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(12) # EUROPEAN PATENT APPLICATION

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(71) Applicant: **Institut Cerac S.A.**
Chemin des Larges Pièces
CH-1024 Ecublens(CH)

(72) Inventor: **Cooper, George Anthony**

CH-1111 Gollion(CH)

(72) Inventor: **Berlie, Jacques**

CH-1181 Bursins(CH)

(74) Representative: **Grundfelt, Gunnar et al,**
c/o Atlas Copco Aktiebolag Patent Department
S-105 23 Stockholm(SE)

(54) **A rotary vane machine.**

(57) A rotary vane machine having vanes comprising two layers of glass fibre reinforced PTFE at a distance from each other and an intermediate layer containing an inorganic solid lubricant, e.g. lead.

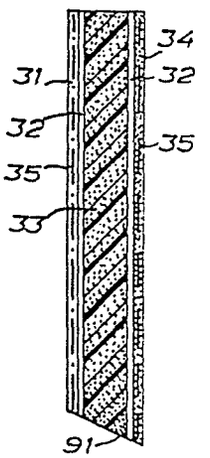

Fig.3

EP 0 022 103 A1

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.

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 solution has been found having a service life directly comparable with the service life of oil lubricated machines. In U.S. patent 3 335 944 it has been suggested to use a vane material consisting of a mixture of polytetrafluoroethylene and ground glass.

The main object of the present invention has been to create a rotary vane machine having vanes being sufficiently hard to make them wear resistant without being brittle so that pieces are broken away from the vanes during operation of the machine. At the same time the vanes should be light and stiff and capable of operation at high sliding speeds, e.g. up to and even above 20 m/sec. for a hand-held grinder.

According to the present invention a rotary vane machine is created in which the substantially radially movable vanes comprise at least two reinforced layers at a distance from each other and a further layer between said two reinforced layers, said further layer comprising an inorganic solid lubricant at least at the surface in sealing contact with the cylinder.

Some embodiments of the invention are described below with reference

to the accompanying drawings in which Fig 1 shows a section through a vane motor according to 1-1 in Fig 2. Fig 2 shows a section according to 2-2 in Fig 1. Fig 3 shows a section through one embodiment of a vane for use in a rotary vane machine according to the invention. Fig 4 shows a section through a second embodiment of a vane. Fig 5 shows a section through a third embodiment of a vane. Fig 6 shows a section through a fourth embodiment of a vane. Fig 7 shows schematically the making of a reinforced layer containing an inorganic solid lubricant. Fig 8 shows schematically the production of laminated vanes.

The vane 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 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.

The vane shown in Fig 3 comprises two layers 31, 34 being reinforced by woven glass fibre mats 35. These layers, which are situated at a distance from each other in order to increase the stiffness of the vane, have been obtained by impregnation of the glass fibre mats with PTFE. The vane furthermore comprises a further layer or core 33 which comprises an inorganic solid lubricant, preferably lead or lead oxide. Furthermore, the core comprises glass, which could be in form of powder or fibre cuttings, as hard phases in order to make the vane wear resistant. The core 33 furthermore comprises a matrix of PTFE in which the hard phases and the inorganic solid lubricant are embedded. The layer 34, which is pressed against the rotor during operation of the motor, contains graphite in order to reduce the friction between the vane and the rotor. The two reinforced layers 31, 34 are bonded to the core 33 by means of two thin foils 32 of fluorinated ethylene-propylene polymer or poly fluor-alkoxy polymer. During operation surface 91 contacts the cylinder 11.

In the embodiment shown in Fig 4 the core or further layer 40 has been reduced so that it only occupies a rather small region near the surfac

in sliding contact with the cylinder 11. This vane comprises a number of reinforced layers 36, 38 of which the latter incorporates graphite. These layers comprising reinforcement mats 39 as in the above described embodiment are bonded together by means of thin foils 37 of fluorinated ethylene-propylene polymer. The core 40 is primarily bonded to the outermost reinforced layers but also to some extent to the layers filling up the space behind the core. During operation surface 92 contacts the cylinder 11.

