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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 :		(11) International Publication Number:
F16D 65/12, 69/00	A1	WO 89/09889
		(43) International Publication Date: 19 October 1989 (19.10.89)

(21) International Application Number: PCT/DK89/00080

(22) International Filing Date: 7 April 1989 (07.04.89)

(30) Priority data:
1891/88 7 April 1988 (07.04.88) DK

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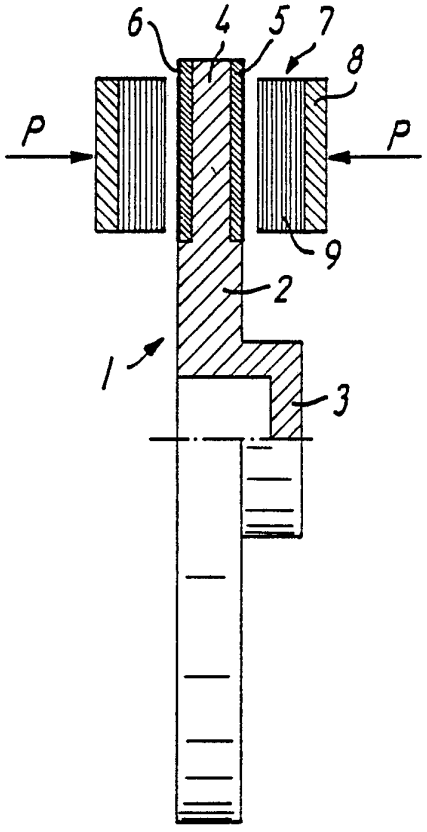
(81) Designated States: AT, AT (European patent), AU, BE (European patent), BR, CH, CH (European patent), DE (Utility model), DE (European patent), DK, FI, FR (European patent), GB, GB (European patent), HU, IT (European patent), JP, KP, KR, LU (European patent), NL, NL (European patent), NO, SE, SE (European patent), SU, US.

Published
With international search report.
In English translation (filed in Danish).

(54) Title: DISc BRAKE DEVICE FOR AUTOMOBILES, BRAKE DISC AND BRAKE BLOCK THEREFOR AND METHODS OF THE MANUFACTURING THEREOF

(57) Abstract

An asbestos-free disc brake device for automobiles and similar vehicles is provided by designing the brake disc (1) with a central cast-iron body (2) with a hub portion (3) integral with a surrounding peripheral edge portion (4), the opposite lateral faces of which are cast together with wearing linings (5) having a metallic surface layer (6) with considerably increased wearability, while each of the brake blocks (7) consists of a rear plate (8) formed from steel and being cast integral with a wearing part (9) made from a cast-iron alloy of increased wearability. In the manufacturing of brake discs (1) and brake blocks (4) the wearing linings of the brake discs (1) formed as separate wearing plates and the rear plates (8) of the brake blocks (7) formed as core elements, respectively, are inserted at one side of uniform mould parts made from compressed sand to form disposable casting moulds stacked on line in an automatically controlled casting plant. The wearing linings (5) of the brake discs with wear-resistant surface layers may be manufactured by spray forming, using the so-called "Osprey"-technology.



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Disc brake device for automobiles, brake disc and brake bloc therefor and methods of the manufacturing thereof.

The invention relates to a disc brake device for automobiles and similar vehicles comprising a brake disc co-rotating with a motor-car wheel and brake blocs arranged at either side of the brake disc close to its periphery and each consisting of a rear plate and a wearing part facing the brake disc, said brake blocs being accommodated in a caliper device in such a manner as to be displaceable in the axial direction of the brake disc towards each other under the influence of a brake pressure power for braking engagement with the brake disc, each brake bloc being retain, when unloaded, at a distance from the brake disc by means of a return spring force.

In context with recent demands for eliminating or reducing the health hazard caused by the atmospheric pollution with asbestos fibres, efforts are generally being made to avoid the usage of asbestos in any connection where asbestos fibres are emitted to the environments.

In view of the fact that such a typical use occurs in traditional motor-car disc brakes whose brake blocs are provided with brake linings containing asbestos, from which asbestos fibres are worn off at braking operations, demands have already also been made for braking materials less harmful to the environments and less injurious to health.

