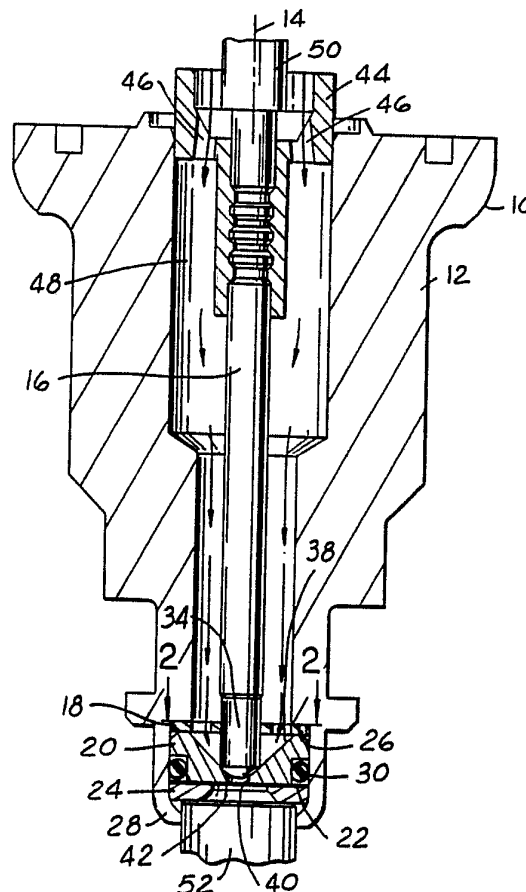




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵ : F02M 51/06, 61/18	A1	(11) International Publication Number: WO 92/07183 (43) International Publication Date: 30 April 1992 (30.04.92)
(21) International Application Number: PCT/EP91/01879 (22) International Filing Date: 1 October 1991 (01.10.91) (30) Priority data: 596,166 11 October 1990 (11.10.90) US (71) Applicant (for CA only): SIEMENS AUTOMOTIVE L.P. [US/US]; 2400 Executive Hills Drive, Auburn Hills, MI 48326-2980 (US). (71) Applicant (for all designated States except CA): SIEMENS AKTIENGESELLSCHAFT [DE/DE]; Wittelsbacher- platz 2, D-8000 München 2 (DE). (72) Inventors: KELLUM, James, A., Jr. ; 212 Dawson Drive, Seaford, VA 23696 (US). LEHMANN, Robert ; 206 Fischer Drive, Newport News, VA 23602 (US). PARISH, James ; 712 Ninebark Court, Newport News, VA 23602 (US).		(74) Agent: FUCHS, Franz-Josef; Postfach 22 13 17, D-8000 München 22 (DE). (81) Designated States: AT (European patent), BE (European patent), CA, CH (European patent), DE (European pa- tent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (Euro- pean patent), IT (European patent), JP, KR, LU (Euro- pean patent), NL (European patent), SE (European pa- tent). Published <i>With international search report.</i>
(54) Title: METHOD FOR IMPROVING VALVE SEALING (57) Abstract A method for improving the metal-to-metal sealing of a needle to a seat, particularly of the rounded tip end of the needle to a frusto- conical depression in the seat, comprises applying a controlled axial compressive load to the seated needle to cause the annular zone of seal- ing to be coined.		



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	ES	Spain	MG	Madagascar
AU	Australia	FI	Finland	ML	Mali
BB	Barbados	FR	France	MN	Mongolia
BE	Belgium	GA	Gabon	MR	Mauritania
BF	Burkina Faso	GB	United Kingdom	MW	Malawi
BG	Bulgaria	GN	Guinea	NL	Netherlands
BJ	Benin	GR	Greece	NO	Norway
BR	Brazil	HU	Hungary	PL	Poland
CA	Canada	IT	Italy	RO	Romania
CF	Central African Republic	JP	Japan	SD	Sudan
CG	Congo	KP	Democratic People's Republic of Korea	SE	Sweden
CH	Switzerland	KR	Republic of Korea	SN	Senegal
CI	Côte d'Ivoire	LI	Liechtenstein	SU ⁺	Soviet Union
CM	Cameroon	LK	Sri Lanka	TD	Chad
CS	Czechoslovakia	LU	Luxembourg	TG	Togo
DE*	Germany	MC	Monaco	US	United States of America
DK	Denmark				

⁺ Any designation of "SU" has effect in the Russian Federation. It is not yet known whether any such designation has effect in other States of the former Soviet Union.

