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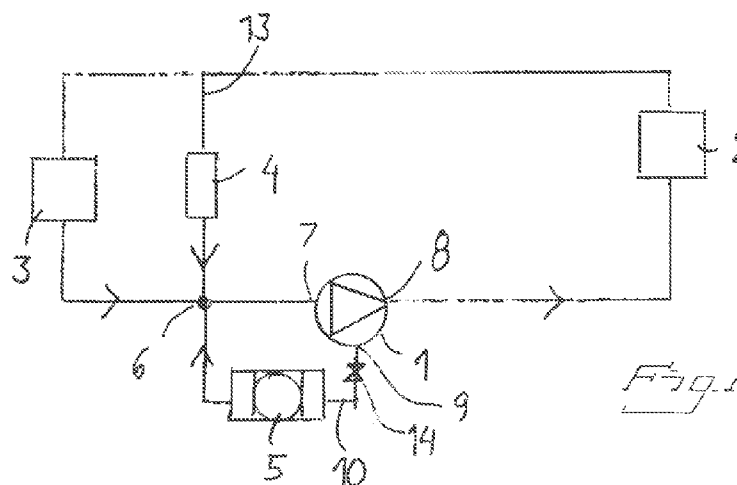
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(54) Title: COOLING SYSTEM FOR LIQUID COOLING OF A COMBUSTION ENGINE



(57) Abstract: The invention relates to a cooling system for liquid cooling of a combustion engine. The system comprises an engine block (2) with cooling ducts, a radiator (3) and a coolant pump (1) of centrifugal type. A line circuit connects these components to one another to form a closed circuit for circulation of coolant. According to the invention, the coolant pump (1) is provided with a secondary outlet aperture (9) adapted to separating a partial flow from the coolant. A return line (10) connects the secondary outlet aperture (9) to the line circuit at a point (6) situated after the engine block (2) but before the coolant pump (1) in the coolant flow direction. A particle filter (5) is provided in the return line (10).

COOLING SYSTEM FOR LIQUID COOLING OF A COMBUSTION ENGINE

Field of the invention

5 The present invention relates to a cooling system for liquid cooling of a combustion engine, which cooling system comprises an engine block provided with cooling ducts, a radiator, a coolant pump of centrifugal type provided with inlet aperture and outlet aperture, and a line circuit connecting said components in a closed circuit for circulation of coolant.

10 The invention relates also to a vehicle provided with such a cooling system.

Background to the invention

 The engine block for a combustion engine is usually made by casting, particularly in the case of a combustion engine in a motor vehicle. The
15 casting process results in the presence of particles from the foundry sand in, inter alia, the cooling ducts of the engine block. Particles also become attached to the duct walls by burning on. Despite thorough cleaning of the ducts after the casting process, particles remain in the engine's coolant even
20 after long operation. Complete elimination of particles from the engine block ducts is impossible with today's casting and cleaning methods.

 During operation of the engine, remaining particles circulate in the coolant circuit and burnt-on particles become detached throughout the engine's service life. Particles accumulate in regions where there is low flow
25 velocity. This may hinder cooling.

 The thermostat of the cooling system is very sensitive to particles in the coolant. When the thermostat closes from an open position, particles become caught in the narrow gap between valve disc and valve seat, preventing full closure of the valve. This causes the engine to be cooled by
30 coolant leaking out in the radiator despite there being no cooling requirement. This may result in the engine not reaching normal coolant temperature when

there is a low outside temperature and the engine load is low. A further result is that the engine's warm-up time from cold is unnecessarily long.

The thermostat is also provided with a valve disc for control of coolant flow to the bypass line. If this valve disc does not close completely because
5 of particles in the valve seat, it means that part of the coolant will bypass the radiator without being cooled, thereby impairing the vehicle's cooling performance.

One way of dealing with the problem is to provide the cooling circuit with a particle filter just before the thermostat. This entails increased
10 pressure drop in the circuit, with impaired cooling performance or increased pump power requirement. It is therefore a disadvantageous solution.

