(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 985 768 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
15.03.2000 Bulletin 2000/11

(51) Int. Cl.[7]: **E01C 19/10**, B01F 7/04, B28C 5/42

(21) Application number: **98202985.2**

(22) Date of filing: **07.09.1998**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(71) Applicant:
Talbot Technology Limited Rothamsted Research Station
Harpenden, Hertfordshire AL5 2JD (GB)

(72) Inventors:
- **Brookfield, Roger**
  Hayes UB3 2LF (GB)
- **Levett, Laurie George**
  Walton-on-Thames, Surrey KT12 2HQ (GB)

(74) Representative:
Whitaker, Iain Mark et al
Sommerville & Rushton
Business Link Building
45 Grosvenor Road
St. Albans, Hertfordshire AL1 3AW (GB)

(54) Process and apparatus for recycling asphalt

(57) An apparatus for the manufacture of hot mix asphalt (HMA) from re-cycled asphaltic pavement (RAP) comprising:-

(i) a loading hopper suitable for charging the apparatus with particulate RAP;

(ii) a processing chamber adapted to intimately mix the particulate RAP and to incorporate any additives as deemed necessary;

(iii) a heating means associated with the processing chamber, said heating means being adapted to heat the RAP in the processing chamber to a substantially uniform and workable temperature;

(iv) a discharge hopper suitable for unloading the rejuvenated product from the apparatus;

characterised in that the heating means comprises one or more short-wave infra-red heaters. The process makes use of this apparatus.

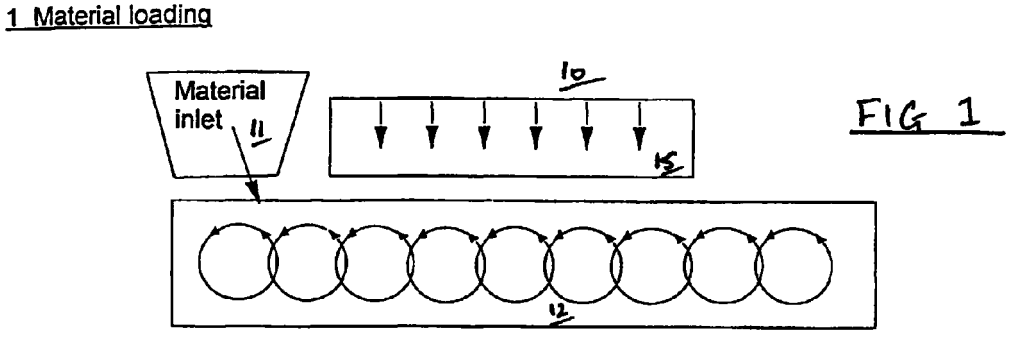

FIG 1

EP 0 985 768 A1

Description

Field of the Invention

[0001] The present invention relates to a process for recycling an asphalt surface and to apparatus for carrying out such a process. The method and apparatus is particularly applicable, but in no way limited to, the treatment of 100% reclaimed asphalt pavement.

Background to the Invention

[0002] As used herein, the term asphalt is also intended to encompass macadam and tarmac and other similar road or runway surfacing materials. Asphalt paved road surfaces typically comprise a mixture of a binder, typically a black, bitumen product, and an aggregate comprising appropriately sized stones and/or gravel. The asphalt mixture is usually laid, compressed and smoothed to provide an asphalt paved road surface.

[0003] Over time, an asphalt paved road surface can deteriorate as a result of a number of factors. For example, seasonal temperature fluctuations can cause the road surface to become brittle and/or cracked. Erosion or compacting of the road bed beneath the road surface may also result in cracking. Moreover, certain of the chemical constituents incorporated in fresh asphalt are gradually lost over time or their properties changed with time, further contributing to brittleness and/or cracking of the road surface. Where concentrated cracking occurs, pieces of pavement may become dislodged. This dislodgement can create traffic hazards, and accelerates the deterioration of adjacent pavement and highway substructure. Even if cracking and the loss of pavement pieces do not occur, the passage of traffic can polish the upper highway surface, and such a surface can be slippery and dangerous. In addition, traffic-caused wear can groove, trough, rut and crack a highway surface. Under wet highway conditions, water can collect in these imperfections and set up dangerous vehicle hydro-planing phenomena. Collected water also contributes to the further deterioration of the pavement.