For the fulfilment of such environmental demands while maintaining a satisfactory braking effect the invention provides a disc brake device of the above type which is characterized in that the brake disc is designed as a central, substantially disc-shaped cast-iron body with a hub portion integral with a surrounding peripheral edge portion, the opposite lateral faces

of which are cast together with comparatively thin wearing linings having a metallic surface layer with considerably increased wearability, said wearing linings having a radial width equal to or larger than the extension of the wearing parts of the brake blocs parallel to the brake disc, the wearing part of each brake bloc consisting of a cast-iron component made from an alloy of increased wearability cast together with the rear plate formed as a steel blank.

Since the braking effect of the disc brake device according to the invention results from friction between the wearing linings of the brake disc and the cast-iron wearing parts of the brake blocs, any emission of unhealthy components to the environments has been eliminated and at the same time, by making use of moderns casting technique, brake discs and brake blocs may be manufactured by mass production at comparatively low costs.

As brake discs and brake blocs for the disc brake device according to the invention may be manufactured entirely independently of each other as separate components the invention further relates to a brake disc and a brake bloc that are characterized by the features specified in the following claims 2 and 8, respectively.

In a preferred embodiment of a brake disc according to the invention the wearing linings are designed as wearing plates composed of supporting parts of comparatively thin sheet material, on the one side 30 of which said metallic surface layer is provided by spray forming.

Spray forming of metals, alloys and metal-based composite materials according to the so-called "Osprey"-technology is described, inter alia, in the article "Recent Developments in the Spray Forming of Metals", by A.R.E. Singer in The International Journal

of Powder Metallurgy & Powder Technology, Vol. 21, No. 3, 1985, page 219 to 234.

In general, said forming technology that is of comparatively recent date and still under development entails that a melt of metal, alloy or a metal-based composite is subjected to atomization in an inactive protective gas atmosphere, whereby a cloud or cone of atomized liquid particles is directed towards and made to impinge on a generally metallic substrate at high rate. At the collision with the relatively colder substrate surface the particles flatten out and solidify instantaneously, thereby providing a coherent deposit on the substrate.

If the deposited material assumes a comparatively solid and homogeneous form, it may in a later step be separated from the substrate for optional further processing, e.g. drop forging. When applied as a thin coating the deposited material may also remain permanently bonded to the substrate.

The material deposited by the atomization may be of an arbitrary composition, in that it is also possible, inter alia, to apply additives, e.g. by injection of powdered additives to the atomization cloud or cone.

In the development up till now the "Osprey"-technology has been suggested for use in the manufacturing of tubes, rods and sheet materials and for the coating of metallic blanks and this technology offers a series of possibilities of producing components with increased wearing corrosion and temperature stability, for use within conventional design fields as well as in applications where particularly heavy demands apply, e.g. within the space technology.

For use in the production of wearing linings for a brake disc according to the invention it is advantageous in order to ensure high wearability that the

surface layers of the wearing plates are provided by spray forming of a material containing aluminium oxide as its main component.

For reasons of costs and for casting integral with the central cast-iron body of the brake disc it is preferred, as mentioned, that the wear-resistant surface layer is applied to a wearing plate supporting part of comparatively thin sheet material, preferably steel plate.

The costs involved by the "Osprey"-technology will thus together with the low cost price of the casting of the brake disc according to the method outlined in the following result in a cost price that is competitive compared to conventional brake discs for motor-cars.

The freedom with respect to material compositions actually characterizing the "Osprey"-technology does not scarcely, however, constitute any obstacle to manufacturing the entire wearing lining as a homogeneous, solid component presenting high wearability, e.g. by applying a coating directly to the cast-iron disc.

Tests carried out with a wearing lining having a coating consisting of aluminium oxide in relation to a counterpart of steel has shown frictional properties keeping fully up to conventional disc brakes for motor-cars besides a very considerably improved wearability without disadvantageous side effects, e.g. in the form of an unacceptable noise level that is not tolerable for motor car brakes.

In order to obtain a satisfactory wearability the wearing parts of the brake blocs are preferably produced from a GG20 cast-iron alloy having a phosphoric content of at least 1%.

For manufacturing brake disc by mass production at a low price, the invention provides a method based on the prior art disclosed, e.g. in DK patent No.

87,462, according to which the casting is carried out in disposable moulds consisting of compressed sand or similarly formable material, whereby a number of uniform mould parts are formed in a successively pressing chamber between a pressing plate and a counter plate provided with one or more pairs of oppositely directed model parts and are sectionwise successively arranged following their manufacture to form a series of consecutive moulds ready for use.