METHOD FOR IMPROVING VALVE SEALING

Field of the Invention

5 An electrically-operated, spring-biased fluid valve, wherein the valve element is an elongate metal needle having a rounded distal end and the valve seat is a a metal annulus containing a frusto-conical seating surface with which the distal end of the needle coacts.
10 The invention relates to a method for improving the sealing of the needle's distal end to the seat's seating surface so as to reduce fluid leakage through the valve when the valve is in use and being operated closed.

15 Background and Summary of the Invention

 One of the uses of a fluid valve of the type to which the present invention relates is as a fuel injector for injecting a combustible fuel into a combustion engine. In
20 the case of a spark-ignited, internal combustion engine for an automotive vehicle, the valve is typically under the control of an electronic control system and injects gasoline into the engine.

25 One of the chief reasons for using a fuel-injected engine is because of the ability to closely control the amount of fuel entering the engine. Close control over injected fuel is important for reasons of both fuel economy and exhaust emissions. When a fuel injector is
30 closed, it should totally prevent fuel from leaking into the engine because such leakage can have undesired consequences. For example, even small amounts of leakage can adversely affect exhaust emissions in very significant ways. Certain countries now impose limits on the amounts

of certain exhaust constituents that can be discharged to the atmosphere, and there is a trend toward making these limits even stricter. Accordingly, a commercially acceptable fuel injector is likely to have to comply with
5 increasingly stringent limits on leakage.

Extremely costly manufacturing procedures could, of course, be invoked to insure precise surface finishes and fits of the cooperating parts by placing extremely small
10 tolerances on the dimensions and surface finishes of the parts involved. Such activities would obviously increase the manufacturing costs, possibly to non-competitive prices for some companies. Alternate procedures that are less costly are therefore desirable.

15

The present invention relates to a new and unique method for reducing leakage in mass-produced fuel injectors of the type described at the beginning. The invention involves the inclusion of an additional step in
20 the manufacturing process, but it eliminates the necessity for stricter tolerances on surface finish and part dimensions. Accordingly, manufacturing procedures that are presently in existence continue to enjoy vitality, and all that is needed to reduce leakage through the injector
25 is the performance of what will be called for convenience a coining step. This coining step however does not involve the use of a coining die to coin a part; rather, it involves the application of axial compressive load to force the rounded distal end of the needle against the
30 frusto-conical valve seat surface so that coining action occurs at an annular zone of surface contact between the two parts involved. The force application is preferably conducted in a particular manner so that the needle is neither irreversibly bent nor buckled by the coining step.

This step is conducted during the manufacturing process so that neither the solenoid nor the spring which are parts of the operating mechanism in the completed injector has an influence on the result of the coining. Actual usage
5 of the method of the invention has been found to to improve the yield of the mass-production process by approximately 10%, meaning that in a typical production run, that many more injectors will comply with applicable fuel leakage specifications when tested after assembly.
10 This improvement reduces the number of injectors that have to be either re-worked or scrapped. Accordingly, the invention provides a significant improvement in the manufacturing process at the cost of only a single additional step. At that, the equipment needed to perform
15 the additional step is neither extremely expensive nor complicated.

The foregoing features, advantages, and benefits of the invention, along with additional ones, will be seen in
20 the ensuing description and claims which should be considered in conjunction with the accompanying drawings. The drawings disclose a presently preferred embodiment of the invention according to the best mode presently contemplated for carrying out the invention.

25

Brief Description of the Drawings

Fig. 1 is a longitudinal view, mainly in cross section, through a portion of a fuel injector during the
30 manufacturing process.

