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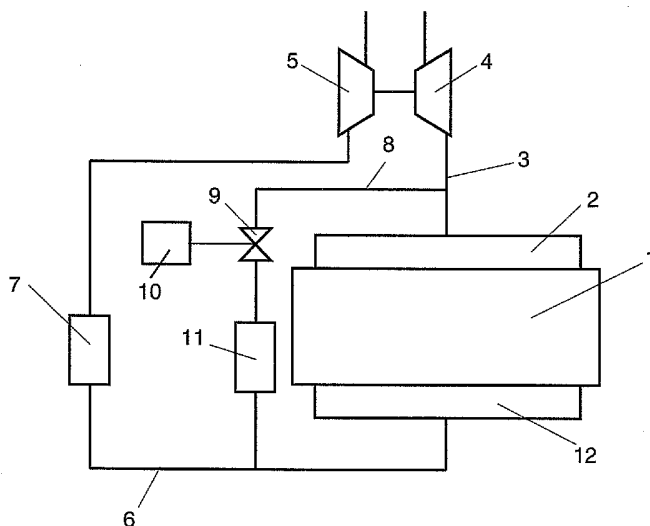
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(54) Title: ARRANGEMENT AND METHOD FOR RECIRCULATION OF EXHAUST GASES OF A COMBUSTION ENGINE



(57) Abstract: The present invention relates to an arrangement and a method for recirculation of exhaust gases of a combustion engine (1). The arrangement comprises a return line (8) which enables recirculation of exhaust gases from the combustion engine (1) to an inlet line (6) which is adapted to supplying air at a positive pressure to the engine (1). The return line (8) comprises a valve (9) which can be placed in open and closed positions and a cooler (11) for cooling the exhaust gases. A control unit (10) is adapted to guiding the valve (9) to a desired position. The control unit (10) is adapted to initiating guidance of the valve (9) to the open position on at least some occasions when the exhaust gases leaving the combustion engine (1) are at a lower pressure than the pressure in the inlet line (6). This results in a backflow of air through the return line (8) with the object of cleaning the cooler (11).

Arrangement and method for recirculation of exhaust gases of a combustion engine

BACKGROUND TO THE INVENTION, AND STATE OF THE ART

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The present invention relates to an arrangement and a method for recirculation of exhaust gases of a combustion engine according to the preambles of claims 1 and 6.

10 A known practice from the technology called EGR (Exhaust Gas Recirculation) is the leading back, via a return line, of part of the exhaust gases from a combustion process in a combustion engine to an inlet line for supply of air to the combustion engine. A mixture of air and exhaust gases thus supplied via the inlet line to the engine's cylinders in which the combustion takes place. Adding exhaust gases to the air causes a lower combustion temperature which results inter alia in the exhaust gases having a
15 reduced content of nitrogen oxides NO_x . This technology is used both for Otto engines and diesel engines.

The return line for the exhaust gases comprises inter alia an EGR valve which can be set to provide a desired amount of EGR. An electrical control unit is adapted to
20 controlling the EGR valve on the basis inter alia of information concerning the load of the combustion engine. In the case of supercharged combustion engines, the exhaust gases are mixed with air which is at a relatively high pressure. When a rapid increase in engine load is desired, the EGR valve is closed in order to increase the flow of fresh air to the engine so that the desired engine load can be reached quickly without
25 increasing the soot emissions. The EGR valve is also closed when there is a rapid reduction of engine load. The EGR valve is closed to maintain the charge pressure of the air as long as possible so that it can be utilised in the event of any subsequent rapid increase in engine load. The return line also comprises an EGR cooler adapted to cooling the exhaust gases in the return line before they are mixed with the air in an
30 inlet line to the engine. In course of time, soot deposits from the exhaust gases inevitably form on the internal surfaces of the EGR cooler. This not only impairs the heat transfer capacity of the EGR cooler but also increases resistance to the flow of

exhaust gases passing through the EGR cooler. Insufficient cooling of the exhaust gases leads inter alia to impaired engine performance.