According to the invention this method is characterized in that the wearing linings of each brake disc are made as separate elements fixed in predetermined mutual positons and inserted as a core element in the pouring cavity part at one side of each mould part, filling ducts for casting material being provided in both sides of each mould part.

By this method the wearing linings designed as separate elements are preferably made as wearing plates by applying to a supporting part of comparatively thin sheet material a metallic surface layer with strongly enhanced wearability by spray forming (the Osprey-process).

Correspondingly, for the manufacturing of brake blocs the invention provides a method based on the same casting technique known per se, which with a view to ensuring a reliable connection between the rear plate of each brake bloc and its wearing part is characterized in that the rear plate of each brake bloc is inserted as a core element at one side of each mould part opposite a pouring cavity for the wearing part of the brake bloc formed in the opposite side of the mould part, the casting material being consituted by a cast-iron alloy with increased wearability and being filled into the cavity at a temperature at which it fuses with a surface zone at the side of the rear plate facing the pouring cavity.

The invention will now be explained in more detail with reference to the schematical drawings, in which

Fig. 1 is a partially sectional view of the main components of a disc brake device according to the invention,

Fig. 2 is a perspective view of a ventilated embodiment of a brake disc,

Fig. 3 is a schematical illustration of an automatic casting plant of the type known per se from DK patent No. 87,162,

Fig. 4 is a sectional view of a mould part for use in the manufacturing of brake discs on a plant as shown in Fig. 3,

Fig. 5 is an enlarged section of Fig. 4 with a core element embedded in the pouring cavity for use in the manufacturing of a brake disc as shown in Fig. 2,

Fig. 6 is a schematical illustration of the manufacturing of wearing plates for the brake disc according to the "Osprey"-technology,

Fig. 7 is a sectional view of a mould part for use in the manufacturing of brake blocs, and

Fig. 8 is a plan view of the left side of the mould part in Fig. 5.

According to the invention brake disc 1 which in the usual way is coaxially mounted with respect to a vehicle wheel, not shown, and co-rotates therewith consists of a central, mainly disc-shaped cast-iron body 2 having a hub portion 3 integral with a surrounding peripheral edge portion 4 the lateral faces of which according to the invention are cast together with comparatively thin wearing linings 5 coated with a surface layer 6 of substantially increased wearability. Two uniform brake blocs 7 are mounted in a caliper device of known design at either side of the edge portion 4 of the brake disc 2 so as to be displaceable

towards each other under the influence of the brake pressure power P in the axial direction of disc 1 for braking engament with the wearing linings 5 whose radial width is preferably a little larger than the extension of the brake blocs 7 parallel to the plane of disc 1.

The central body 2 of brake disc 1 may be made from a traditional cast-iron alloy, e.g. GG20.

In the illustrated embodiment the wearing linings 5 of the brake disc 2 are formed as separate wearing plates, actually consisting of a supporting part that may be a steel plate or a cast-iron plate and on one side of which the wear-resistant surface layer 6 has been provided by spray forming by application of the "Osprey"-technology explained in the following.

The wearing plates 5 are permanently and solidly fastened to the cast-iron disc 2 by casting in accordance with the method specified in the following.

As shown in Fig. 2 a brake disc according to the invention may be made in a ventilated design in that from a central cavity, not shown in the figure, in hub portion 3 a considerable number of radial ventilation ducts 10 extend through the edge portion 4' of the cast-iron disc to the periphery of the brake disc.

Each of the brake blocs consists of a rear plate 8 of commercially available normal steel, e.g. steel 37, and a wearing part 9 cast therewith which according to the invention is made from a cast-iron alloy, e.g. GG20, whose wearability has been increased, e.g. in that the alloy has a phosphoric content of at least 1%.

Since for use in vehicle brakes a reliable and durable connection is required between the rear plate 8 of brake bloc 7 and the wearing part 9 so that

the wearing part 9 cannot get loose from the rear plate 8, nor in case it is worn down to a comparatively poor thickness, the two elements are preferably cast together during the manufacturing as will be described in the folowing.

As in conventional disc brakes for motor-cars with asbestos containing braking linings, the braking effect results from the friction between brake disc 1 and the wearing parts 9 of brake blocs 7. Tests have shown that frictional values may be obtained at a level similar to those obtained between conventional brake discs and brake blocs, thereby making it possible in practice without difficulty to dimension vehicle brakes to produce a brake pressure power P offering a completely satisfactory braking effect.