[0004] Local authorities are generally responsible for the upkeep of the roads in their area. Concern with the environment along with the need to maximise the use of natural resources and conservation in general has been something that many authorities have been urging upon the general public for many years. Local authorities concerned by the ever growing mountains of rubbish and debris that they have to deal with, have encouraged salvage and recycling schemes, good examples being the salvaging of glass and paper with separate containers to deposit the items sited in strategic positions such as supermarket car parks. Sadly despite these efforts, 70% of all glass collected still ends up being dumped in a hole in the ground. Similarly it is a moot point whether the cost of salvaging paper and then re-cycling is actually worth it in terms of the energy expended in process of re-cycling the paper, there is a body of opinion that suggests it would be better to incinerate the paper to create energy. Industry has long been cynical of the benefits of re-cycling, holding that re-cycling was expensive and the resulting product would never be as good as one made from virgin materials.

[0005] The civil engineering, road building and repair industries have come under pressure from the "Green" lobby to conserve resources. Used asphalt and macadam retains many of the characteristics of the new material, and is eminently suitable for re-cycling, the only element that degrades is the bitumen. However, the industry, held that it was cheaper to quarry new stone than to re-cycle existing material.

[0006] In recent times there has been a change of attitude, in the main this has been forced upon the industry by circumstances. It is no longer a cheap option to simply tip debris into land-fill sites. In the 1995 budget a tax of £7.00 per tonne on tipping building waste into land-fill sites was imposed, this came into force in October 1996, and asphalt and macadam are classed under the regulation as building waste. In addition a further premium is levied because the bitumastic content of the material is held to be calcogenic. Special precautions have to be taken to ensure that it does not leech out into the water table. A further incentive to re-use the material has come about because of successive squeezing of Local Authority budgets on road building and repair, and many road building projects have been abandoned. The councils are now having to look at ways of maintaining their roads within very limited budgets.

[0007] In the past, there have been several attempts to achieve workable methods and apparatus for re-cycling asphalt. For example, PCT/CA 93/00069 (Artec Equipment Company Limited) describes a great deal of the background art and the text thereof is imported herein by reference. This PCT patent application describes a method of re-cycling asphalt in situ involving heating the ruptured asphalt with gas-fired infra-red heaters prior to re-compacting.

[0008] EP 0440423 (Cyclene Limited) describes an apparatus for the treatment of 100% re-cycled asphalt pavement (RAP). The RAP is first heated using a gas burner followed by down stream treatment with microwave radiation. The re-processing process takes place in a counter-flow rotating drum heater.

[0009] These two references, and the apparatus therein described, represent the closest prior art known to the applicant.

[0010] Although the conventional mixing plants are able to add a percentage of re-cycled material, typically 10%, to the mix of virgin material, in certain types of plant this can be increased to 30%. None of the conventional mixing plants appear capable of dealing with re-cycling 100% of salvaged material.

[0011] Most asphalt plants can be considered portable, the degree of portability being limited more by the

time involved in dismantling and re-building than by dependence on mains services. Several of the patents reviewed describe applications which appear to be concerned with mobile plant, either mounted directly upon the vehicle or towed.

[0012] Heating, where stated as mobile, the heating equipment is almost certainly some form of gas heating, butane, propane or possibly gas oil. On static plant, steam heating has sometimes been employed, other methods have included micro-wave as a heating source. In some cases reference is made to employing gas fired medium wave infra-red, this at the low end of the medium wave spectrum and is probably employed to apply heat directly to the road surface for small scale repair patching operations.

[0013] With the exception of the cyclene system (see above) which uses gas heating to bring the material upto an intermediate temperature and then switches to micro-wave to bring it to full temperature and which the applicants believe can process 100 tons per hour, none of the prior art systems state a capability to process a given amount of material per hour. It is fair comment to assume that with exception mentioned nearly all of the applications are for low level re-cycling, and relate primarily to patching operations.