Fig. 2 is an enlarge fragmentary transverse cross sectional view taken in the direction of arrows 2-2 in Fig.1 but omitting the valve element.

Fig. 3 is a graph plot for explaining certain aspects of the method.

Description of the Preferred Embodiment

5

Figs. 1 and 2 illustrate the tip end portion of a fuel injector 10 comprising: a generally tubular metal body 12 having a longitudinal axis 14; an elongate metal needle 16 disposed coaxial with axis 14 within body 12; and axially captured within body 12 at the distal end thereof, a stack composed of a metal needle guide member 18, a metal annulus 20, a thin metal orifice disc member 22, and a metal back-up ring 24, all four of which are coaxial with and transverse to axis 14. The stack is axially captured on body 12 between a distally facing internal shoulder 26 and a flange 28 of body 12, the latter having been crimped over the margin of the stack after the stack has been inserted through the open distal end of the body and against shoulder 26. An O-ring seal 30 is disposed in a circular groove extending around the outside of annulus 20 to seal between the stack and the I.D. of the body.

Needle guide member 18 has a central circular guide hole 32 through which a circular cylindrical portion 34 of needle 16 passes with a close sliding fit. A series of circular through-holes 36 are arranged in a circular pattern about hole 32.

Annulus 20 contains a depression 38 that is coaxial with axis 14 and that has a frusto-conical surface. A circular through-hole 40 extends from the bottom of depression 38 coaxial with axis 14.

Orifice disc member 22 contains one or more metering orifices in registry with through-hole 40.

Back-up ring 24 contains a central through-hole 42 that is in registry with the orifices of disc 22.

A bushing-like member 44 is attached to needle 16 adjacent the proximal end of the needle. Member 44 is shaped to leave the proximal end of the needle exposed. Member 44 has a close sliding fit with the inside of body 12 at the opposite end thereof from flange 28, and it also has several through-holes 46 that are eccentric to axis 14.

When the completed fuel injector is in use, pressurized liquid fuel that has been introduced into the injector passes through through-holes 46 in the sense indicated by the arrows and fills the annular space 48 surrounding needle 16 within body 12. Through-holes 36 serve to convey fuel from space 48 to fill depression 38 with pressurized fuel.

In the completed fuel injector, needle 16 is reciprocated axially to seat on and unseat from the valve seat that is formed by the frusto-conical depression 38. Fig. 1 illustrates the seated condition wherein the rounded distal end of the needle has an annular zone of sealing contact with the depression to thereby close through-hole 40, and hence prevent pressurized fuel from being emitted from the injector via the orifices in orifice disc 22. This represents the closed condition of the injector. The completed fuel injector has a helical coil spring (not appearing in the drawings) which exerts an axially directed bias force on the needle urging the

rounded distal end thereof into forceful seating on depression 38. The spring bias is overcome by the energization of a solenoid coil (not shown in the drawings) which is operatively coupled to the needle.

5 Solenoid energization lifts the needle from the seat to permit the injector to emit fuel from the injector's tip end.

The method of the present invention is conducted at a station of the assembly line on which the injectors are assembled. Fig. 1 represents that station. Essentially the station comprises a suitable fixture for supporting that much of an injector as is portrayed, preferably in an upright orientation. The station has a mechanism which is

10 capable of axially clamping needle 16 and annulus 20 in such a manner that an axial compressive load can be applied to the clamped parts in a controlled manner.

Fig. 1 illustrates two elements of the station's mechanism, a support pin 50 and a push pin 52. The two are arranged coaxial and so that the parts to be clamped can be placed coaxially between them. The two pins are then relatively moved toward each other along axis 14 so that clamping occurs in the manner presented in Fig. 1.

20 In this regard flange 28 circumscribes an opening sufficiently large to allow for through-passage of the distal end of push pin 52 into abutment with back-up ring 24. Member 44 allows the distal end of support pin 50 to abut the proximal end of the needle. Preferably the

25 abutment surfaces for the parts involved are flat and smooth, as shown.