Another way is to provide the coolant circuit with a filter situated in a partial flow circuit. It then takes a very long time for all of the coolant to pass the filter. There is no assurance that particles becoming detached will
15 immediately be captured in the filter.

A way of effectively separating the particles from the coolant is to use a rotary separator according to the state of the art. Such a separator will deliver a particle-enriched partial flow. The partial flow containing the particles may thereafter pass a particle filter in which they are captured.
20 Such a separator requires some form of mechanical drive.

Cyclone cleaners of centrifugal type are known per se from, for example, GB 1352 655, GB 2210 297A, US 3 516 551 and 4 033 877.

GB 1352655 describes a centrifugal pump with a device for separation of particles from the liquid. The separation is effected, however, by the liquid
25 being forced to change direction sharply after it has been pressurised by the pump impeller. The change of direction is from the periphery of the pump to a space within the impeller via a filter. This device does not result in a simple and, at the same time, effective way of separating solid particles. It is mainly intended as a fuel pump in aircraft and is not advantageous for separation of
30 particles of the kind which arise from foundry sand.

GB 2 210 297A describes a mechanically driven centrifugal cleaner with no pump action, which is intended to cooperate with a centrifugal pump fitted as a separate unit.

5 US 3 516 551 describes a traditional cyclone cleaner entirely separated from a pump.

US 4 033 877 describes a cyclone cleaner co-assembled with a pump in a single housing. The pump's centrifugal action is not directly combined with the cyclone function.

10 None of the devices described in those specifications is suitable for use in a cooling system of the kind to which the invention relates, and none of them describes any such system.

Summary of the invention

15 The stated object is achieved by a cooling system of the kind indicated in the introduction having the special features that the coolant pump is provided with a secondary outlet aperture adapted to separating a partial flow from the coolant and that a return line connects the secondary outlet aperture to the line circuit at a point situated after the engine block but before the coolant pump in the coolant flow direction, in which return line a particle filter
20 is provided.

The invention thus entails the engine's coolant pump being used as a cyclone cleaner for the coolant. In the pump's outlet volute, the particles accumulate at its outer periphery by centrifugal action. A partial flow with enriched particles is drawn from the pump close to the outlet of the volute.
25 The partial flow passes thereafter a particle filter before being returned to the cooling circuit at a suitable point upstream of the pump.

The coolant will thus be quickly and effectively relieved of the contaminating particles so that the disadvantages arising from a liquid which contains particles are eliminated. Unlike the traditional solutions, the solution
30 according to the invention involves neither any major pressure drop in the coolant circuit nor the need for separate devices for the separation.

Compared with conventional filtration of a partial flow, the particles are eliminated far more quickly and completely.

According to a preferred embodiment, the point at which the secondary outlet aperture is connected is situated after the radiator in the coolant flow direction.

Maximum pressure drop across the particle filter provided in the return line is thus achieved, and hence the separation becomes as effective as possible and the interval at which filter changing becomes necessary is maximised.

According to a further preferred embodiment, the particle filter has a mesh size adapted to separation of foundry sand.

As particles from foundry sand are the most significant solid contaminant in the coolant, it is particularly advantageous that the mesh size of the filter be adapted specifically to these particles.

According to a further preferred embodiment, the mesh size is of the order of 0.01 to 0.1 mm.

The particle size for foundry sand for engine blocks is usually of such a kind that the smallest particles have a size of about 0.05 mm, so the range indicated is an advantageous adaptation thereto. Large mesh size entails risk of too many of the particles passing the filter, whereas small mesh size increases the pressure drop across the filter. The range indicated is a balanced compromise between these two aspects. Mesh size within the range 0.03 to 0.07 mm is particularly advantageous with regard to this balance.

According to a further preferred embodiment, the coolant pump comprises an outlet volute situated radially outside the pump impeller and bounded by two sidewalls and an outer wall which runs between these latter and whose radial distance from the impeller axis increases in the flow direction, the secondary outlet aperture being situated in said outer wall.

An outlet volute thus configured and the secondary outlet aperture situated in its outer wall result in optimum flow conditions for separation of the particle-enriched coolant fraction by maximum utilisation of the pump's

centrifugal action which causes the particles to move out towards the periphery.