It is a further advantage that the brake disc may be provided with wearing linings having a surface layer of such a composition and structure as to obtain desired specified friction properties, e.g. so that during braking a sliding friction occurs between the wearing linings 5, 6 of brake disc 1 and the wearing parts 9 of brake blocs 7, this being particularly advantageously when using the disc brake device according to the invention in anti-blocking brake systems.

The manufacture of the brake disc as well as the brake blocs for a disc brake device according to the invention is preferably carried out according to the mould producing and casting technique disclosed, inter alia, in DK patent 87,162 by using an automatic casting plant structured as schematically illustrated in Fig. 3.

The casting operation is effected in disposable moulds formed in the interfaces between a number of consecutive uniform mould parts 11 successively produced from compressed sand with or without additives in

a pressing chamber 12 between a pressing plate 13 that is reciprocating, e.g. by hydraulic actuation, and a counter plate 14 that may be swung 90° from the position shown in solid lines in the figure, in which it forms a wall in the pressing chamber 12, to the position 14 illustrated in dotted lines, in which a completed mould part 11 may pass under the plate and be pushed against the pile of already manufactured mould parts 11.

Pouring cavities 15 and filling ducts 16 are formed by arranging model parts 17 and 18, resp., on the pressing plate 13 and/or on the counter plate 14.

The mould production and the filling of liquid casting material as well as the solidification thereof and the successive separation of mould parts 11 and the removal of the completed cast members are automatically controlled and supervised at a very high capacity of production, the production of one mould part lasting typically about 10 secs.

In the production of brake discs the wearing linings 5 of each brake disc that are designed as separate pre-fabricated elements are inserted in predetermined mutual positions as illustrated in Fig. 4, as a core element in a pouring cavity part 15 at one side of each mould part 11a, while filling ducts 16a and 17a are formed at either side of the mould part 11a.

In view of the fact that the filling duct 17a will then be adjacent to one side of the wearing linings inserted as a core element, it is important, in the production of brake discs, that the casting is carried out in such a manner that the applied cast-iron alloy may freely pass this wearing lining without damaging it. For that purpose the actual wearing lining may for instance be blackened in a manner known per se.

The enlarged section in Fig. 5 illustrates the method practised in the production of a ventilated brake disc as illustrated in Fig. 2.

In order to provide the cavity necessary for that purpose in the hub portion and the ventilation ducts 10 connected therewith a core element 116 of compressed sand and containing an adhesive combustible during the casting process is inserted in the pouring cavity 115. Wearing linings 105 are fixed in predetermined positions at either side of the core element 116 by means of spacers extending therethrough, e.g. in the form of pins 117 which by the casting process are cast into the cast-iron body of the brake disc.

Fig. 6 illustrates the production of wearing linings for the brake disc by spray forming, using the so-called "Osprey"-technology. A furnace 20 contains a melt 21 of metallic material, in the actual case mainly aluminium oxide. The metallic melt is passed to an atomizer 22 in which by introduction of an inactive gas, e.g. nitrogen, at a high pressure an atomization of liquid particles of the melt is generated. The atomized material in the protective atmosphere provided by the inactive gas is directed in a conical cloud 23 towards a substrate 24 passed through the otherwise closed atomization forming chamber on a belt conveyor 25. In the production of wearing linings for brake discs according to the invention the substrate 24 acting as supporting part of each wearing lining is preferably made from steel plate. The final achievement of wearing linings may then be accomplished by punching from the substrate plate 24.

At the collision with the substrate plate 24 the liquid particles in the atomizing cloud 23 flatten out into flat blots and solidify instantaneously, thereby providing a homogeneous coherent surface coating 26.

Due to the great hardness and wearability of the deposited material the thickness of the surface coating 26 may be quite small, e.g. in the range of 50 to

100μ, while the thickness of the substrate in dependence on the material may for instance be about 2 mms.

In the production of brake blocs rear plate 8 made from steel is, as shown in Fig. 7, in a similar way inserted as the core element at one side of the mould part 11b so as to face a pouring cavity 15b with associated filling duct 16b provided at the opposite side of the mould part.