SUMMARY OF THE INVENTION

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The object of the present invention is to provide an arrangement and a method of the kind mentioned in the introduction whereby the cooler's internal surfaces are kept substantially free from soot deposits from the exhaust gases in a simple manner and without using any special cleaning equipment.

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This object is achieved with the arrangement of the kind mentioned in the introduction which is characterised by the features indicated in the characterising part of claim 1. During the operation of vehicles with supercharged combustion engines, operating situations occur in which the exhaust gases from the combustion engine are at a pressure which is lower than the pressure in the inlet line. When a conventional EGR system is used, the valve of the return line closes in such operating conditions. The valve closes to save the charge pressure of the air as long as possible so that the charge pressure can be utilised in the event of any subsequent rapid increase in engine load. According to the present invention, however, the valve is kept open on at least some occasions when such operating conditions occur. With the valve open, the difference in pressure between the air and the exhaust gases results in a flow of fresh air from the inlet line being led back through the return line. The flow velocity of the air depends on the magnitude of the pressure difference. A relatively moderate pressure difference results in a relatively high velocity of air flow through the return line. This flow of fresh air therefore passes also through the first cooler. This air flow coming into contact with the internal surfaces of the cooler at a relatively high velocity effectively cleans soot deposits off the surfaces. The more often such a flow of fresh air is led at high velocity through the first cooler, the more effectively will the build-up of soot deposits on the internal surfaces of the cooler be prevented. As such a pressure difference occurs spontaneously during operation of a vehicle, no special cleaning equipment need be used for cleaning the first cooler. Such regular cleaning of the inside surfaces of the first cooler substantially maintains the cooler's original exhaust

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gas cooling capacity and low flow resistance. The returned exhaust gases are thus guaranteed cooling as necessary to prevent the engine's performance being affected.

According to a preferred embodiment of the present invention, said occasions occur
5 when the load of the combustion engine has rapidly decreased. When there is a rapid reduction of the engine's load, the pressure of the exhaust gases is reduced correspondingly. When the control unit receives information about such a rapid reduction in engine load, the control unit keeps the valve in an open position. In such operating conditions the compressed air in the inlet line is at a substantially higher
10 pressure than that of the exhaust gases. The pressure difference initiates a rapid flow of fresh air through the return line and hence through the valve, which is thereby provided with effective clearing away of soot deposits. When the fresh air has passed through the return line, it mixes with the combustion engine's exhaust gases, after which the air together with the exhaust gases is led out through the vehicle's existing
15 exhaust line system.

According to a preferred embodiment of the present invention, the arrangement comprises a turbine adapted to being driven by the exhaust gases from the combustion engine, and a compressor adapted to being driven by the turbine in order to supply
20 compressed air to the inlet line. When the valve is kept open during such a sudden reduction in engine load, the pressurised air is supplied to the exhaust line and is led through the turbine together with the exhaust gases. The turbine thus receives extra driving power which is transmitted to the compressor while at the same time relieving the load on the high pressure side of the compressor. The risk of compressed air from
25 the inlet line flowing back and out via the compressor with a disturbing noise (so-called compressor pumping) is thereby considerably reduced. The control unit need not necessarily keep the valve open on the occasion of every rapid reduction in engine load but only when cleaning of the cooler is required and only when a pressure difference of a certain value which results in a sufficiently high velocity of the air to
30 achieve optimum cleaning of the cooler is reached.