According to a further preferred embodiment, the secondary outlet aperture is situated a short distance before the coolant pump's outlet
5 aperture in the flow direction.

The nearer the secondary outlet aperture is situated to the outlet aperture, the longer the time during which the particles will be acted upon by the centrifugal force and the more significant the particle enrichment of the radially outer layer of liquid will therefore become. A late-situated secondary
10 outlet aperture is therefore most effective from the separation perspective. Short distance means quite adjacent to the outlet aperture or a distance from it which is less than 20% of the extent of the outlet run in the circumferential direction, preferably less than 10%.

According to a further preferred embodiment, the coolant pump is
15 provided with guide means adapted to guiding a partial flow towards the secondary outlet aperture.

The effect of the centrifugal force is thus boosted so that the separation becomes still more effective.

According to a further preferred embodiment, the guide means takes
20 the form of a radially directed wall portion disposed on the outer wall and situated after the secondary outlet aperture but before the coolant pump outlet aperture in the flow direction.

A guide means configured in this way will halt the radially outer fraction which contains the particles and redirect the flow effectively out
25 through the secondary outlet aperture.

According to a further preferred embodiment, the secondary outlet aperture is dimensioned for a flow corresponding to 2 to 5 % of the total flow through the coolant pump.

The magnitude indicated for the flow which is separated is a balanced
30 compromise intended, on the one hand, to ensure that the separated flow is great enough to separate an advantageously large proportion of the particles

and, on the other hand, to keep down the energy loss involved in recirculation of coolant.

According to a further preferred embodiment, the system is provided with a regulating device for regulating the flow through the return line.

5 The amount which is separated can thus be adapted to the respective conditions. The amount of residual particles from the foundry sand may vary somewhat depending on how the casting process is conducted and the dimensions of the engine block's cooling ducts. The regulating device makes it possible for the flow to be optimised in this respect. The amount of
10 particles also decreases progressively during operation of the cooling system, so the amount of liquid which needs to be separated decreases over time. The regulating device affords the possibility of adapting the separation with regard also to this time aspect. If the amount of particles dwindles to almost nil, the regulating device may be set to halt the flow completely.

15 According to a further preferred embodiment, the cooling system comprises a thermostat situated in a bypass line from the line circuit, which bypass line has an outlet situated at the same point in the line circuit as the return line's connection to the line circuit.

A cooling system of the respective kind is usually provided with a
20 thermostat situated in a bypass line. As described in the introduction, the thermostat is one of the components which are sensitive to malfunctions due to particles in the coolant. The invention is therefore of particular relevance in a cooling system with a thermostat thus situated. Connecting both the bypass line outlet and the return line outlet at the same point also results in
25 simplified line layout.

The preferred embodiments indicated above of the invented cooling system are indicated in the claims which depend on claim 1.

The invention relates also to a motor vehicle provided with a cooling system according to the invention, particularly according to any of its
30 preferred embodiments.

The invented motor vehicle affords advantages of similar kinds to the invented cooling system and its preferred embodiments described above.

The invention is further explained by the detailed description set out below of an embodiment example with reference to the accompanying drawings.

5 **Brief description of the drawings**

Fig.1 illustrates an example of a cooling circuit according to the invention.

Fig. 2 is an exploded view in perspective of the coolant pump in the cooling circuit in Fig. 1.

10 Fig. 3 is a side view of part of the outlet volute of the pump in Fig. 2.

Figs. 4-6 are side views corresponding to that in Fig. 3 and illustrating alternative arrangements for the pump's secondary outlet aperture.

15 **Description of embodiment examples**

Fig. 1 illustrates schematically a cooling circuit for cooling a liquid-cooled engine in a motor vehicle. The centrifugal pump 1 circulates the coolant from its outlet aperture 8 to the cooling ducts in the engine block 2, thence to the radiator 3 and thereafter back to the inlet aperture 7 of the pump 1. Parallel with the radiator, a thermostat 4 is provided in a bypass line
20 13.