30

With the clamping having occurred, the station's mechanism applies an axial compressive load to the clamped

parts. Fig. 3 presents a graph plot of force vs. time. The compressive loading is built up to substantially maximum value over 0.3 seconds. The maximum force is held for an additional time which is at least as long as the
5 0.3 second build time and is preferably 0.7 seconds. Thereupon, the force is allowed to quickly decay. Pins 50, 52 are then retracted sufficiently to enable the partial injector to be moved to the next station in the assembly line.

10

The process that has just been conducted on the partial injector coins the annular zone of sealing contact between the rounded tip end of the seated needle and the frusto-conical shaped seat. This improves the seal and
15 tends to reduce leakage that might otherwise occur through the closed fuel injector. By way of example, the needle and the annulus should have approximately the same hardness, Rc 56-60, and that of pins 50, 52 should be at least that hard, Rc 58-60 for example. The force that is
20 applied should not irreversibly bend or buckle the needle. For a needle having a length of 28-30 mm., a diameter of 2 mm. and a radius of 1.18-1.32 mm. for the rounded tip end, a maximum force of about 490 pounds has been successfully used.

25

While a presently preferred embodiment of the invention has been illustrated and described, it should be appreciated that the inventive principles may be practiced in other equivalent ways.

WHAT IS CLAIMED IS:

1 1. A method of making an electrically-operated,
2 spring-biased fluid valve so as to reduce fluid leakage
3 through the valve when the valve is in use and being
4 operated closed, said valve being of the type which
5 comprises for its movable valve element, an elongate metal
6 needle that has a rounded distal end and that is
7 susceptible to bending and/or buckling under axial
8 compression loads exceeding permissible axial compression
9 loading, and for its valve seat element, a metal disc
10 annulus having a frusto-conical wall that circumscribes a
11 through-hole and is coaxial with said needle, said fluid
12 valve operating in response to electrical energization and
13 de-energization thereof to open and close said
14 through-hole by unseating and seating said rounded distal
15 end of said needle from and on said frusto-conical wall,
16 said method comprising disposing said needle and said
17 annulus, free of the valve's electrical operation and
18 spring bias, axially between a pair of aligned elements
19 that are relatively movable toward and away from each
20 other along the direction of said axis, relatively moving
21 said pair of aligned elements toward each other to axially
22 clamp said needle and annulus, and causing said pair of
23 aligned elements to deliver to said needle and said
24 annulus a controlled clamping force that acts to coin an
25 annular zone of surface contact between said rounded
26 distal end of said needle and said frusto-conical wall
27 without irreversibly bending or buckling said needle.

1 2. A method as set forth in claim 1 wherein said
2 pair of aligned elements are caused to deliver said
3 controlled clamping force in such a manner that the force

4 builds to substantially its maximum value within about 0.3
5 seconds.

1 3. A method as set forth in claim 2 wherein after
2 said force has built to substantially its maximum value,
3 said pair of aligned elements are caused to maintain said
4 force substantially at its maximum value for an additional
5 time of at least 0.3 seconds before said force is allowed
6 to decay.

1 4. A method as set forth in claim 3 wherein said
2 pair of aligned elements are caused to maintain said force
3 substantially at its maximum value for an additional time
4 of 0.7 seconds before said force is allowed to decay.

1 5. A method as set forth in claim 1 wherein said
2 clamping force is delivered by causing one of said pair of
3 aligned elements to bear directly against a proximal end
4 of said needle that is opposite said distal end of said
5 needle.

1 6. A method as set forth in claim 1 wherein said
2 clamping force is delivered by causing one of said pair of
3 aligned elements to bear directly against an annular
4 back-up member of said valve that is itself disposed
5 directly against said annulus.

1 7. A method as set forth in claim 1 wherein said
2 clamping force is delivered by causing one of said pair of
3 aligned elements to bear directly against a proximal end
4 of said needle that is opposite said distal end of said
5 needle and by causing the other of said pair of aligned
6 elements to bear directly against an annular back-up

7 member of said valve that is itself disposed directly
8 against said annulus.

