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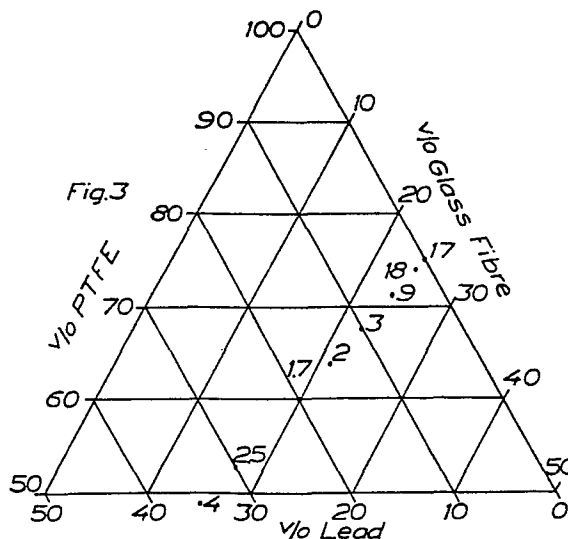
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A rotary vane machine.

A rotary vane machine having vanes with a three component wear resistant material. The matrix is a fluorocarbon polymer, e.g. PTFE. Furthermore, there are hard phases whose hardness deviates less than 20% from that of the counterface. Glass or carbon is preferable against steel or cast iron. Furthermore an inorganic solid lubricant has been added to the wear resistant material. Lead and lead oxides are particularly good.



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A rotary vane machine

The present invention relates to a rotary vane machine particularly suitable for operation with a dry and oil-free compressible working medium, e.g. compressed air, at high speeds.

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A considerable amount of experiments has been made during several decades in order to find out how a vane machine should be designed in order to operate without oil lubrication over a substantial period of time. So far no
10 solution has been found having a service life directly comparable with the service life of oil lubricated machines . In US patent 3 335 944 it has been suggested to use a vane material consisting of a mixture of polytetrafluoroethylene and ground glass.

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The main object of the present invention has been to find a material combination which is sufficiently hard to make it wear resistant without being brittle so that pieces are broken away from the vanes. Since a working medium
25 which is believed to be dry and oil-free often contains small amounts of moisture and oil, the vane machine according to the invention should be capable of operation also under these circumstances without any serious effects on the service life.

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As mentioned above nobody has found a suitable material combination for the vanes of a rotary vane machine before the present invention was made, in spite of all the efforts that have been made during several decades. One important
35 problem has been the high sliding speeds which often exist between the vanes and the cylinder housing. The sliding speed can for instance be up to and even above 20 m/sec. in a rotary vane motor for a hand-held grinder. Since the

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contact pressure between the substantially radially movable vanes and the cylindrical countersurface is approximately proportional to the square of the sliding speed it is obviously desirable to make the vanes as light as possible in order to counteract the effect of high sliding speeds.

According to the present invention a rotary vane machine is created in which the substantially radially movable vanes are provided with portions, at least at the surface in sealing contact with the cylinder housing, of a wear resistant material comprising a matrix with hard phases having a hardness on the Vickers scale deviating less than 20 % from the hardness of the cylinder, and an inorganic solid lubricant.

The matrix should preferably be a fluorocarbon polymer, particularly polytetrafluoroethylene, fluorinated ethylene-propylene, or poly fluor alkoxy resin.

The wear resistant material should preferably contain between 5 and 30 % by volume of hard phases. Glass or carbon is preferred as hard phases, which advantageously could be in form of particles of fibres. The fibres should preferably be systematically oriented, e.g. woven, in order to increase vane stiffness.

The inorganic solid lubricant should preferably be chosen from a group of materials which do not react chemically with the cooperating cylinder material. Particularly good performance has been obtained with lead or lead oxides as solid lubricant in the wear resistant material when the cylinder is made of steel or cast iron. It is reasonable to suppose, outgoing from these findings, that other compounds of lead would perform satisfactorily

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because no significant difference in performance has been found between non-oxidised lead metal, semi-oxidised lead metal and lead oxide.

