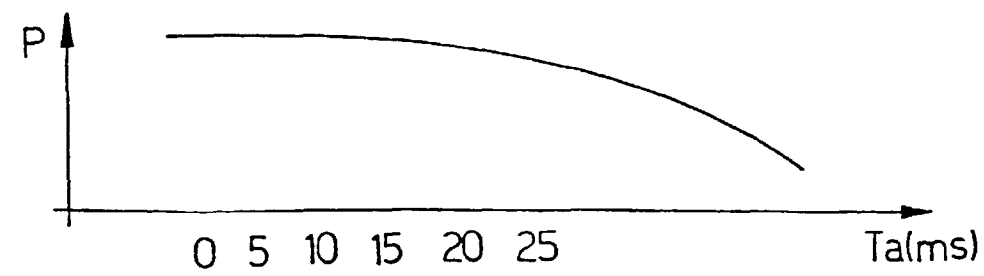


Fig.5



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EUROPEAN SEARCH REPORT

Application Number
EP 99 10 6831

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.6)
X	EP 0 459 429 A (TOYOTA) 4 December 1991 (1991-12-04)	1-3	F02M63/02
A	* column 5, line 1 - line 25; figure 1 *	4	
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	* column 1, line 38 - line 60 * * column 3, line 35 - line 58 * * column 4, line 1 - line 30 * * column 4, line 41 - line 46 * * column 4, line 63 - line 67 * * column 5, line 50 - line 67 *		
A	* column 6, line 5 - column 7, line 18; figures 1-4 *	6	
X	EP 0 656 471 A (SIEMENS) 7 June 1995 (1995-06-07)	1-3	
	* column 2, line 13 - line 43 * * column 2, line 48 - line 56 * * column 4, line 29 - line 33; figure 2 *		
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	* column 4, line 21 - line 54 * * column 5, line 6 - line 12 * * column 15, line 23 - line 38 * * column 16, line 7 - line 11 *		
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	* page 3, line 34 - page 4, line 4; figure 1 * * page 4, line 22 - line 26 *		
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 14 July 1999	Examiner Joris, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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ANNEX TO THE EUROPEAN SEARCH REPORT
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