However, in view of the fact that the rear plate 8 and the wearing part 9 are only connected in a plane it is essential in the production of brake blocs to ensure that the casting is carried out at a temperature at which an actual fusing together is effected of the cast-iron alloy and a surface zone of the rear plate 8 is effected, e.g. by carburizing a surface zone having a thickness of at least 0.5 mms. In order to ensure such a reliable connection the surface of the rear plate 8 may according to the invention be processed prior to being inserted as a core element, e.g. by the so-called jet whipping, thereby making the surface to open by impingement of small steel balls or the like.

As illustrated in Fig. 8, rear plates for a considerable number of brake blocs may be inserted and pouring cavities with associated filling ducts may be provided in the same mould part, thereby enhancing the production capacity.

In dependence on the dimensions a corresponding capacity increase may be effected in the prodcution of brake discs.

PATENT CLAIMS

1. A disc brake device for automobiles and similar vehicles comprising a brake disc (1) co-rotating with a motor-car wheel and brake blocs (7) arranged at either side of the brake disc close to its periphery and each consisting of a rear plate (8) and a wearing part (9) facing the brake disc, said brake blocs (7) being accommodated in a caliper device in such a manner as to be displaceable in the axial direction of the brake disc (1) towards each other under the influence of a brake pressure power (P) for braking engagement with the brake disc (1), each brake bloc (7) being retained, when unloaded, at a distance from the brake disc by means of a return spring force, characterized in that the brake disc (1) is designed as a central, substantially disc-shaped cast-iron body (2) with a hub portion (3) integral with a surrounding peripheral edge portion (4), the opposite lateral faces of which are cast together with comparatively thin wearing linings (5) having a metallic surface layer (6) with considerably increased wearability, said wearing linings (5, 6) having a radial width equal to or larger than the extension of the wearing parts (9) of the brake blocs (4) parallel to the brake disc (1), the wearing part (9) of each brake bloc (7) consisting of a cast-iron component made from an alloy of increased wearability cast together with the rear plate (8) formed as a steel blank.

2. A brake disc for a disc brake device as claimed in claim 1, characterized in that the brake disc (1) is designed as a central, substantially disc-shaped cast-iron body (2) with a hub portion (3) integral with a surrounding peripheral edge portion (4), the opposite lateral faces of which are cast together with comparatively thin wearing linings (5) having a metallic surface layer (6) with considerably

increased wearability, said wearing linings (5, 6) having a radial width equal to or larger than the extension of the wearing parts (10) of the brake blocs (4) parallel to the brake disc (1).

3. A brake disc as claimed in claim 2, characterized in that said wearing linings (5, 6) are designed as wearing plates composed of supporting parts of comparatively thin sheet material, on one side of which said metallic surface layer (6) is provided by spray forming (the "Osprey"-process).

4. A brake disc as claimed in claim 3, characterized in that the surface layers (6) of the wearing plates are provided by spray forming of a material containing aluminium oxide as its main component.

5. A brake disc as claimed in claim 3 or 4, characterized in that the supporting parts of the wearing plates (5) are made from steel plate.

6. A brake disc as claimed in claim 3 or 4, characterized in that the supporting parts of the wearing plates are made from cast-iron.

7. A brake disc as claimed in any of claims 2 to 6, characterized in that a considerable number of radial ventilation channels (10) extend from a central cavity in the hub portion (3') through the edge portion of the cast-iron body to the periphery of the brake disc.

8. A brake bloc for a disc brake device as claimed in claim 1, characterized in that it includes a rear plate (8) formed as a steel blank and a wearing part (9) made from a cast-iron alloy of increased wearability and cast integrally with said rear plate.

9. A brake bloc as claimed in claim 5, characterized in that the wearing part (9) is made from a GG20 cast iron alloy having a phosphoric content of at least 1%.

10. A method of manufacturing a brake disc as claimed in claims 2 to 7 by casting in disposable

moulds consisting of compressed sand or any other similarly formable material, whereby a number of uniform mould parts (11) are formed in a successively pressing chamber (12) between a pressing plate (13) and a counter plate (14) provided with one or more pairs of oppositely directed model parts (17, 18) and are sectionwise successively arranged following their manufacture to form a series of consecutive moulds ready for use, characterized in that the wearing linings (5) of each brake disc (1) are made as separate elements fixed in predetermined mutual positons and inserted as a core element in the pouring cavity part (15a) at one side of each mould part (11a), filling ducts (16a, 17a) for casting material being provided in both sides of each mould part (11a).