The centrifugal pump is provided with a secondary outlet aperture 9 which in a return line 10 leads part of the pumped coolant back to the cooling circuit at a point 6 between the radiator 3 and the pump 1.

25 In the return line, a particle filter 5 is provided to separate solid particles from the partial flow which leaves the pump 1 via its secondary outlet aperture 9. The particle filter is adapted to separating grains of foundry sand which accumulate or become caught in the cooling ducts of the engine block 2 as described in the introduction. Its mesh size is therefore with
30 advantage about 0.05 mm, corresponding to the smallest grain size of the sand grade commonly used in engine block casting.

In the return line 10 in the example depicted a regulating device 14, e.g. a throttle valve, is provided. Such a regulating device can be used to regulate the amount of the partial flow which is led back through the return line 10. A regulating function may alternatively be achieved by making the size of the secondary outlet aperture 9 variable or by variably shielding the aperture. The regulating device 14 may be configured for manual setting or be acted upon automatically by a sensor which detects the particle concentration in the coolant at a suitable point in the cooling circuit.

The exploded view depicted in Fig. 2 of the centrifugal pump 1, in which its impeller is omitted for greater clarity, illustrates how the secondary outlet aperture 9 may be arranged. It is situated at the end of the outlet volute 11 just before the ordinary outlet aperture 8. Liquid enters the pump through the inlet aperture 7 which communicates with the line from the radiator. In the outlet volute 11, the particles will be hurled by centrifugal force out towards the peripheral outer wall. When the coolant reaches the secondary outlet aperture 9, its fraction which contains the particles will be pushed out through this aperture and through the return line 10 to the particle filter 5 (see Fig. 1). The particles are separated in the filter 5 and the filtered coolant is transferred to the inlet of the pump. The main flow of coolant, which will be free from, or contain a relatively small concentration of, particles will flow out through the centrifugal pump's ordinary outlet aperture 8 and thence to the engine block.

Fig. 3 illustrates more clearly how the secondary outlet aperture 9 is situated relative to the pump's ordinary outlet aperture 8.

Fig. 4 illustrates an alternative embodiment example in which the secondary outlet aperture 9a is situated on the sidewall of the outlet volute, at the latter's radially outermost portion. With advantage, such an outlet aperture is provided on each of the two sidewalls. It is of course possible to combine the examples according to Figs. 2 and 3 and to have both a radial secondary outlet aperture 9 and axial secondary outlet apertures 9a.

The secondary outlet aperture may, as indicated by the examples in Figs. 5 and 6, be provided with guide means to boost the separation of the

coolant fraction which contains the particles. In Fig. 5, the guide means takes the form of a step 12 in the outer wall of the outlet volute 11 just after the secondary outlet aperture. In Fig. 6, the guide means takes the form of a short flange 12a directed inwards at a corresponding location.

CLAIMS

1. A cooling system for liquid cooling of a combustion engine, which cooling system comprises an engine block (2) provided with cooling ducts, a radiator (3), a coolant pump (1) of centrifugal type provided with impeller, inlet aperture (7) and outlet aperture (8), and a line circuit connecting said components (1, 2, 3) in a closed circuit for circulation of coolant, **characterised** in that the coolant pump (1) is provided with at least one secondary outlet aperture (9, 9a) adapted to separating a partial flow from the coolant and that a return line (10) connects the secondary outlet aperture (9, 9a) to the line circuit at a point (6) situated after the engine block (2) but before the coolant pump (1) in the coolant flow direction, in which return line (10) a particle filter (5) is provided.
2. A cooling system according to claim 1, **characterised** in that said point (6) is situated after the radiator (3) in the coolant flow direction.
3. A cooling system according to claim 1 or 2, **characterised** in that the particle filter (5) has a mesh size adapted to separation of foundry sand.
4. A cooling system according to claim 3, **characterised** in that the mesh size is within the range 0.01 – 0.1 mm.
5. A cooling system according to any one of claims 1-4, **characterised** in that the coolant pump (1) comprises a outlet volute (11) situated radially outside the pump impeller and bounded by two sidewalls and an outer wall which runs between the latter and whose radial distance from the impeller centreline increases in the flow direction, the secondary outlet aperture (9) being situated in said outer wall.