- 5 In bearing technology lead and tin are recommended because they are soft and ductile metals. However, these recommendations cannot be applied in the present case because the addition of tin to a mixture of polytetrafluoroethylene and glass seriously impairs the performance. The wear rate is about three times as high with 10 % by volume of tin in the material than without. As mentioned above lead does not have to be in its metal form. Furthermore, as mentioned above, it is desirable to make the vanes as light as possible. The addition of 15 lead constitutes a considerable step away from this idea. It is, therefore, quite surprising that the addition of lead decreases the wear rate of the vanes. Improvements by about a factor ten have been observed in high speed tests with lead or lead oxide as solid 20 lubricant. Tests have shown that the wear rates obtained with the invention, under dry and oil-free conditions, are as low as the wear rates obtained with conventional phenolic vanes with full oil lubrication.
- 25 Fig. 1 is a longitudinal section through an air motor according to 1-1 in fig. 2. Fig. 2 is a cross-section through the motor according to 2-2 in fig. 1. Fig. 3 shows the wear rates obtained in a series of tests with different amounts of lead. Fig. 4 shows the wear rate 30 as a function of the amount of lead.

The air motor shown in figs. 1 and 2 comprises a cylinder housing 11 provided with two end plates 13. A rotor 16 having an outgoing shaft 12 is eccentrically

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journalled relative to cylinder 11 in the end plates 13 by means of bearings 14. The rotor is further provided with a number of vanes 20 which are movable in substantially radial slots 19. Substantially radial in this context means that the slots may deviate from the radial direction with up to 30° . The housing is provided with an inlet port 30 for compressed air and outlet ports 31.

Fig. 3 shows the wear rates obtained with different amounts of semi-oxidised lead metal. These tests have been made with an air motor operating unloaded at 10000 rpm, corresponding to a sliding speed of 20 m/sec. The ratio of glass fibre, cut into short pieces, to polytetrafluoroethylene (PTFE) has been kept konstant at one to three. All amounts are given in percent by volume (V/o). In fig. 4 the wear rates in $\mu\text{m/hr}$ are shown as a function of the amount of lead. The wear rate obtained without lead is the wear rate obtainable with the combination of materials disclosed in the above mentioned U.S. patent 3 335 944. The wear rate obtained with one percent of lead ($18 \mu\text{m/hr}$) has been deleted when fig. 4 was plotted because it is very unlikely that there should be a peak value in that position. This value is probably wrong and no efforts have been made to obtain the correct value since it is not, from a practical point of view, interesting to know this value precisely. As can be seen in figs. 3 and 4 the wear resistant material should contain between 5 and 30 % by volume of inorganic solid lubricant. The wear rates obtained with from 10 to 20 % by volume of inorganic solid lubricant are particularly interesting. In applications where the demand for quick speed changes is particularly high an amount of 5 % would be very interesting even though the wear rate is considerably higher than the optimum value. However, the wear

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rate is in this case only about 50 % of the value obtained without the inorganic solid lubricant.

Tests have also been made, at the above mentioned
5 operating speeds, with carbon fibre instead of glass
as the hard phase material. In these tests two varieties commonly known as type I (high modulus, moderate strength) and type II (high strength, moderate modulus) were used. As in the above mentioned tests with glass
10 the ratio of carbon fibres to PTFE was kept constant at one to three. Tests were made with up to 20 % of lead with the type II fibres. A wear rate of 4 $\mu\text{m/hr}$ was obtained with 60 % PTFE, 20 % carbon fibre type II and 20 % lead. With a composition comprising 60 %
15 PTFE, 20 % carbon fibre type I and 20 % lead a wear rate of 1.5 $\mu\text{m/hr}$ was obtained. It can be seen from these results that very good performance is obtainable with carbon fibres as hard phases. The best value obtained with type I fibres is as good as the value ob-
20 tained with glass.

The above description gives examples only of preferred alternatives and must not be regarded as limiting the scope of the invention which is defined by the subsequent
25 claims. The matrix could be a phenolic resin. In some cases it could be advantageous to use graphite or molybdenumdisulfide as inorganic solid lubricant.

