PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : B04B 5/04, 7/08, 7/02

A1

(11) International Publication Number: **WO 00/47328**

(43) International Publication Date: 17 August 2000 (17.08.00)

(21) International Application Number: PCT/GB00/00401

(22) International Filing Date: 8 February 2000 (08.02.00)

(30) Priority Data:

9903100.7	11 February 1999 (11.02.99)	GB
9903101.5	11 February 1999 (11.02.99)	GB

(71) Applicant *(for all designated States except US)*: SEWARD LIMITED [GB/GB]; 98 Great North Road, London N2 0GN (GB).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: BUXTON, Adrian, Christopher [GB/GB]; Cruachan, Norton Road, Tostock, Bury St Edmunds, Suffolk IP30 9PY (GB).

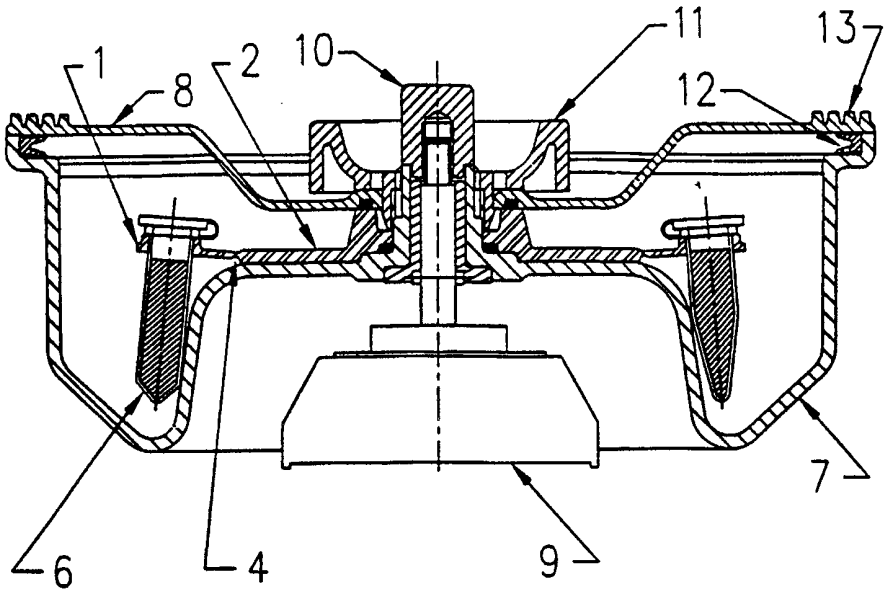
(74) Agents: FAULKNER, Thomas, John et al.; fJ Cleveland, 40–43 Chancery Lane, London WC2A 1JQ (GB).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published

With international search report.

(54) Title: CENTRIFUGE ROTORS



(57) Abstract

A centrifuge rotor including a sample carrier (1) enclosed within an outer housing (7, 8) and being rotatable about a principal axis of rotation of the rotor, the sample carrier (1) having a peripheral zone for holding sample tubes (6) in an orientation parallel to the said axis when at rest and the sample carrier being capable of deflecting to enable sample tubes (6) to swing out under the effect of centrifugal force. The swinging out of the tubes (6) is constrained and controlled by the arrangement of the sample carrier (1) and contact between the tubes (6) and outer housing (7, 8).

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

Centrifuge Rotors

The present invention relates to centrifuge rotors.

More particularly the invention relates to centrifuge rotors of the kind described in GB Patent Specification 2 233 584B. The invention is concerned with providing improvements to the device of the said GB Patent which enable higher speeds, and more consistent performance to be achieved. It is also desirable if when using a transparent rotor, performance of the centrifuging of the sample tubes is readily monitored by a strobing means.

One problem with the previously described centrifuge rotor was that the degree to which the sample tubes swung out during rotation was variable, and moreover there was variability of flexure around the disc carrier which therefore gave inconsistent performance. The present invention aims to solve these problems and to provide a higher speed of operation.

Another problem with the previously described centrifuge rotor was the effectiveness of the seal.