[0014] All of the current equipment on offer have significant limitations for economic re-cycling of asphalt and macadam's, in some cases the equipment has been deliberately targeted at small scale mobile on-site operations. Other innovations which use either steam or hot air as the heat source between an outer and inner drum suffer progressively from lack of efficiency as the material produces a coking effect when hot and sticks to the sides of the drum. The equipment needs frequent cleaning during a day's operations.

[0015] The most effective system known to the applicant is produced by Cyclene which uses gas heating to bring the material upto an intermediate temperature of 105 degrees centigrade and then switches over to micro-wave heating to bring the material to the optimum temperature of approximately 150 degrees centigrade. This unit is contained within three standard TRU containers for transport and is capable of producing 100 tonnes of material per hour and typically can convert between 700 and 1000 tonnes per day. The drawbacks of this system are the high cost of micro-wave equipment, typically the cost of the magnetrons for this unit would be in the order of £2.5 million, the life of a magnetron is limited to 5000/6000 hours then they have to be replaced. Because of the use of microwave radiation, it is not possible to use a conventional steel conveyor and the belt has to be replaced with a special high temperature PVC material which because of the abrasiveness of the material requires frequent changes, is expensive and difficult to obtain. There are also concerns about the possible environmental hazards posed by the use of high power micro-wave systems. These are at present unproven and, when coupled to the high cost of micro-wave equipment, there is a reluctance to invest in these systems.

[0016] It is the object of the present invention to overcome or at least mitigate some or all of the above problems.

Summary of the Invention

[0017] According to a first aspect of the present invention, there is provided an apparatus for the manufacture of hot mix asphalt (HMA) from re-cycled asphaltic pavement (RAP) comprising:-

(i) a loading hopper suitable for charging the apparatus with particulate RAP;

(ii) a processing chamber adapted to intimately mix the particulate RAP and to incorporate any additives as deemed necessary;

(iii) a heating means associated with the processing chamber, said heating means being adapted to heat the RAP in the processing chamber to a substantially uniform and workable temperature;

(iv) a discharge hopper suitable for unloading the rejuvenated product from the apparatus;

characterised in that the heating means comprises one or more short-wave infra-red heaters.

[0018] Short-wave infra-red heaters have proved significantly more effective at heating through the RAP without over-heating or carbonising the bitumen binder.

[0019] Preferably the short-wave infra-red heaters are electrically powered.

[0020] Preferably the processing chamber further comprises a series of rotatable paddles adapted to both mix the RAP and to progress the mixture along the processing chamber.

[0021] In a particularly preferred embodiment, the paddles are mounted on rotatable shafts, the shafts being in substantially parallel, non-coaxial corresponding end alignment inside the processing chamber, the axis of said shafts being substantially perpendicular to the longitudinal axis of the processing chamber. The paddles can be akin to the paddles on a water wheel or paddle boat and thus provide intimate mixing or the RAP mixture.

[0022] Preferably, alternate shafts are adapted to both counter-rotate and co-rotate during different phases of the regenerating process under the control of the operator.

[0023] This is an important feature of the invention. By co-rotating the paddles, the RAP mixture can be made to progress along the process chamber in either direction. By counter-rotating the paddles, the mixture will remain within the process chamber and intimate mixing will take place.

[0024] Preferably the radii swept out by the adjacent rotating paddles overlap one with another.

[0025] According to a second aspect of the present invention, there is provided a process for re-cycling the upper surface of an asphalt pavement comprising the steps of:-

(a) providing a source of particulate RAP;

(b) providing an apparatus as described in the first aspect of the present invention

(c) loading said particulate RAP into said apparatus;

(d) mixing RAP and adding rejuvenating compounds and/or additional bitumen binder as necessary;

(e) heating said RAP to the desired working temperature;

(f) discharging said RAP from the processing chamber.

[0026] The RAP treatment process of this invention results in the production of high grade asphalt from waste material with very low or no substantial pollution of the air. This is an important consideration when operating in urban areas such as town on city centres.

[0027] The invention will now be described, by way of example only, with reference to the accompanying drawings wherein:-

Figures 1 to 3 illustrate in diagrammatic form the loading, heating and unloading/discharge phases of the present invention.