6. A cooling system according to any one of claims 1-5, **characterised** in that the secondary outlet aperture (9) is situated a short distance before the outlet aperture (8) of the coolant pump (1) in the flow direction.
- 5 7. A cooling system according to any one of claims 1-6, **characterised** in that the coolant pump (1) is provided with guide means (12, 12a) adapted to guiding a partial flow towards the secondary outlet aperture (9, 9a).
8. A cooling system according to claim 7, **characterised** in that the guide
10 means (12, 12a) takes the form of a wall portion directed radially (12, 12a), disposed on the outer wall and situated after the secondary outlet aperture (9) but before the coolant pump outlet aperture (8) in the flow direction.
9. A cooling system according to any one of claims 1-8, characterised in
15 that the secondary outlet aperture (9) is dimensioned for a flow corresponding to 2 to 5% of the total flow through the coolant pump (1).
10. A cooling system according to any one of claims 1-9, **characterised** in
20 that the system is provided with a regulating device (14) for regulating the flow through the return line (10).
11. A cooling system according to any one of claims 1-10, **characterised**
in that the cooling system comprises a thermostat situated in a bypass line (13) from the line circuit, which bypass line (13) has an outlet situated at the
25 same point in the line circuit as the connection of the return line (10) to the line circuit.
12. A vehicle provided with a cooling system according to any one of
30 claims 1-11.
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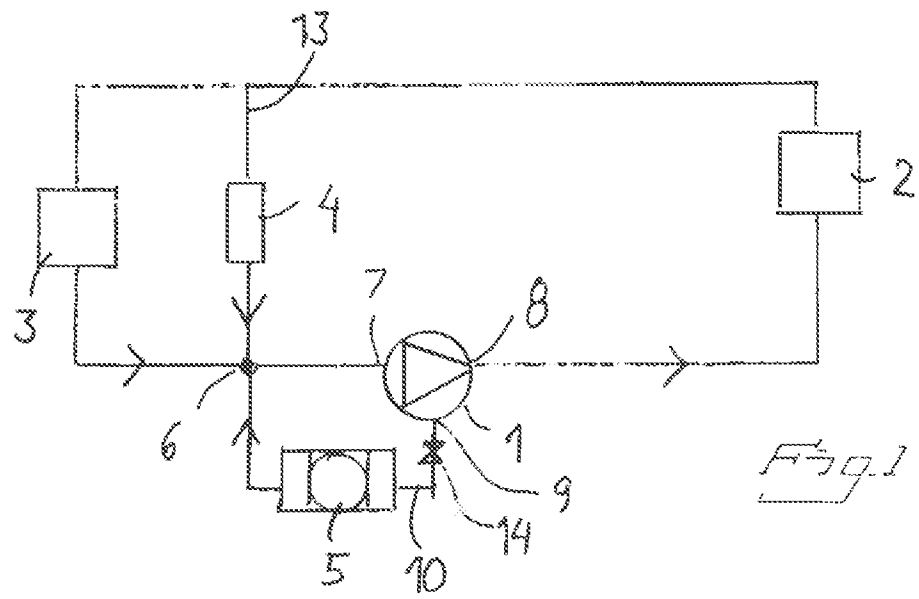