According to another preferred embodiment of the present invention, the arrangement comprises a second cooler arranged in the inlet line to cool the air which has been compressed by the compressor. Such a second cooler is adapted to cooling the compressed air to an acceptable temperature before it is mixed with any recirculating exhaust gases. The arrangement may be adapted to recirculate exhaust gases of both supercharged diesel engines and supercharged Otto engines. In the case of supercharged Otto engines it is relatively easy to add the recirculating exhaust gases to the air, since in substantially all operating conditions of such engines the exhaust gases are at a higher pressure than the air in the inlet line. As supercharged Otto engines require relatively uncomplicated equipment to lead the exhaust gases back, it is usual for this technology to be used in that type of engine for reducing the level of harmful exhaust emissions. The arrangement may however also be used with advantage for recirculating exhaust gases from a diesel engine. The combustion in a diesel engine normally takes place with an air excess. This leads indirectly to relatively large amounts of exhaust gases having to be transferred if the intended function is to be achieved. Moreover, in supercharged diesel engines the charge air pressure over a large portion of the engine's working range is greater than the pressure of the exhaust gases. In diesel engines the return line may lead into a so-called venturi used for locally lowering the static pressure of the air so that the exhaust gases can be led into the inlet line. There may also be other solutions for mixing the returned exhaust gases from a diesel engine with the pressurised air in the inlet line. Here again, achieving a backflow of air through the return line with the object of cleaning the cooler is a relatively uncomplicated matter.

The object indicated above is also achieved with the method of the kind mentioned in the introduction which is characterised by the features indicated in the characterising part of claim 6. When the exhaust gases leaving the combustion engine are at a pressure which is lower than the pressure in the inlet line, the result is a pressure gradient which can drive the air through the return line so as to effect a clearance of soot deposits off the internal surfaces of the first cooler. Thus no special cleaning equipment need be used for providing such clearance other than already existing equipment which is intended to reduce exhaust emissions from the engine.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention is described below by way of example with reference to the attached drawing, in which:

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Fig. 1 depicts schematically an arrangement for recirculation of exhaust gases of a supercharged combustion engine.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE

10 INVENTION

Fig. 1 depicts schematically an arrangement for enabling recirculation of part of the exhaust gases of a supercharged combustion engine 1, which may be a diesel engine or an Otto engine. Such recirculation is commonly known as EGR (Exhaust Gas
15 Recirculation). The combustion engine 1 may for example be intended as a power unit for a heavy vehicle. Exhaust gases from the cylinders of the combustion engine 1 are led via an exhaust manifold 2 to a common or branched exhaust line 3. The exhaust gases in the exhaust line 3, which are at a positive pressure, are led through a turbine 4. The turbine 4 thus receives driving power. The driving power of the turbine 4 is
20 transferred via a connection to a compressor 5. The compressor 5 then compresses air which is led via an inlet line 6 to the combustion engine 1. A cooler in the form of a charge air cooler 7 is arranged in the inlet line 6 to enable cooling of the compressed air before it is supplied to the combustion engine 1.

25 A return line 8 is adapted to enabling recirculation of part of the exhaust gases from the exhaust line 3. The recirculating portion of the exhaust gases is intended to be mixed into the compressed air in the inlet line 6. The return line 8 comprises a valve in the form of an EGR valve 9 which can be used as necessary to shut off the exhaust gas flow in the return line 8. To some extent the EGR valve 9 may also be used for
30 controlling the amount of exhaust gases being led to the inlet line 6. An electrical control unit 10 is adapted to receiving information concerning, for example, the load of the engine 1 with a view to guiding the EGR valve to a desired position. The return

line 8 also comprises a cooler in the form of a EGR cooler 11 for cooling the recirculating exhaust gases. The exhaust gases contain soot emissions which, while passing through the EGR cooler, risk being deposited on the heat transfer surfaces of the EGR cooler in such a way that soot deposits are formed. Such soot deposits on the heat transfer surfaces of the EGR cooler impair the exhaust gas cooling capacity of the cooler. Soot deposits also increase resistance to the flow of exhaust gases through the EGR cooler 11. Insufficient cooling of the exhaust gases leads inter alia to impairment of the engine's performance.

When the vehicle is in motion, the control unit 10 receives information concerning the engine's load. The control unit 10 may form part of an electrical engine control unit of the vehicle. The control unit 10 may use information about, for example, the fuel supply to the engine 1, and stored information concerning the specific combustion engine, to determine the engine load and hence when rapid changes in engine load occur. When the engine 1 is operating at substantially constant load, the control unit 10 is adapted to keeping the EGR valve in an open position. This results in a suitable amount of exhaust gases from the exhaust line 3 being led into the return line 8. After they have passed through the open EGR valve 9, the exhaust gases are led through the EGR cooler 11 to cool them. During the cooling process there is inevitably a certain deposition of soot from the exhaust gases on the heat transfer surfaces of the EGR cooler 11. The cooled exhaust gases are led to the inlet line 6. The combustion engine may be a supercharged Otto engine or a supercharged diesel engine. As the exhaust gases of supercharged Otto engines in most operating situations are at a higher pressure than the air in the inlet line, the exhaust gases can in this case be mixed into the air in the inlet line 6 without any special auxiliary means. In a diesel engine, the mixing can when necessary be achieved by means of a venturi or similar auxiliary means.