Description of the Preferred Embodiments

[0028] The present invention will now be described by way of example only. These are not the only ways of putting the invention into practice but represent the best ways known to the applicant.

[0029] Figures 1 to 3 illustrate diagramatically the type of apparatus and process involved. Reclaimed asphalt pavement (RAP) is obtained from any suitable source. This may be from directly adjacent the apparatus or from a variety of sources which are brought to a central processing point. Material is loaded into the apparatus generally defined as 10 through an inlet hopper 11. The hopper mechanism is of a type known per se and may incorporate any suitable funnelling arrangement and valve features as would be incorporated by a person skilled in the art.

[0030] The inlet hopper 11 leads to a first end of a processing chamber 12, which according to a first aspect of the invention, this chamber can be of a wide variety of types such as a rotating drum processor.

[0031] The processing chamber is adapted to intimately mix the RAP during the heating process and to evenly distribute any rejuvenated compound(s) and additional bitumen material. Once completely mixed and heated to the required operating temperature, the material progresses to the exit or second end of the processing chamber and to a discharge hopper generally shown as 14.

[0032] A heating means (15) is provided either in or associated with a processing chamber. In the first aspect of the invention, the heating means comprises a battery of short wave infra-red heaters. Typically wave lengths for the infra-red radiation are between 0.9 to 1.2 nm in wave length for short wave radiation and 1.2 to 3.6nm for medium wave radiation.

[0033] It has unexpectedly been discovered that by using short, or very short wave infra-red radiation, the tendency for the surface of the asphalt to deteriorate by overheating or charring is very much reduced when compared to other forms of heating. The infra-red radiation tends to heat the material from the inside out and therefore tends to bring the whole contents of the processing chamber up to the desired temperature in an even fashion, providing that efficient mixing is achieved.

[0034] One of the major problems with re-activating asphalt is that it is difficult to re-heat the material to obtain a workable product without causing appreciable degradation to the bitumen binder, plasticiser and other organics. These difficulties can be overcome by using short wave infra-red radiation with, or without, a conventional pre-heat using gas burners, steam or the like.

[0035] In certain circumstances, medium wave infra-red emitters can be used. In any event, short and medium wave infra-red is a form of dielectric heating and provides a much more acceptable alternative to micro waves.

[0036] Short wave infra-red emitters are commercially available and a suitable type can be obtained from Heraeus Ltd.

[0037] Advantageously, a bank of infra-red heaters are mounted over a conveyor system which both transports and mixes the material being processed, ensuring that the material is heated evenly. In the second aspect of this invention, the conveying means comprises a series of rotatable paddles much as would be found on a paddle steamer. Typically, these consist of two or more blades or paddles mounted on and displaced from a central shaft. The shafts are mounted substantially parallel to each other transverse to, and along the length of, the processing chamber. The shafts are, in effect, in substantially parallel, non-coaxial corresponding end alignment with their axes substantially perpendicular to the longitudinal axis of the processing chamber. Most advantageously, the arcs described by rotation of adjacent paddles overlap. The adjacent paddles are prevented from fouling each other by a gear mechanism used to drive them in harmony.

[0038] The gear mechanism can be of any conventional type and may comprise any suitable arrangement of motor(s), gears, belts, pulleys, clutches and the like.

[0039] It will be appreciated from figures 1 to 3 that if all the paddles are rotated in the same direction, (see figure 1) then the RAP will be transported along the processing chamber towards the discharge hopper. However, if alternate paddles rotate in different directions, i.e. the paddles rotate clockwise, anti-clockwise, clockwise in turn, then the RAP load will be mixed without any significant overall movement towards either end of the processing chamber. In this aspect, the gearing arrangement associated with the paddles is such that the operator can switch between uni-rotation and alternating contra rotation at will. Gearing mechanisms that can achieve this are known per se. One simple method is to have the two types of gearing, one on each end of the paddle drive shafts. Applying motive power to the one respective end of each shaft while allowing the other respective end to free-wheel results in the desired effect.

[0040] In summary, we have identified an effective alternative to micro-waves which although costly until now seemed to be the only viable system for large scale re-cycling. In addition we have devised a system which is cost effective, has minimal environmental impact and can be sited virtually anywhere that has access to a three phase 415 volt supply. We have also considered variants which can be powered from a portable motor generator set.