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Claims

A rotary vane machine comprising a cylinder having two opposite end plates, inlet and outlet means for a compressible working medium, a rotor eccentrically journaled in the cylinder, and a number of vanes slidable in substantially radial slots in the rotor to maintain sealing contact with the cylinder during rotation of the rotor, characterized thereby that each vane at least at the surface in sealing contact with the cylinder is provided with a portion which is formed of a wear resistant material comprising a matrix with hard phases having a hardness on the Vickers scale deviating less than 20 % from the hardness of the cooperating cylinder material, and an inorganic solid lubricant.

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2. A rotary vane machine according to claim 1, characterized thereby that the matrix is a fluorocarbon polymer.

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3. A rotary vane machine according to claim 1 or 2, characterized thereby that the wear resistant material contains between 5 and 30 % by volume of hard phases.

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4. A rotary vane machine according to claim 1, 2 or 3, characterized thereby that said hard phases comprise glass or carbon.

30 5. A rotary vane machine according to any of the preceding claims, characterized thereby that the hard phases are in form of fibres which are systematically oriented to increase vane stiffness.

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6. A rotary vane machine according to claim 5,
c h a r a c t e r i z e d t h e r e b y t h a t
the fibres are woven.

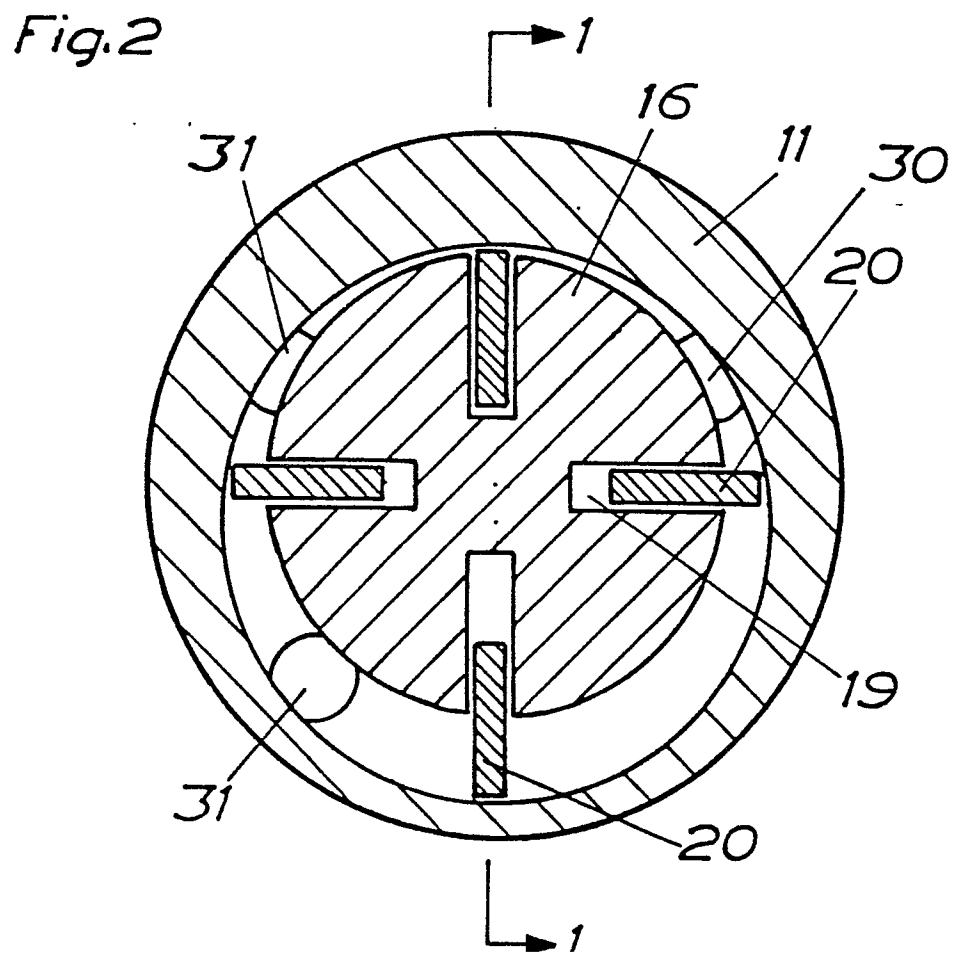
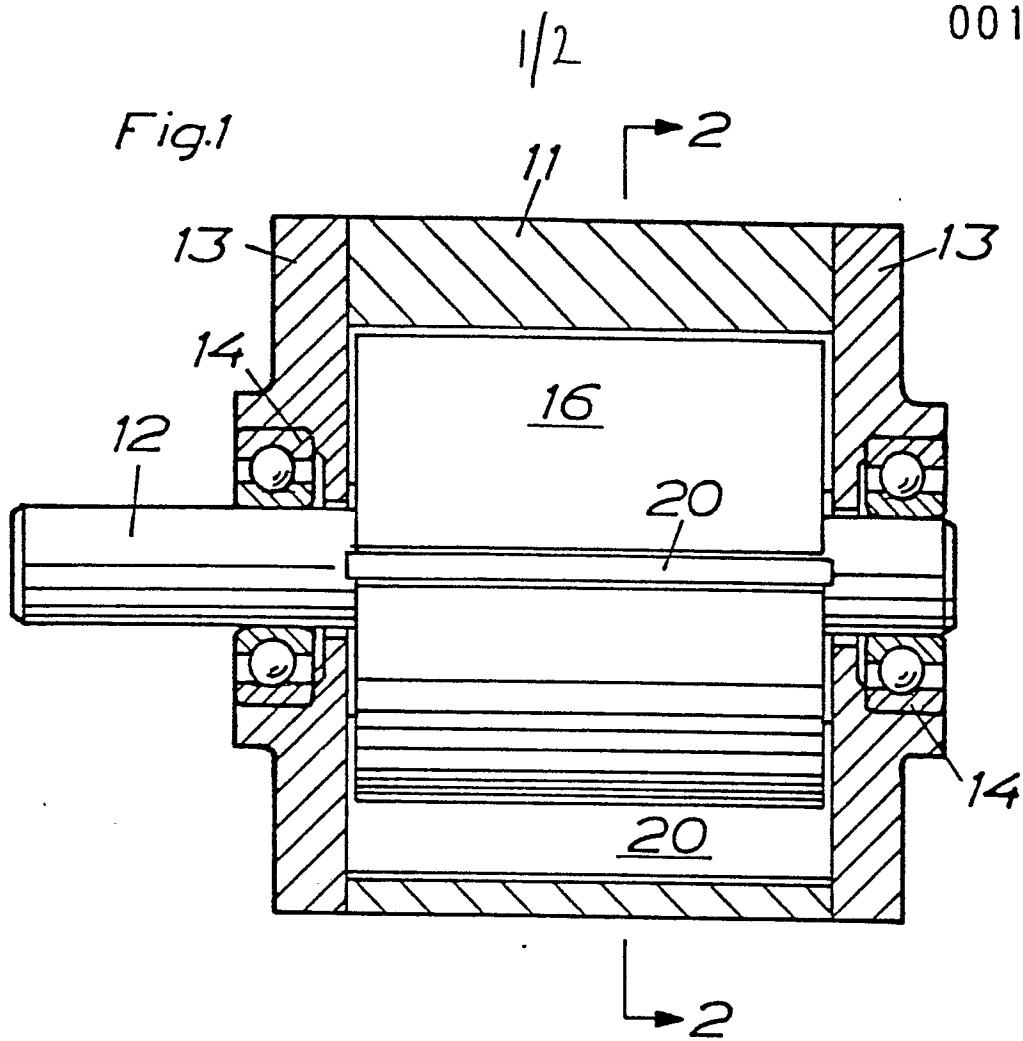
5 7. A rotary vane machine according to any of the
preceding claims, c h a r a c t e r i z e d t h e r e b y
that the inorganic solid lubricant is chosen
from a group of materials which do not react chemically
with the cooperating cylinder material.