According to a first aspect of the present invention there is provided a centrifuge rotor including a sample carrier enclosed within an outer housing and being rotatable about a principal axis of rotation of the rotor, the sample carrier having a peripheral zone for holding sample tubes in an orientation parallel to the said axis when at rest and the sample carrier being capable of deflecting to enable sample tubes to swing out under the effect of centrifugal force, wherein the sample carrier incorporates petal-like carriers for each tube equally spaced around said sample carrier, and characterised in that the central region of the sample carrier is of a thicker material than that of material forming said petal-like carriers, so that any flexing is concentrated in the region of said petal-like carriers.

According to a second aspect of the present invention there is provided a centrifuge rotor which comprises a sample carrier rotatable about a principal axis of rotation of the rotor, the sample carrier having a peripheral zone for holding sample tubes to permit centrifuging, and an outer casing having two parts and enclosing the sample carrier, the two parts of the outer casing being sealed together at a peripheral

zone by sealing means which is arranged so that sealing is increased by the effect of the centrifugal force arising during centrifuging.

Preferably the sealing means is a sealing ring having a profile in the form of a V-shape whose vertex is directed outwards. The limbs of the V then flex outwards during the centrifugal force and seal to the two parts in an effective manner.

According to another aspect of the present invention there is provided a centrifuge rotor including a sample carrier enclosed within an outer casing and being rotatable about a principal axis of rotation of the rotor, the sample carrier having a peripheral zone for holding sample tubes in an orientation parallel to the said axis when at rest and the sample carrier being capable of deflecting to enable sample tubes to swing out under the effect of centrifugal force, said centrifuge rotor being arranged so that beyond a given speed of rotation of the sample carrier deflection of the tubes is constrained to a predetermined angle.

In practice, for example, a rotor may have an

operational speed in the region of about 12,000 rpm and the deflection would be constrained at speeds above about 6 to 6.500 rpm. Thus, from start up the tubes progressively swing out and become constrained from about half operational speed and upwards as the rotor builds up in speed to its operational level.

Suitably the predetermined angle to which the tubes are constrained may be in the region of 40° to 45°. Constraint may be achieved by arranging for the tube to deflect to a point where it touches and is thereby constrained by the outer casing of the centrifuge; or an alternative means of achieving this constraint is by use of a sample carrier having a peripheral end region which constrains movement of the sample tubes.

Thus, conveniently the centrifuge rotor is enclosed within a transparent outer casing and strobing means can then be provided for examination of samples when being centrifuged.

It is preferable for the sample carrier to incorporate apertured petal-like carriers for each tube equally spaced around said sample carrier and integrally connected to a central region of the carrier which is

of a thicker material than that of material forming said petal-like carriers, so that any flexing of the sample carrier during centrifuging is concentrated in the region of said petal-like carriers. This arrangement enables the petal-carriers to each flex independently to a controlled angle without significantly affecting the rest of the carrier. Each petal-like carrier can be joined to the central region of the carrier along a line of weakness which enables each petal-carrier to flex about said line of weakness as the tube swings outwards under the effect of the centrifugal force.

The term petal-like carrier is used here to refer to a carrier of thin material which behaves like a petal or leaf opening out and closing relative to the central region.

Preferably the centrifuge rotor should be enclosed within an outer casing which can be opened and which when closed and during the rotation of centrifuging maintains an effective seal.

Thus the centrifuge rotor may include an outer casing of essentially two parts enclosing the sample carrier,

the two part outer casing being sealed together at a peripheral zone by sealing means which is arranged so that sealing is increased by the effect of the centrifugal force arising during centrifuging.

Preferably the sealing means is a sealing ring having a profile in the form of a V-shape whose vertex is directed outwards. The limbs of the V then flex outwards during the centrifugal force and seal to the two parts in an effective manner.

An embodiment of the invention will now be described by way of example with reference to the accompanying diagrammatic drawings in which:

Figure 1 is a sectioned side view of a centrifuge;

Figure 2 is a view of the centrifuge in use, and

Figure 3 is a plan view of a sample carrier.