[0041] Our research indicated that short-wave and in certain applications medium wave infra-red emitters could be employed for the purpose. This form of radiation has similar characteristics to micro-wave, and is used extensively by industry for drying paint, curing adhesives, paper making, copying and in the food industry for sealing prepared food before freezing. In comparison with micro-wave, it has the following advantages:-

1) it is a fraction of the cost;
2) the life of the emitters are typically in excess of 10000 hours; and
3) apart from the normal safety precautions there are no specific health hazards.

[0042] In our innovation, which accepts 100% recycled material, we have combined shod-wave and ultra short-wave or for certain application medium wave infra-red emitters. The amount of heat applied can be varied to suit the material to be processed. The innovation can be used for either batch or continuous process. The heating system is mounted above a conveyor system which both transports and mixes the material being heated ensuring the material is evenly heated throughout to the required temperature without degrading the bitumen content. Both the mixing action and transport speed are infinitely variable allowing the processor to accommodate all types of asphalt's and macadam's. the material is fed from a loading hopper into the processor and before it is loaded into a heated storage hopper, the material is passed through a second mixing chamber where if necessary rejuvenator is added to the mix in measured amounts then thoroughly mixed before it is put into the storage hoppers.

Claims

1. An apparatus for the manufacture of hot mix asphalt (HMA) from re-cycled asphaltic pavement (RAP) comprising:-

(i) a loading hopper suitable for charging the apparatus with particulate RAP;

(ii) a processing chamber adapted to intimately mix the particulate RAP and to incorporate any additives as deemed necessary;

(iii) a heating means associated with the processing chamber, said heating means being adapted to heat the RAP in the processing chamber to a substantially uniform and workable temperature;

(iv) a discharge hopper suitable for unloading the rejuvenated product from the apparatus;

characterised in that the heating means comprises one or more short-wave infra-red heaters.

2. An apparatus as claimed in claim 1, wherein the short-wave infra-red heaters are electrically powered.

3. An apparatus as claimed in claim 1 or claim 2, wherein the processing chamber further comprises a series of rotatable paddles adapted to both mix the RAP and to progress the mixture along the processing chamber.

4. An apparatus as claimed in claim 3, wherein the paddles are mounted on rotatable shafts, the shafts being in substantially parallel, non-coaxial corresponding end alignment inside the processing chamber, the axis of said shafts being substantially perpendicular to the longitudinal axis of the processing chamber.

5. An apparatus as claimed in claim 4, wherein alternate shafts are adapted to counter-rotate and co-rotate during different phases of the regenerating process under the control of the operator.

6. An apparatus as claimed in claim 3, 4 or 5, wherein the radii swept out by the adjacent rotating paddles

overlap one with another.

7. A process for re-cycling the upper surface of an asphalt pavement comprising the steps of:-

(a) providing a source of particulate RAP;

(b) providing an apparatus as claimed in any preceding claim.

(c) loading said particulate RAP into said apparatus;

(d) mixing RAP and adding rejuvenating compounds and/or additional bitumen binder as necessary;

(e) heating said RAP to the desired working temperature;

(f) discharging said RAP from the processing chamber.