11. A method as claimed in claims 3 to 6, characterized in that the wearing linings designed as separate elements are made as wearing plates by applying to a supporting part of comparatively thin sheet material a metallic surface layer (26) with strongly enhanced wearability by spray forming (the Osprey-process).

12. A method as claimed in claims 10 or 11 of manufacturing brake discs according to claim 7, characterized in that a core element (116) made from sand with a binding agent combustible during the casting process is inserted in each pouring cavity (115) to provide said cavity in the hub portion and said ventilation ducts (10), the wearing linings (105) being fixed in said predetermined mutual positions at either side of the core element (116) by means of spacers (117) extending therethrough and being cast together with the cast-iron body of the brake disc during the casting process.

13. A method of manufacturing brake blocs as claimed in claims 8 or 9 by casting in disposable

moulds consisting of compressed sand or similarly formable material, whereby a number of uniform mould parts (11) are formed successively in a pressing chamber (12) between a pressing plate (13) and a counter plate (14) having one or more pairs of model parts (17, 18) directed towards each other, and are sectionwise successively arranged following their manufacture to form a series of consecutive moulds ready for use, characterized in that the rear plate (8) of each brake bloc (7) is inserted as a core element at one side of each mould part (11b) opposite a pouring cavity (15b) for the wearing part (9) of the brake bloc formed in the opposite side of the mould part, the casting material being consituted by a cast-iron alloy with increased wearability and being filled into the cavity at a temperature at which it fuses with a surface zone at the side of the rear plate (8) facing the pouring cavity (15b).

14. A method as claimed in claim 13, characterized in that the part of the surface of the rear plate (9) inserted as core element and facing the pouring cavity is processed by jet whipping prior to insertion in the mould part (11b).