Referring to Figure 1, a sample carrier 1 essentially in the form of a disc includes a central region 2 of a stiff plastics material having a plurality of petal-like carriers 3 (see Figure 3). The petal-like

carriers are each of a thinner material than the central region 2 and are joined to the central carrier at a line of weakness 4. It should be noted that this line of weakness is an optional feature and in some embodiments there is no specific line of weakness.

Each petal-like carrier 3 includes an aperture 5 to accommodate the neck of a sample tube 6. The sample carrier 1 includes thickened collars of material around each of the tube receiving apertures 5. The disc carrier is enclosed within an outer casing in the form of a housing which consists of two parts 7 and 8. The housing parts 7 and 8 and each sample tube are of transparent material so that the samples are visible when in use and when centrifuging is taking place.

The disc carrier rests on a surface of the housing 7 thereby providing greater stiffness and stability to the central region of the sample carrier 2 and the whole sample carrier and housing is carried on a shaft of a motor 9. The lower section 7 of the housing, and the sample carrier 1 are each attached to the shaft of the motor 9 by a nut 10 while the lid section 8 of the housing is attached by a nut 11 which is concentric with and surrounding the nut 10. Thus, the whole unit

can be detached from the motor while retaining the carrier and housing components locked together or just the lid section 8 can be removed as desired.

The lid section 8 is connected to the lower section 7 at a peripheral region which includes a V-shaped sealing gasket 12. The V-section 12 thus increases its sealing effectiveness while the system is in rotation due to centrifugal forces forcing the limbs of the V to splay outwards against the housing components, thereby providing an effective seal. The V-shape of the gasket 12 also helps to ensure that the seal is not extruded out through the interface between the lid and lower sections 7, 8 during high speed rotation. In operation, as the V-shape gasket 12 tends to open up, the upper and lower limbs of the V press against the corresponding adjacent flat surfaces of the lid and lower sections 7, 8. The underside of the lid section 8 in the region of the gasket 12 and from the gasket 12 to the lid's periphery is substantially flat. A recess housing the gasket 12 is provided entirely by an upstanding flange on the lower section 7. This means that the gasket 12 can be conveniently and neatly seated on the lower section 7. The upper section, that is the lid section 8,

includes reinforcing circumferential ribs 13 to ensure that distortion does not arise at the point of seal during high speed rotation.

Figure 2 shows a sectional view of the centrifuge in use, and it can be seen that the sample tube 6 has splayed outwards to an angle of substantially 45° due to the centrifugal forces arising, and the petal-like carrier has hinged about the line of weakness 4. The dimensions are selected so that the sample tube can only flex to this 45° position where its lower end abuts the edge of the housing 7.

In practice at start up the sample tubes progressively move outwards as the speed builds up and they reach a constrained condition at about half operational speed, and remain in that condition as the speed increases further. Thus in the specific example the operational speed is 11,750 rpm and the tubes reach their constrained condition at around 6-6.500rpm

The fact that the petals 3 are of thinner material and the provision of line of weakness in the sample carrier 1 are important because they limit deformation of the material surrounding the tube receiving

apertures 5 in use. Without these features the apertures 5, which are circular at rest, would tend to an oval shape in use. Such deformation would typically cause the inserted tubes 6 to be damaged and/or the petals 3 to rip and the tubes 6 to fall out.

The structure of the sample carrier and in particular the petals and any plastic hinge formed by a line of weakness have to be strong enough to withstand the "swinging out" which occurs in use.

It will be noted that in the fully swung out position each of the tube ends directly contacts with the internal surface of the outer casing 7. The high loads generated on the samples/tubes 6 during high speed rotation are shared between the structure of the sample carrier 1 itself and the outer casing 7 by virtue of the contact between it and the tube ends. The overall design avoids the provision of tube carriers of the type which substantially surround and provide support for the tubes 6. This minimizes the number of components and allows alternatives where the whole of the sample carrier 1, including the tubes 6 is moulded in one piece.

The left hand side of the figure shows a sample tube 6 of one capacity while 6' on the right hand side of the figure shows a sample tube of a slightly lower capacity which is so shaped that it also abuts the wall at the same 45° angle.