The embodiment shown in Fig 5 comprises a number of reinforced layers 41 each comprising a web of woven glass fibre impregnated with PTFE. These layers are bonded together by means of thin foils 42 of fluorinated ethylene-propylene polymer. The inorganic solid lubricant, preferably lead or lead oxide, is introduced in the form of a dispersion on the foils 42. These are made by covering a large sheet of fluorinated ethylene-propylene polymer deeply with lead or lead oxide powder, and heating it from below. The foil then softens and bonds to the particles in contact with the foil. The foil is then allowed to cool and excess powder is shaken off. By varying the thickness of the foil or the size of the particles, different concentrations of the inorganic solid lubricant can be obtained. Instead of covering the whole foil 42 with lead or lead oxide powder one could cover only those parts which are going to be near the surface in sliding contact with the cylinder. In this case a vane having further layers 42 provided with regions 44 containing inorganic solid lubricant is obtained. Such a vane would be lighter but more complicated to manufacture. During operation surface 93 contacts the cylinder 11.

The embodiment shown in Fig 6 comprises a number of layers 45 reinforced with webs 46 of woven glass fibre. In this case the layers comprise a mixture of PTFE and an inorganic solid lubricant, e.g. lead or lead oxide. The layers 45 are bonded directly to each other. Alternatively the layers 45 may comprise a mixture of a phenolic resin and an inorganic solid lubricant. In that case the reinforcement webs 46 may comprise woven cotton. During operation surface 94 contacts the cylinder 11.

Fig 7 shows schematically one way of producing a reinforced layer

according to any of the above described embodiments. A web 52 of woven glass fibre or carbon fibre, or a high stiffness organic fibre, e.g. the fibre sold under the trade mark "Kevlar" by Du Pont, is passed from a spool 51 over a number of rolls 53 through a vessel 47 containing a water suspension of PTFE and an inorganic solid lubricant, e.g. lead or lead oxide powder. For certain layers the inorganic solid lubricant may be excluded. A propeller 49 driven by motor 50 is used in order to obtain an even distribution of the particles in the suspension. During its passage through the suspension the web 52 is impregnated with the mixture of PTFE and the inorganic solid lubricant. The impregnated web is then passed through a drying and curing oven 54 to a take-up spool 55.

Fig 8 shows schematically the production of laminated vanes. Several layers 57 are mounted on spools 56 in the desired order. The layers may be reinforced with woven glass fibre or be bonding foils. The layers 57 are heated by a hot air preheater 58, which delivers air of about 300° C when PTFE is used in the layers. The layers 57 are then pressed together between a pair of hot rolls 59, the temperature of which is about 350°C. The laminated web is then passed between a pair of rolls 60 for cooling of the laminate. Vanes 64 are then stamped from the web by a stamping press 61. The vanes 64 are collected in a container 63 and the waste material taken up by a take-up spool 62. This method is particularly suitable for the making of vanes of the types shown in Figs 5 and 6.

The further layers or cores 33, 40 used in the embodiments shown in Figs 3 and 4 are produced from a mixture of PTFE glass and an inorganic solid lubricant. The mixture is then compacted and sintered.

The above described and in the drawings shown embodiments of the invention are only to be regarded as examples which may be modified within the scope of the subsequent claims.

Claims

1. A rotary vane machine comprising a cylinder (11) having two opposite end plates (13), inlet (30) and outlet means (31) for a compressible working medium, a rotor (16) eccentrically journalled in the cylinder, and a number of vanes (20) slidable in substantially radial slots (19) in the rotor to maintain sealing contact with the cylinder during rotation of the rotor, c h a r a c t e r i z e d t h e r e b y that each vane (20) comprises at least two layers (31,34) at a distance from each other and containing a fluorocarbon polymer reinforced with glass fibre or carbon fibre, each said vane (20) comprising a further layer (33) between said reinforced layers, said further layer comprising a metal-based solid lubricant at least at the surface in sealing contact with the cylinder (11).