1 Material loading

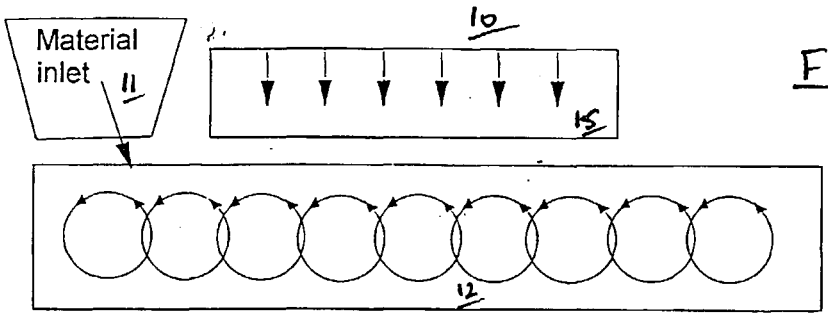

FIG 1

2 Heating phase

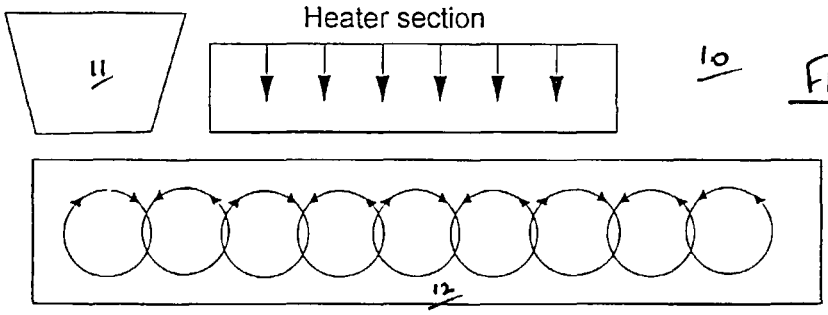

FIG 2

3 unloading phase

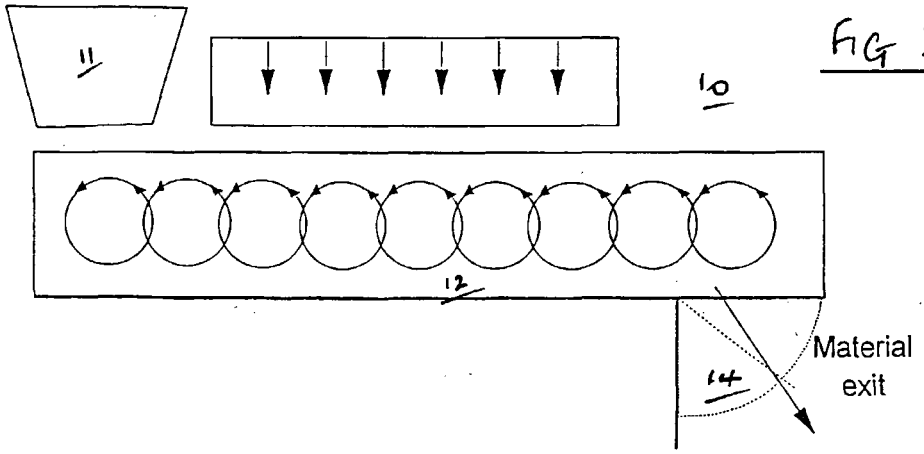

FIG 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 20 2985

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 Y	EP 0 146 939 A (DEUTAG MISCHWERKE GMBH) 3 July 1985 * the whole document *	1,2,7 3,4	E01C19/10 B01F7/04 B28C5/42
Y	US 2 626 875 A (CONNAUGHAY) 27 January 1953 * the whole document *	3,4	
X	GB 2 115 711 A (TRAVIS BEN) 14 September 1983 * the whole document *	1,2,7	
A	EP 0 465 766 A (HERAEUS QUARZGLAS) 15 January 1992 * abstract; figure 1 *	1,2	
A	US 4 797 080 A (WANNINGER PETER) 10 January 1989 * abstract; figure 1 *	6	
A	US 3 778 032 A (MILLING T) 11 December 1973 * figures 1-3 *	4,6	TECHNICAL FIELDS SEARCHED (Int.Cl.6) E01C B01F B28C
E	GB 2 325 176 A (TALBOT TECHNOLOGY LIMITED) 18 November 1998 * the whole document *	1-7	
A	DE 863 470 C (BRENN)		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26 January 1999	Dijkstra, G

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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 20 2985

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European 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.

26-01-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0146939 A	03-07-1985	DE 3347370 C	23-05-1985
		DK 620284 A	30-06-1985
US 2626875 A	27-01-1953	NONE	
GB 2115711 A	14-09-1983	NONE	
EP 0465766 A	15-01-1992	DE 4022100 C	24-10-1991
US 4797080 A	10-01-1989	DE 3519349 A	04-12-1986
		EP 0203260 A	03-12-1986
US 3778032 A	11-12-1973	NONE	
GB 2325176 A	18-11-1998	NONE	
DE 863470 C		NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82