The mixture of air and exhaust gases is led from the inlet line 6 to the respective cylinders of the engine 1 via a manifold 12. This addition of exhaust gases to the air reduces the combustion temperature in the cylinders 1 and hence also the amounts of nitrogen oxides (NO_x) formed during the combustion processes. Recirculation of

exhaust gases is thus a relatively simple way of reducing the level of nitrogen oxides (NO_x) in the exhaust gases.

When a rapid increase in engine load is required during operation of the vehicle, the control unit 10 is adapted to closing the EGR valve 9 so that the exhaust gas flow through the return line 8 ceases. This increases the proportion of fresh air which is led to the engine 1 via the inlet line 6. The necessary engine load is thus achieved quickly without increasing the amount of exhaust emissions. In conventional EGR arrangements, the EGR valve 9 also closes in operating conditions in which there is rapid reduction of the load of the engine 1. In such conditions, the purpose of closing the EGR valve 9 is to maintain as long as possible the charge pressure of the air, for possible utilisation in the event of any rapid increase in engine load occurring soon after. According to the present invention, however, the control unit 10 is adapted to opening the EGR valve 9 on at least some occasions when the exhaust gases leaving the combustion engine 1 are at a lower pressure than the air pressure in the inlet line 6. Such a pressure difference enables a backflow of air through the return line 8 when the EGR valve 9 is in an open position. Such a pressure difference occurs, for example, when the load of the combustion engine 1 is rapidly reduced. Fresh air is then led at high velocity through, inter alia, the EGR cooler 11. The rapidly flowing air thus comes into mechanical contact with the internal surfaces of the EGR cooler, thereby providing effective clearance of any soot deposits off the internal surfaces.

The more frequently such a fresh air flow at high velocity is led through the EGR cooler 11, the more effectively will the occurrence of soot deposits on the internal surfaces of the EGR cooler 11 be prevented. The control unit 10 need not necessarily keep the EGR valve open on the occasion of every rapid reduction of engine load but only when the EGR cooler 11 needs cleaning. Alternatively, the control unit 10 may keep the EGR valve 9 open when pressure differences are such as to provide a sufficiently high air flow velocity to achieve effective cleaning of the EGR cooler 11. As such a pressure difference resulting in air flow occurs spontaneously during operation of a vehicle, no special equipment need be arranged beyond that already existing for providing cleaning of the EGR cooler 11. Another advantage of such a

backflow of air through the return line is that after passing through the return line the pressurised air is led through the turbine 4. The turbine 4 thereby receives extra driving power which drives the compressor 5 and at the same time relieves the load on the high pressure side of the compressor. The risk of air already compressed flowing
5 back from the inlet line 6 and out via the compressor 5 (so-called compression pumping), with a disturbing noise, is thereby considerably reduced.

The invention is in no way limited to the embodiment described in the drawing but may be varied freely within the scopes of the claims. The invention is applicable to
10 substantially all types of combustion engines in which air is supplied at positive pressure to the combustion engine. In certain operating conditions, this air is usually at a pressure which exceeds the pressure of the exhaust gases, resulting in a pressure gradient which, with an open EGR valve, provides a backflow of air through the return line.