2. A rotary vane machine according to claim 1, c h a r a c t e r i z e d t h e r e b y that each vane (20) comprises a laminate of a number of reinforced layers (41) being separated by non-reinforced layers (42) containing the inorganic solid lubricant.

3. A rotary vane machine according to claim 1, c h a r a c t e r i z e d t h e r e b y that each vane (20) comprises a laminate of a number of reinforced layers (45) being directly bonded to each other and containing the inorganic solid lubricant.

4. A rotary vane machine according to claim 1, 2 or 3, 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 provided only in the neighbourhood of the surface (92) in sealing contact with the cylinder (11).

5. 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 reinforced layers (31,34) comprise PTFE reinforced with woven glass fibre.

6. 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 lead or lead oxide.

7. A rotary vane machine according to claim 2, c h a r a c t e r i z e d t h e r e b y that the non-reinforced layers (42) are foils of fluorinated ethylene-propylene polymer.

8. A rotary vane machine according to claim 2, c h a r a c t e r i z e d t h e r e b y that the non-reinforced layers (42) are foils of poly flouor-alkoxy polymer.

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 reinforced layers (31,34) comprise PTFE reinforced with carbon fibre.

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Fig.1

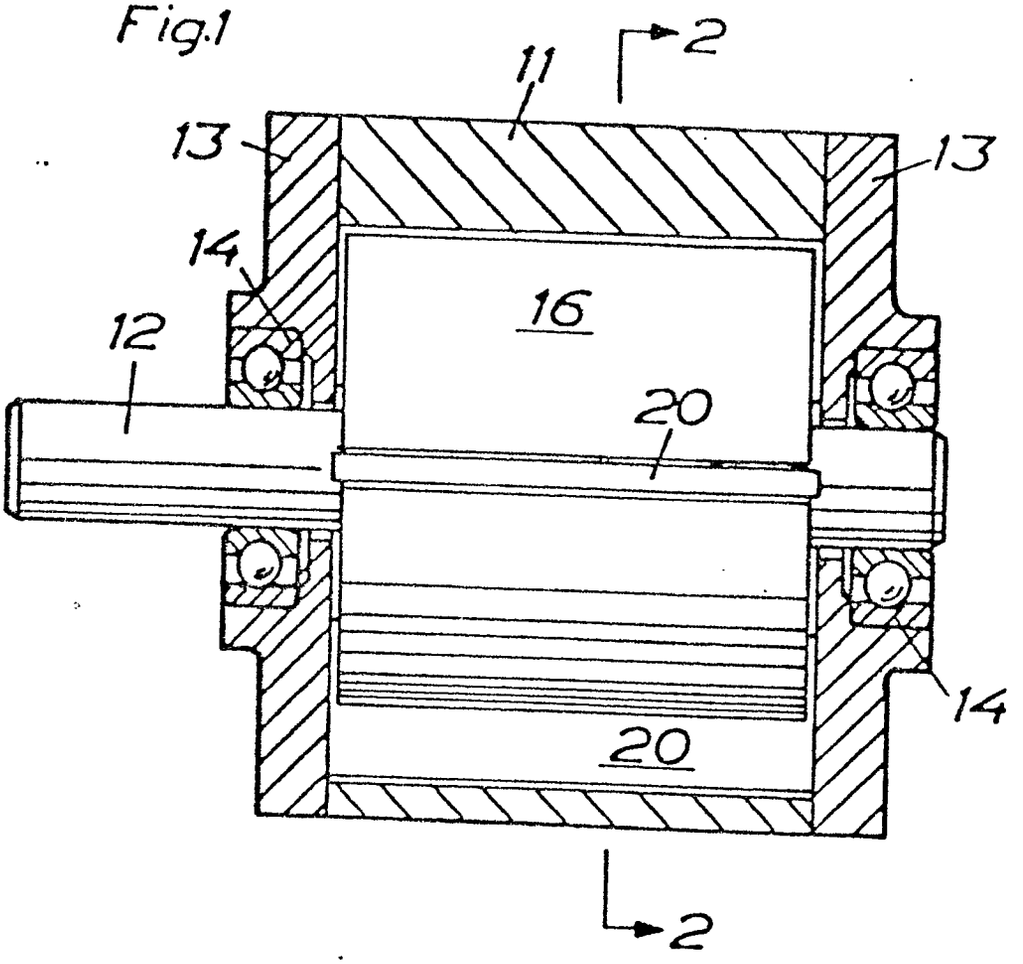
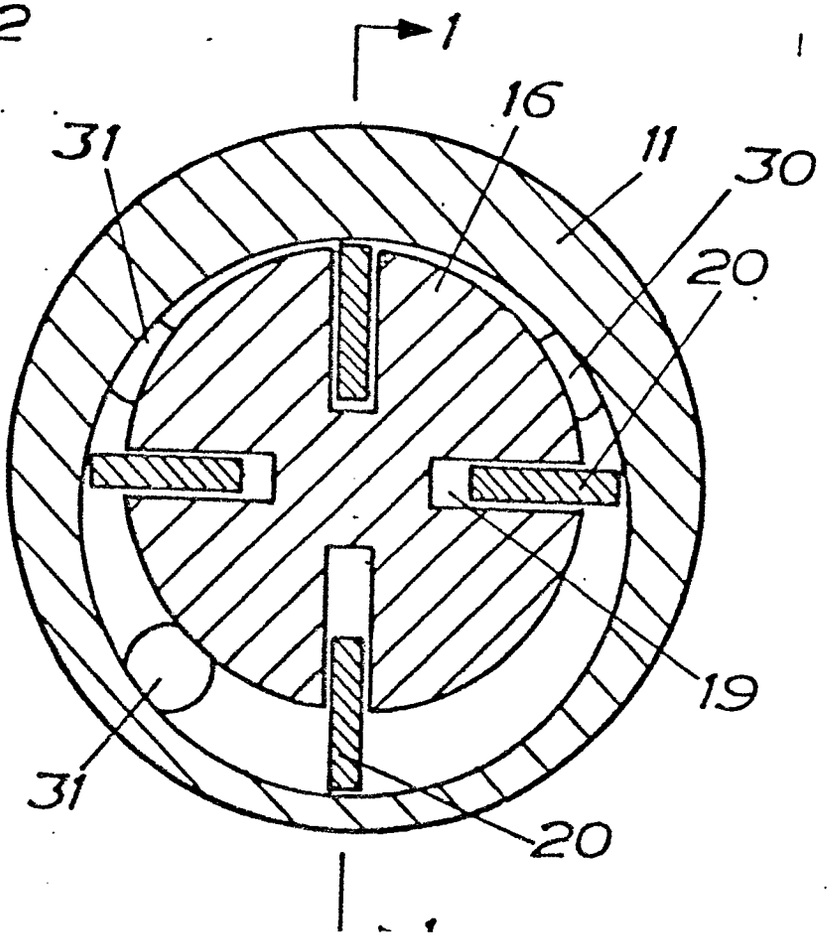


Fig.2



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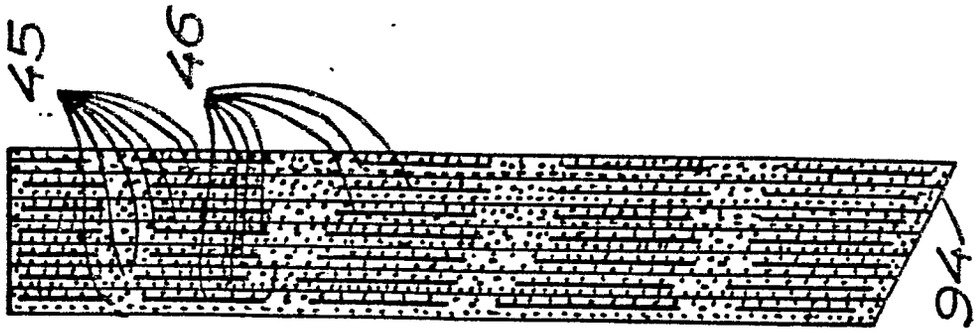