In use the centrifuge allows the sample tubes to be rotated at high speed with a controlled orientation so that when viewed by a strobe light, a stable image is shown and the centrifuging operation within the sample tube is visible.

CLAIMS:

1. A centrifuge rotor including a sample carrier enclosed within an outer housing and being rotatable about a principal axis of rotation of the rotor, the sample carrier having a peripheral zone for holding sample tubes in an orientation parallel to the said axis when at rest and the sample carrier being capable of deflecting to enable sample tubes to swing out under the effect of centrifugal force, wherein the sample carrier incorporates petal-like carriers for each tube equally spaced around said sample carrier, and characterised in that the central region of the sample carrier is of a thicker material than that of material forming said petal-like carriers, so that any flexing is concentrated in the region of said petal-like carriers.

2. A centrifuge rotor according to Claim 1 each petal-like carrier being joined to the central region of the sample carrier along a line of weakness which enables the petal carrier to flex about said line of weakness as the tube swings outwards under the effect of centrifugal force.

3. A centrifuge rotor according to claim 1 or 2

which is arranged so that beyond a given speed of rotation of the sample carrier, deflection of the tubes is constrained to a predetermined angle.

4. A centrifuge rotor according to Claim 3 in which deflection of the tubes is constrained by direct contact between the tubes and an internal surface of the outer housing.

5. A centrifuge rotor according to any preceding claim in which said outer housing is an enclosure in two parts enclosing said sample carrier, said two part enclosure being sealed together at a peripheral zone by sealing means which is arranged so that sealing is increased by the effect of the centrifugal force arising during centrifuging, said sealing means being a sealing ring having a profile in the form of a V-shape whose vertex is directed outwards.

6. A centrifuge rotor including a sample carrier enclosed within an outer housing and being rotatable about a principal axis of rotation of the rotor, the sample carrier having a peripheral zone for holding sample tubes in an orientation parallel to the said axis when at rest and the sample carrier being capable

of deflecting to enable sample tubes to swing out under the effect of centrifugal force, characterised by said centrifuge rotor being arranged so that beyond a given speed of rotation of the sample carrier, deflection of the tubes is constrained to a predetermined angle by direct contact between the tubes and an internal surface of the outer housing.

7. A centrifuge rotor according to Claim 6 in which said outer housing is an enclosure in two parts enclosing said sample carrier, said two part enclosure being sealed together at a peripheral zone by sealing means which is arranged so that sealing is increased by the effect of the centrifugal force arising during centrifuging, said sealing means being a sealing ring having a profile in the form of a V-shape whose vertex is directed outwards.

8. A centrifuge rotor which comprises a sample carrier rotatable about a principal axis of rotation of the rotor, the sample carrier having a peripheral zone for holding sample tubes to permit centrifuging, and an outer housing having two parts and enclosing said sample carrier, said two parts of the outer housing being sealed together at a peripheral zone by

sealing means which is arranged so that sealing is increased by the effect of the centrifugal force arising during centrifuging, said sealing means being a sealing ring having a profile in the form of a V-shape whose vertex is directed outwards.

9. A centrifuge rotor according to any preceding claim in which the housing is transparent to enable its contents to be viewed in use.

10. A centrifuge rotor according to Claim 9 in which strobing means are provided for examination of samples when being centrifuged.

11. A centrifuge rotor according to any preceding claim in which the sample carrier is a one piece moulding including sample tubes.

12. A centrifuge rotor according to any preceding claim in which collars are provided on the sample carrier to surround and support the sample tubes.