Claims

1. An arrangement for recirculation of exhaust gases of a combustion engine (1), whereby the arrangement comprises a return line (8) adapted to enabling recirculation
5 of exhaust gases from the combustion engine (1), a valve (9) adapted to enabling a flow of exhaust gases through the return line (8) when it is placed in an open position and to preventing a flow of exhaust gases through the return line (8) when it is placed in a closed position, a control unit (10) adapted to guiding the valve (9) to a desired position, a first cooler (11) adapted to cooling the exhaust gases in the return line (8),
10 and an inlet line (6) which is connected to the return line (8) so as to allow a supply to the engine (1) of exhaust gases from the return line (8) together with air at a positive pressure, characterised in that the control unit (10) is adapted to guiding the valve (9) to the open position on at least some occasions when the exhaust gases leaving the combustion engine (1) are at a pressure which is lower than the pressure in the inlet
15 line (6), in order to achieve a backflow of air through the return line (8) with the object of cleaning the first cooler (11).
2. An arrangement according to claim 1, characterised in that said occasions occur when the load of the combustion engine (1) has been rapidly reduced.
20
3. An arrangement according to claim 1 or 2, characterised in that the arrangement comprises a turbine (4) adapted to being driven by exhaust gases from the combustion engine (1), and a compressor (5) adapted to being driven by the turbine in order to supply compressed air to the inlet line (6).
25
4. An arrangement according to claim 3, characterised in that the arrangement comprises a second cooler (7) which is arranged in the inlet line (6) in order to cool the air which has been compressed by the compressor (5).
- 30 5. An arrangement according to any one of the foregoing claims, characterised in that the combustion engine (1) is a diesel engine or an Otto engine.

6. A method for recirculation of exhaust gases of a combustion engine (1), whereby the method comprises the steps of enabling recirculation of exhaust gases from the combustion engine (1) via a return line (8), of controlling the flow of exhaust gases through the return line (8) by means of a valve (9) which in an open position allows a
5 flow through the return line (8) and which in a closed position prevents such a flow, of initiating guidance of the valve (9) to a desired position by means of a control unit, of cooling the exhaust gases in the return line (8) by means of a first cooler (11) and of allowing a supply to the engine (1) of exhaust gases from the return line (8) together with air at a positive pressure via an inlet line (6) which is connected to the return line
10 (8), characterised by the step of initiating guidance of the valve (9) to the open position on at least some occasions when the exhaust gases leaving the combustion engine (1) are at a pressure which is lower than the pressure in the inlet line (6), in order to achieve a backflow of air through the return line (8) with the object of cleaning the first cooler (11).
- 15
7. A method according to claim 6, characterised by the step of initiating guidance of the valve (9) to the open position on occasions when the load of the combustion engine has been rapidly reduced.
- 20
8. A method according to claim 6 or 7, characterised by the steps of driving a turbine (4) by means of exhaust gases from the combustion engine (1), and of supplying compressed air to the inlet line (6) by means of a compressor (5) which is connected to the turbine (4).
- 25
9. A method according to claim 8, characterised by the step of cooling in the inlet line (6) by means of a second cooler (7) the air compressed by the compressor (5).
- 30
10. A method according to any one of claims 6-9 above, characterised by the step of recirculating exhaust gases of a combustion engine (1) in the form of a diesel engine or an Otto engine.