Fig.6

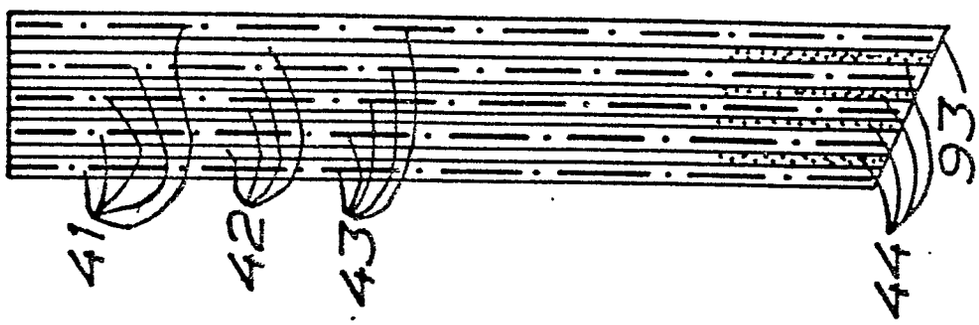

Fig.5

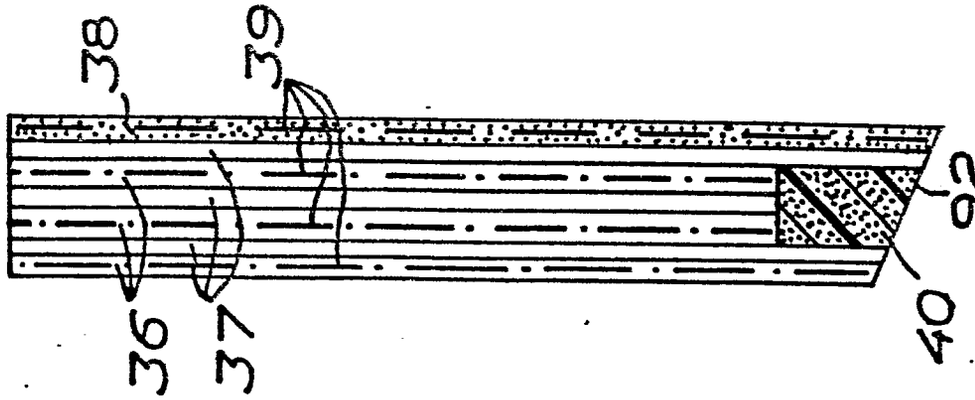

Fig.4

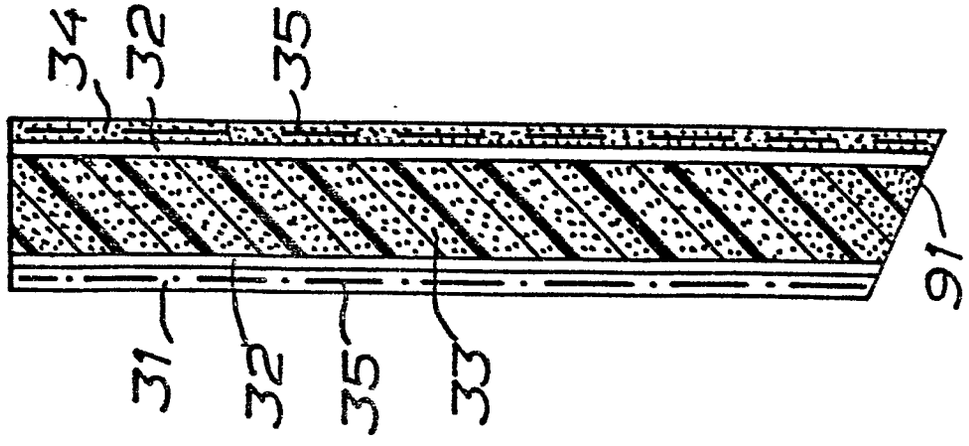

Fig.3

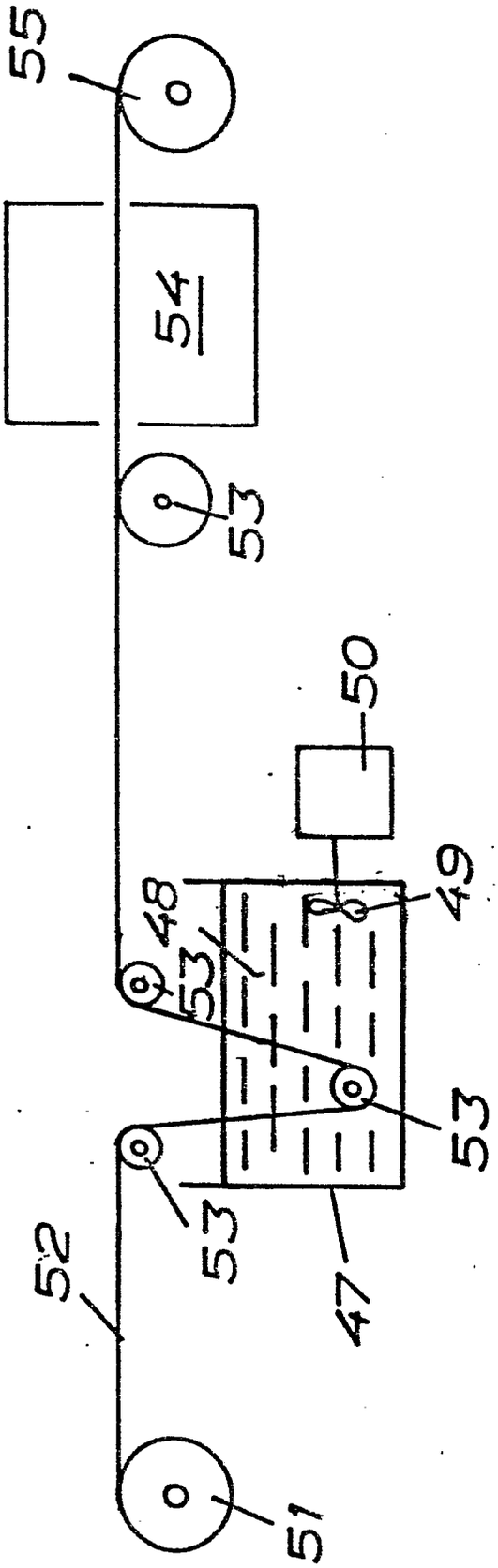

Fig.7

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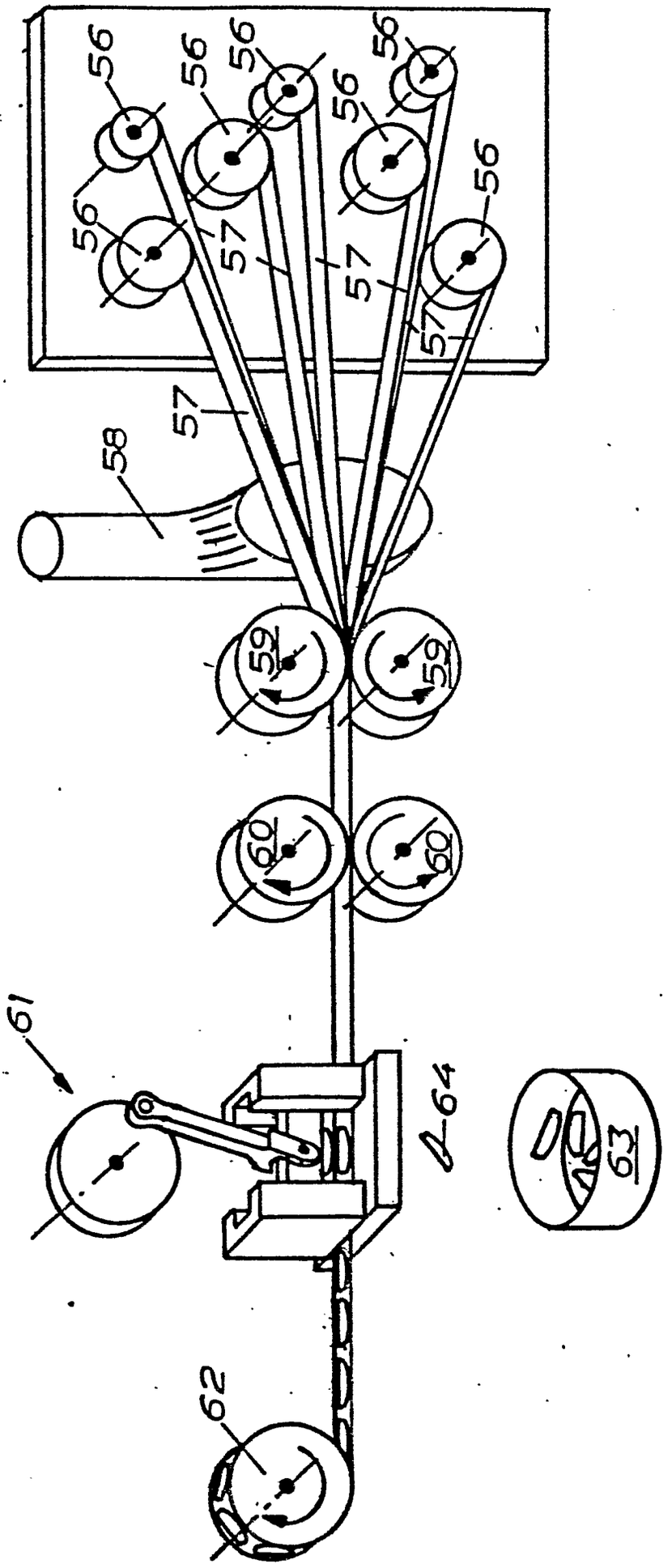

Fig.8

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EUROPEAN SEARCH REPORT

0022103
Application number
EP 80 85 0087

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	DE - A - 2 600 972 (HOLZ) * Page 3, paragraph before last; page 7, second and last