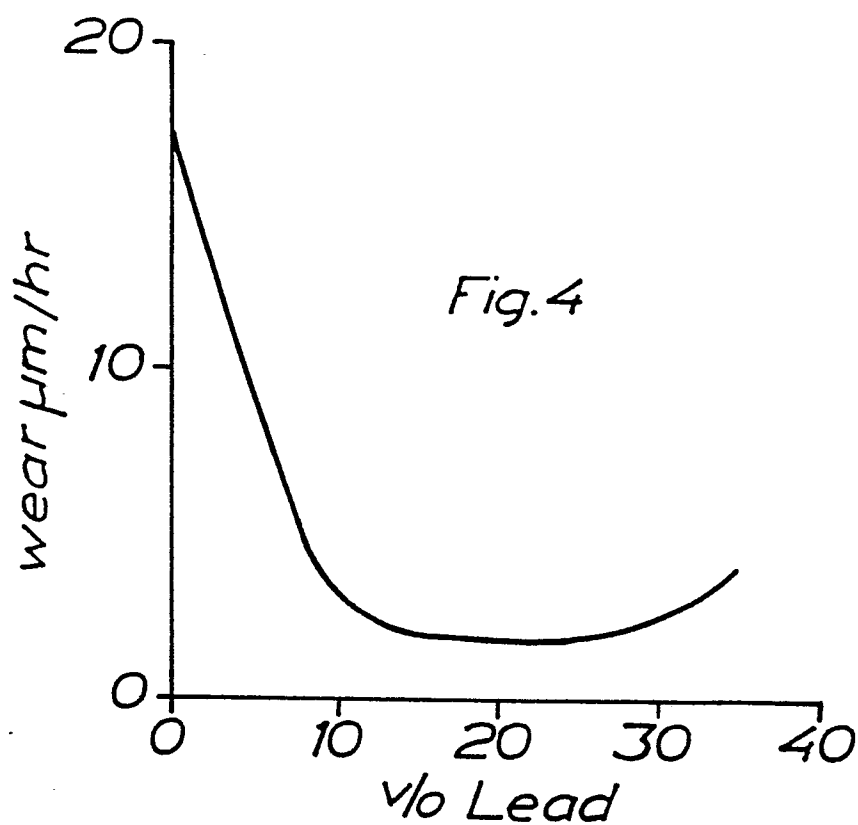
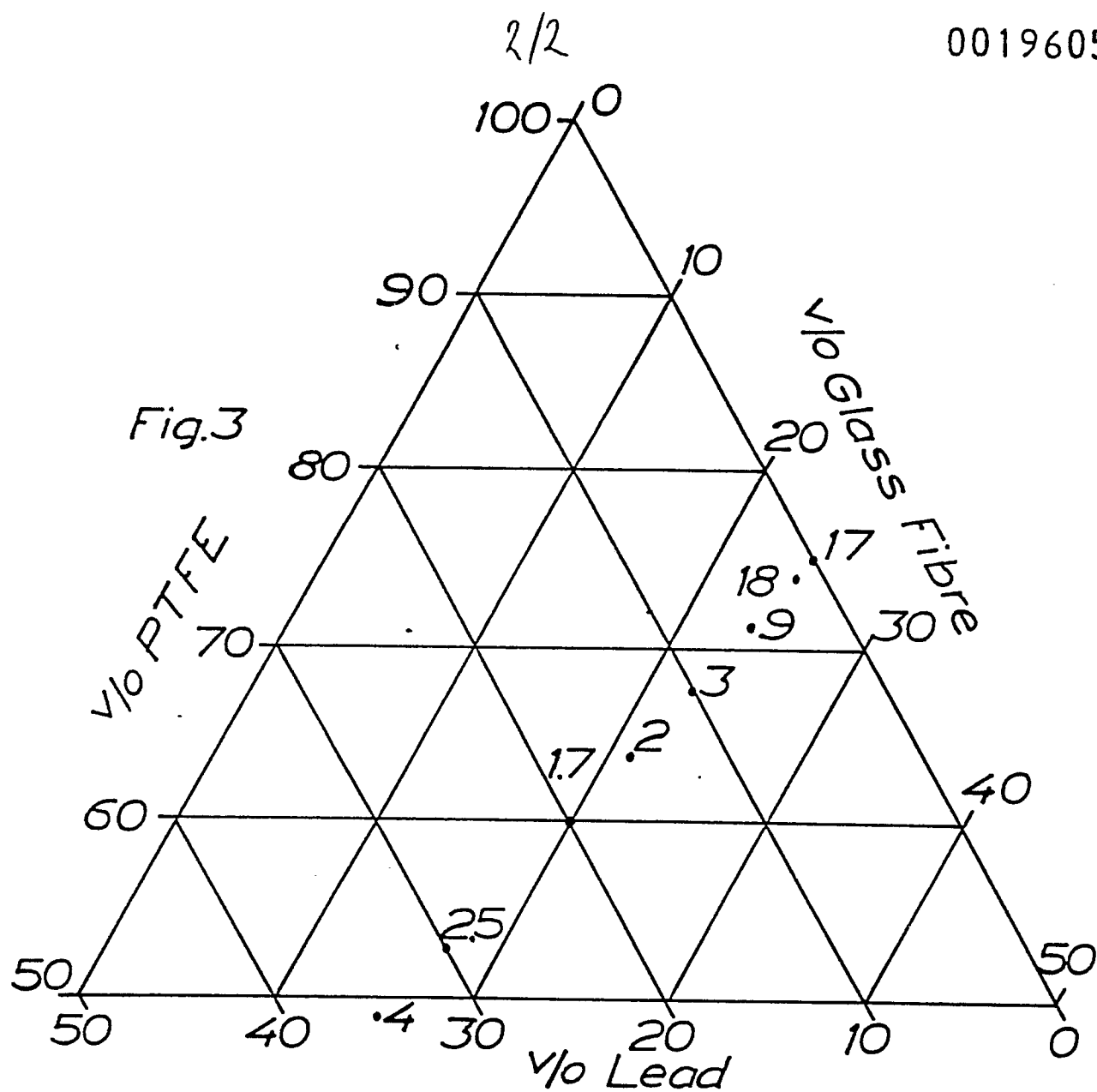
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8. A rotary vane machine according to claim 7,
c h a r a c t e r i z e d t h e r e b y t h a t t h e i n -
organic solid lubricant is lead or a compound of lead
and that the cooperating surface of the cylinder is of
15 steel or cast iron.