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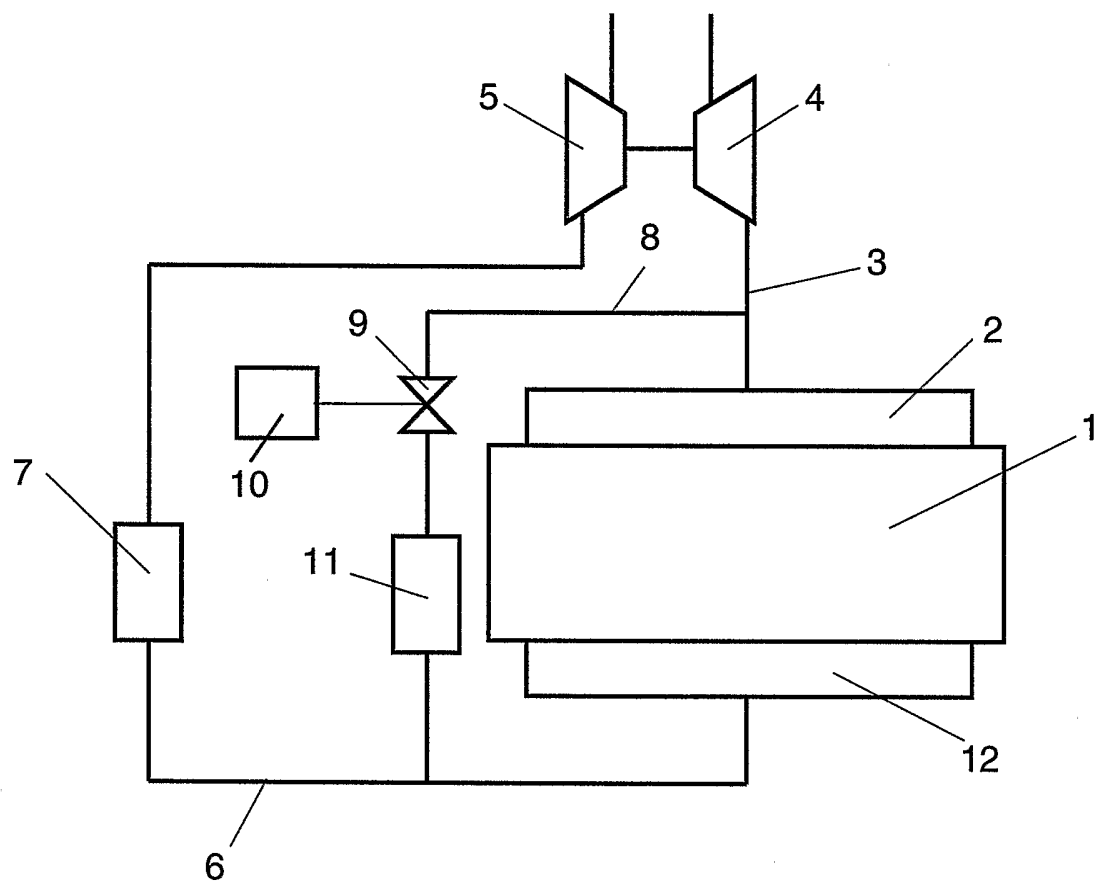


Fig 1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 2003/001972

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F02M 25/07, F02B 47/08, F28G 1/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 2725045 A1 (MOTOREN- UND TURBINEN-UNION FRIEDRICHSHAFEN GMBH), 14 December 1978 (14.12.1978), page 3, line 23 - page 4, line 10 --	
A	US 3779213 A (KNUDSEN), 18 December 1973 (18.12.1973), abstract --	
A	US 5082502 A (LEE ET AL), 21 January 1992 (21.01.1992), abstract -- -----	

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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DE	2725045	A1	14/12/1978	NONE		
US	3779213	A	18/12/1973	DE	2155897 A	18/05/1972
				GB	1351664 A	01/05/1974
				NL	7115243 A	15/05/1972
				NO	135330 B	13/12/1976
				SE	379083 B,C	22/09/1975
US	5082502	A	21/01/1992	AU	621920 B	26/03/1992
				AU	4107589 A	15/03/1990
				BR	8904122 A	10/04/1990
				CA	1333319 A,C	06/12/1994
				CS	8905109 A	16/07/1991
				CZ	281059 B	12/06/1996
				DD	287665 A	07/03/1991
				DE	3928339 A,C	15/03/1990
				ES	2015210 A	01/08/1990
				FR	2635994 A,B	09/03/1990
				GB	2222652 A,B	14/03/1990
				GB	8919137 D	00/00/0000
				HU	51513 A	28/05/1990
				IT	1231938 B	15/01/1992
				IT	8921642 D	00/00/0000
				JP	1937939 C	09/06/1995
				JP	2174984 A	06/07/1990
				JP	6067507 B	31/08/1994
				KR	9709341 B	10/06/1997
				MX	165493 B	13/11/1992
				NL	193932 B,C	01/11/2000
				NL	8902244 A	02/04/1990
				PT	91657 A,B	30/03/1990
				TR	25824 A	09/08/1993