1 8. A fluid valve made by the method of claim 1.

1 9. A fluid valve made by the method of claim 2.

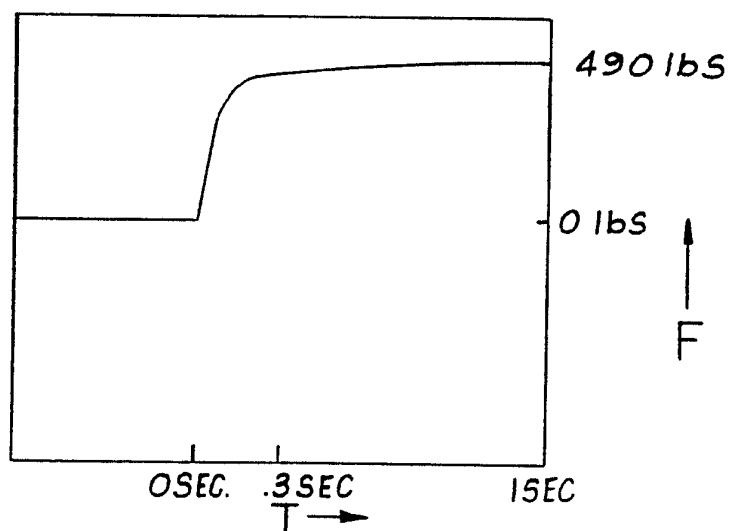
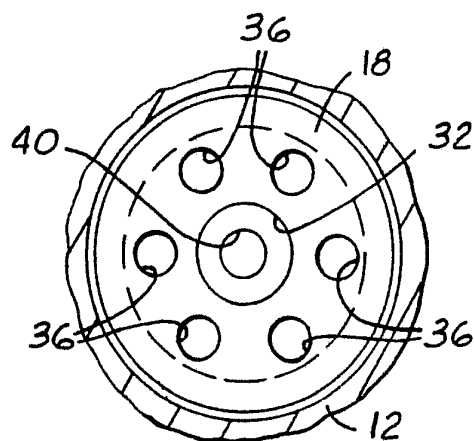
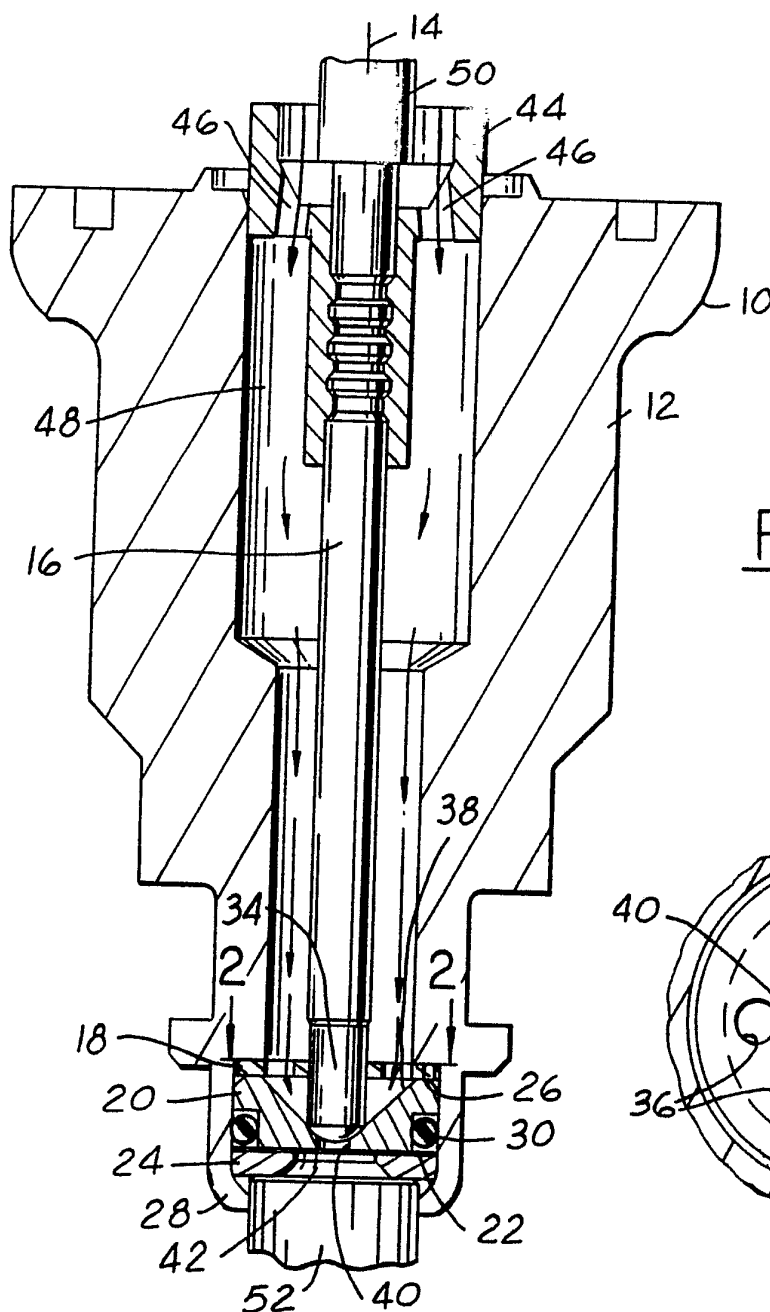
1 10. A fluid valve made by the method of claim 3.