Fig. 1

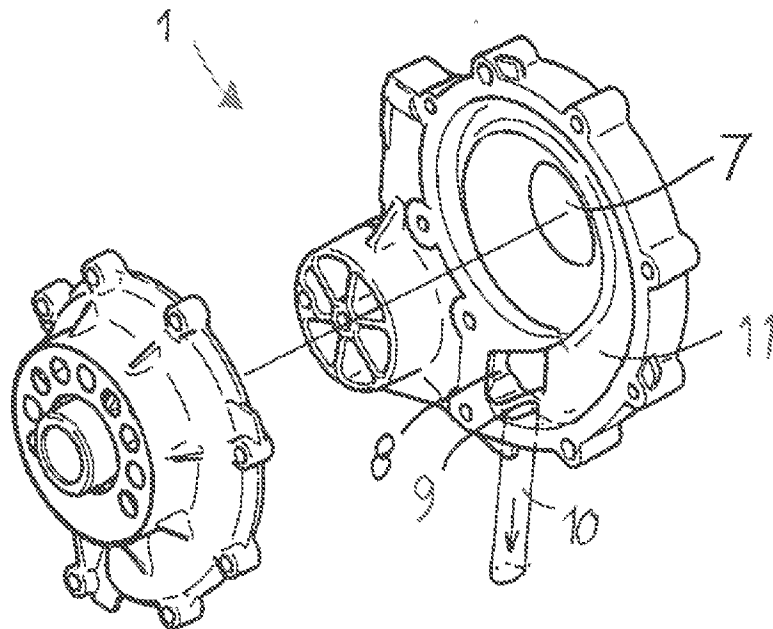


Fig. 2

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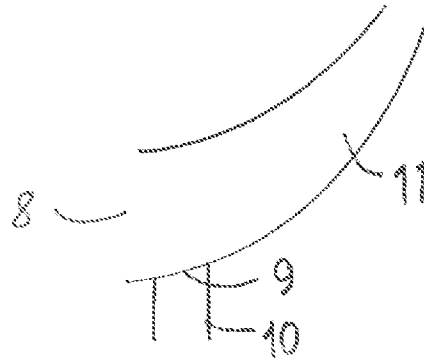


Fig. 3

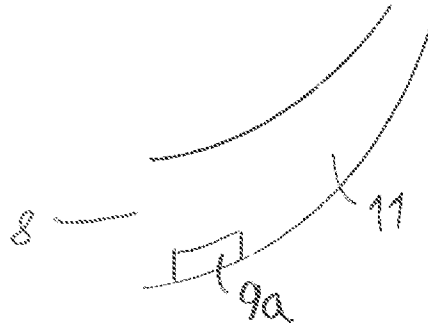


Fig. 4

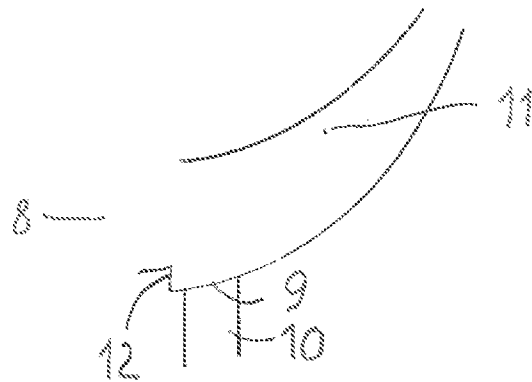


Fig. 5

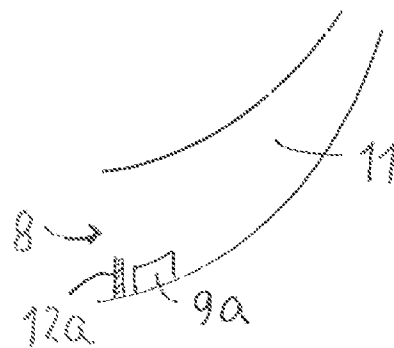


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE2010/050050

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: F01P, F04D, B01D

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)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3002624 A (J.A. VETTEL, SR. ET AL), 3 October 1961 (03.10.1961), column 1, line 11 - line 24; column 1, line 49 - line 51; column 2, line 7 - column 3, line 11, figure 3 --	1,2,5,6,10, 12
P,A	US 20090194061 A1 (W. ARDES), 6 August 2009 (06.08.2009), figures 2,3, abstract, paragraphs (0011), (0018)-(0022) --	1-12
A	US 3186513 A (J.T.E. DUNN ET AL), 1 June 1965 (01.06.1965), column 3, line 42 - line 66, figure 1 --	1-12

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE2010/050050

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5753116 A (D. BAUMANN ET AL), 19 May 1998 (19.05.1998), abstract --	1-12
A	US 3949578 A (R.L. HELDRETH), 13 April 1976 (13.04.1976), figures 1,2, claim 1, abstract -- -----	1-12

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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