9. A rotary vane machine according to any of the
preceding claims, c h a r a c t e r i z e d t h e r e b y
that the wear resistant material contains between
20 5 and 30 % by volume of inorganic solid lubricant.

10. A rotary vane machine according to claim 9,
c h a r a c t e r i z e d t h e r e b y t h a t t h e
wear resistant material contains from 10 to 20 %
25 by volume of inorganic solid lubricant.







European Patent
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EUROPEAN SEARCH REPORT

Application number

EP 80 85 0073

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	<u>GB - A - 1 336 128 (TAC)</u> * Page 1, lines 24-30 and 45-75; page 2, example 2 * --	1-5	F 01 C 1/34 21/08
	<u>GB - A - 1 324 443 (BRITISH OXYGEN)</u> * Page 2, lines 23-54 * --	1,2,4,5	
	<u>FR - A - 2 250 904 (PFEIFFER)</u> * Page 1, lines 30-34; page 2, lines 19-21 * --	1,4,5	TECHNICAL FIELDS SEARCHED (Int.Cl. 3)
	<u>GB - A - 1 213 552 (BLACK AND DECKER)</u> * Page 3, lines 15-44 * --	1,4,6	F 01 C
	<u>FR - A - 1 574 999 (BALZERS)</u> * Page 2, lines 7-10; page 4, lines 8-11 * --	1,4	
	<u>GB - A - 1 324 248 (BRITISH OXYGEN)</u> * Page 2, lines 42-54 * ----	1,2,8	CATEGORY OF CITED DOCUMENTS
			X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
	X The present search report has been drawn up for all claims		& member of the same patent family, corresponding document
Place of search		Date of completion of the search	Examiner
The Hague		24-07-1980	KAPOULAS