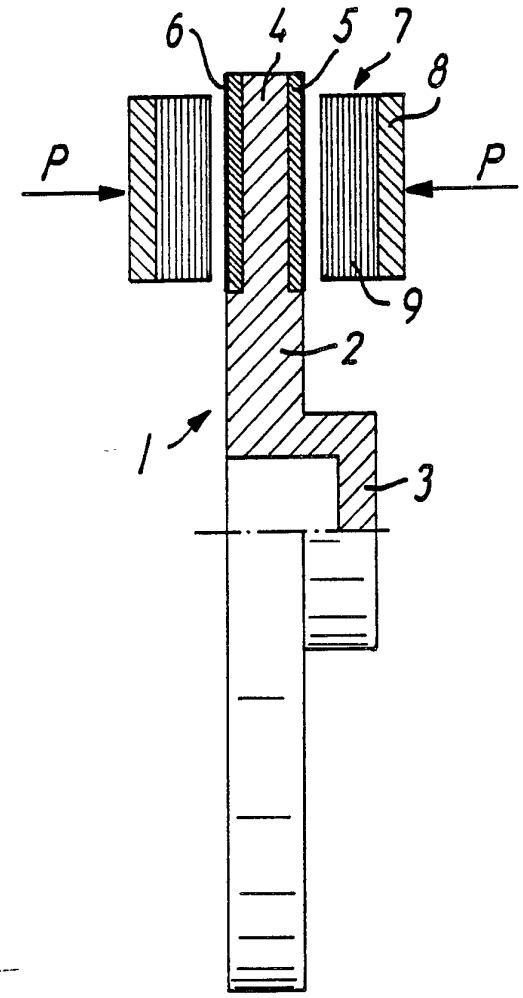

FIG. 1

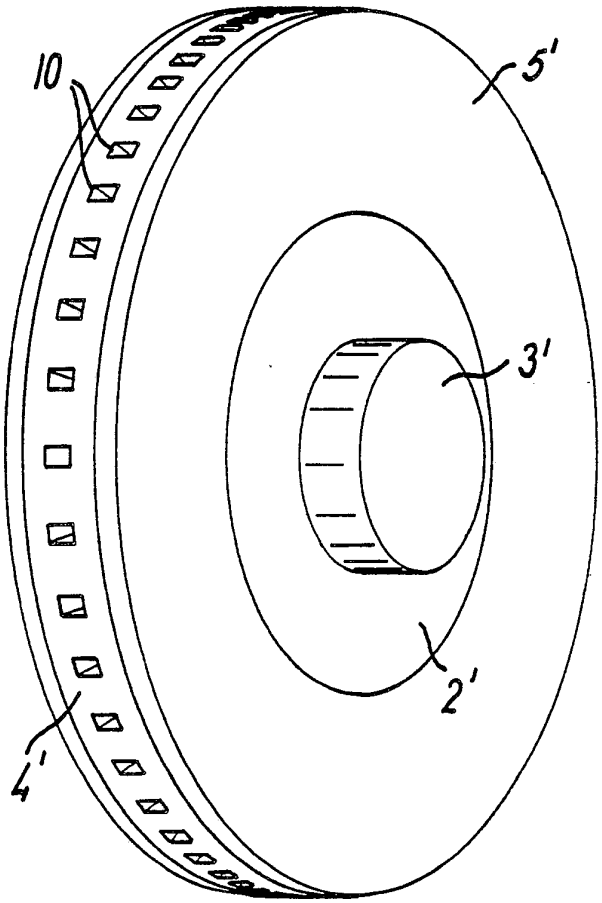

FIG. 2

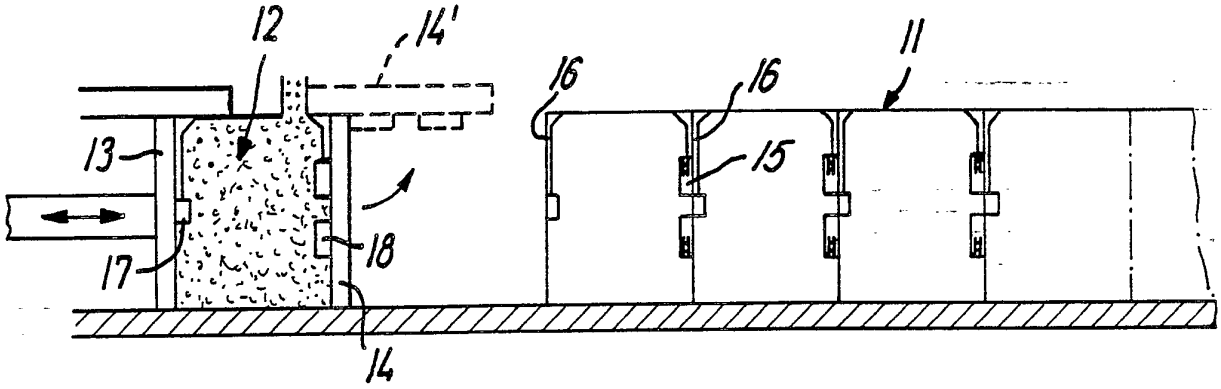

FIG. 3

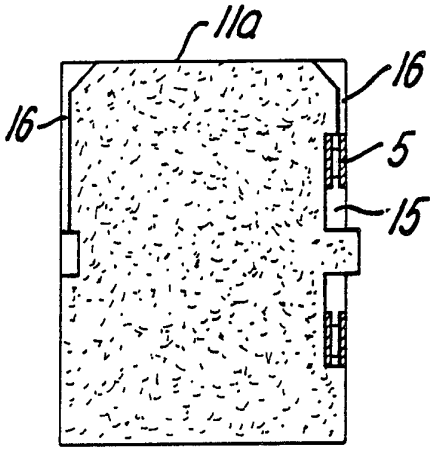

FIG. 4

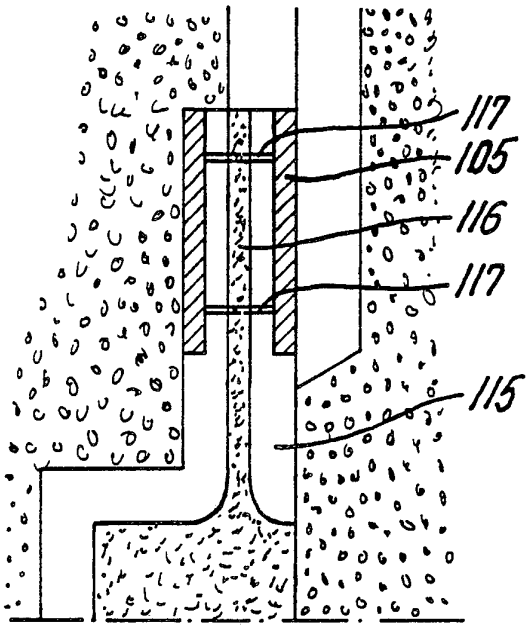

FIG. 5

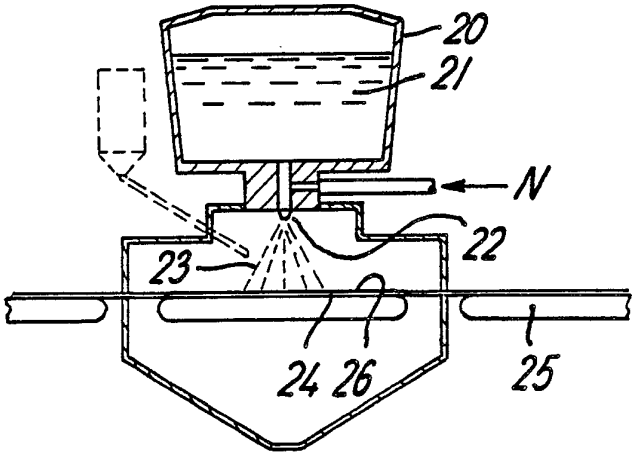

FIG. 6

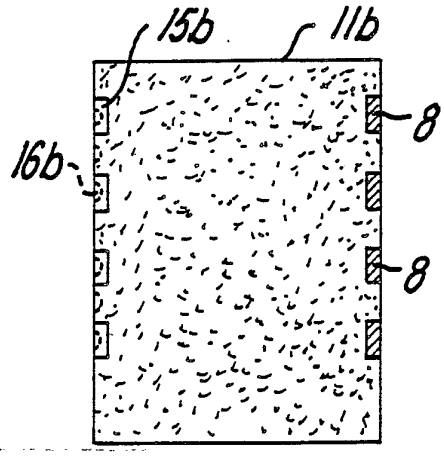

FIG. 7

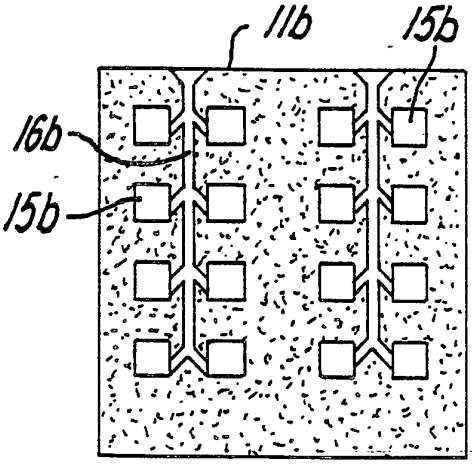

FIG. 8

INTERNATIONAL SEARCH REPORT

International Application No PCT/DK89/00080

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [5]

According to International Patent Classification (IPC) or to both National Classification and IPC [4]

F 16 D 65/12, 69/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC 4	F 16 D 65/00, /10, /12, 69/00-/04; B 22 D 19/00, /04, /08
US Cl	188:17, 18, 72.41-72.47, 218, 251; 164:98, 112, 133

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	GB, A, 1 323 832 (DAIMLER-BENZ AG) 18 July 1973 See claims and column 2, line 69-91 & FR, 2100193 DE, 2033033	1, 2, 5