1 11. A fluid valve made by the method of claim 4.

1 12. A fluid valve made by the method of claim 5.

1 13. A fluid valve made by the method of claim 6.

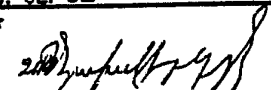
1 14. A fluid valve made by the method of claim 7.



INTERNATIONAL SEARCH REPORT

PCT/EP 91/01879

International Application No

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int.Cl. 5 F02M51/06; F02M61/18		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
Int.Cl. 5	F02M ; C21D	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	EP,A,0 216 010 (ALLIED CORPORATION) 1 April 1987 see the whole document ---	1
A	EP,A,0 219 591 (VOEST-ALPINE-FRIEDMANN) 29 April 1987 see the whole document ---	1
A	GB,A,2 058 466 (ROBERT BOSCH GMBH) 8 April 1981 see page 4, line 55 - line 129; figures 12-14 ---	1
A	US,A,4 275 844 (W.A. GRGURICH ET AL.) 30 June 1981 see column 4, line 32 - column 5, line 19; figures 1-3 ---	1
A	FR,A,972 143 (S.A.M.M.) 25 January 1951 see page 3, paragraph 3; figures 1,3 ---	1
	-/--	
¹⁰ Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
2 16 JANUARY 1992	03.02.92	
International Searching Authority EUROPEAN PATENT OFFICE	Signature of Authorized Officer HAKHVERDI M. 	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	FR,A,1 553 610 (ROBERT BOSCH GMBH) 10 January 1969 see page 3, paragraph 7 -paragraph 8; figure 1 ---	1

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.**

EP 9101879
SA 51687

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 16/01/92

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-0216010	01-04-87	US-A- 4610080 CA-A- 1264624 JP-A- 62032275	09-09-86 23-01-90 12-02-87
EP-A-0219591	29-04-87	JP-A- 62101881 US-A- 4819871	12-05-87 11-04-89
GB-A-2058466	08-04-81	DE-A- 2936425 FR-A, B 2468757 JP-B- 3043465 JP-A- 56044450 US-A- 4365747 US-A- 4481699	02-04-81 08-05-81 02-07-91 23-04-81 28-12-82 13-11-84
US-A-4275844	30-06-81	None	
FR-A-972143		None	
FR-A-1553610	10-01-69	DE-A- 1576463	21-05-70