paragraph; page 8 six last lines; pages 9,10, figures 4-7; page 1, claims 1,4,5,6; page 2, claims 7,11 * --	1,3,5, 9
	GB - A - 2 213 552 (BLACK and DECKER) * Page 1, lines 42-84; page 3, lines 15-48 and last paragraph; page 4, 1st paragraph; figure 5 * --	3,5
	GB - A - 1 324 443 (BRITISH OXYGEN) * Page 2, lines 23-54 and 71-84 * --	1,9
	GB - A - 1 336 128 (TAC) * Page 1, lines 24-75; page 2, example 2 * --	1,2,5, 9
A	GB - A - 1 324 248 (BRITISH OXYGEN) * Page 2, lines 11-54 * --	1,6
A	FR - A - 2 151 982 (GENERAL MOTORS) * Page 3, lines 36-38 * --	3,5
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CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)

F 01 C 21/08
1/34

TECHNICAL FIELDS SEARCHED (Int.Cl. 3)

F 01 C

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

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	22-09-1980	KAPOULAS

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Application number
EP 80 85 0087

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	
A	GB - A - 795 204 (ELECTRIC & MUSICAL LTD.) * Page 1, lines 73-75; figure *	1	TECHNICAL FIELDS SEARCHED (Int. Cl. 3)