X	DE, A, 2 201 885 (DR.-ING. H.C.F. PORSCHE KG) 16 August 1973 See claim 1 and figure 1	1
X	DE, A, 1 217 225 (VYZKUMNY USTAV PRISLUSENSTVI MOTORVYCH VOZIDEL) 18 May 1966 See claims and figure	1
X	DE, A, 1 530 576 (DAIMLER-BENZ AG) 11 September 1969 See claim 1 and figures	1, 2
A	DE, A, 2 002 437 (ALFRED TEVES GMBH) 29 July 1971 See claims and figure1	1, 2

.../...

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"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
1989-06-12	1989 -06- 29
International Searching Authority	**Signature of Authorized Officer**
Swedish Patent Office	Rune Kirsten

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	FI, A, 42337 (ESCHER WYSS AKTIENGESELLSCHAFT) 31 March 1970 See claim 7	9
A	FR, A, 1 575 746 (SOCIETE ANONYME FRANCAISE DU FERODO) 25 July 1969 See page 11	9
X	US, A, 4 590 981 (WEBER) 27 May 1986 & EP, 0112790 EP, 83440064 FR, 2538277 DE, 3374119	10
X	GB, A, 1 589 392 (ABEX PAGID EQUIPMENT S.A.) 13 May 1981 & FR, 2366157 DE, 2743869	10, 13