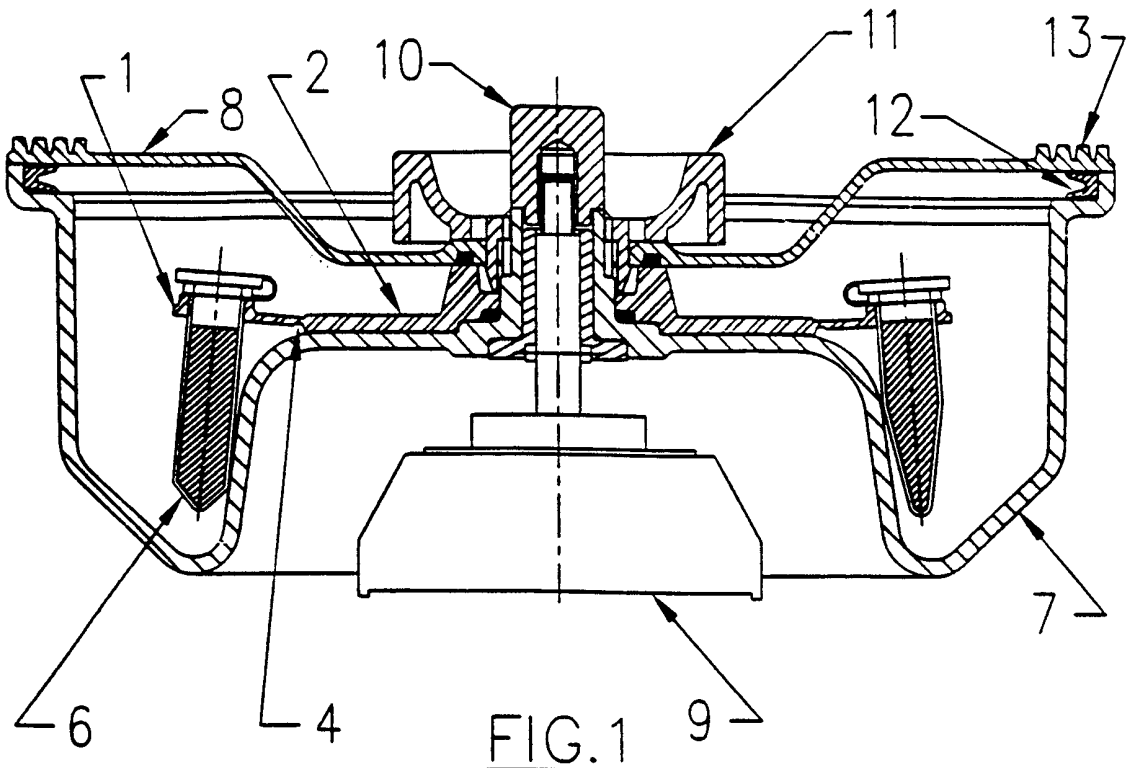


FIG.1

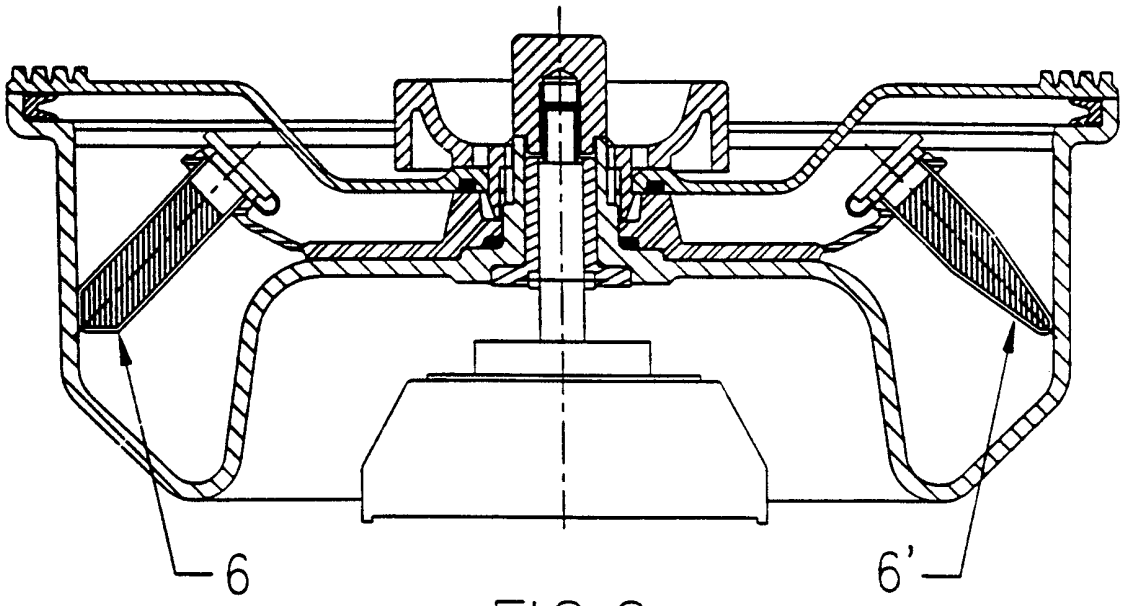


FIG.2

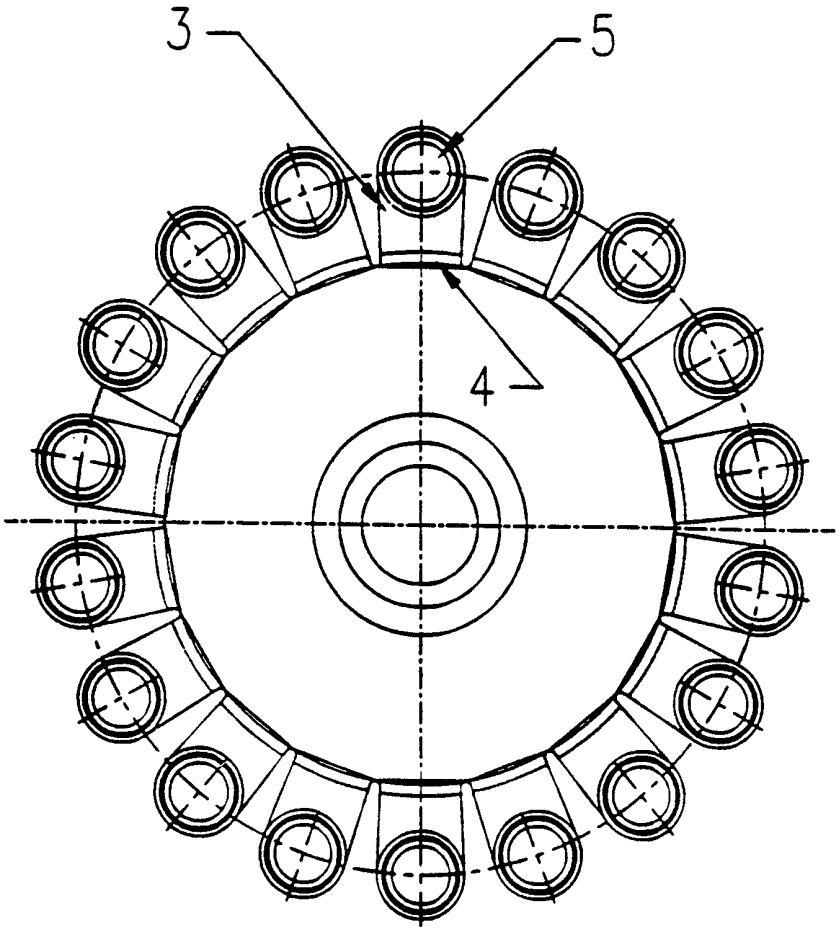


FIG. 3

INTERNATIONAL SEARCH REPORT

Intern ial Application No
PCT/GB 00/00401

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B04B5/04 B04B7/08 B04B7/02

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 7 B04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 2 233 584 A (R.A. KERBY) 16 January 1991 (1991-01-16) cited in the application	6,9-11
A	page 2, paragraph 2 -page 3, paragraph 2; claims 1-4; figures 1-3	1,5,7,8
Y	US 3 877 634 A (V.C. RHODE) 15 April 1975 (1975-04-15)	6,9-11
A	column 3, line 18 - line 55; figure 2	1,3,4
A	US 3 361 343 A (I.S. LERNER) 2 January 1968 (1968-01-02) column 2, line 26 - line 51 column 3, line 31 - line 73; figures	1,2,6,12

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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 when the document is taken alone

"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

Date of the actual completion of the international search	Date of mailing of the international search report
11 April 2000	18/04/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Leitner, J

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Interr ..al Application No
PCT/GB 00/00401

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 047 840 A (SHANDON SOUTHERN PRODUCTS) 24 March 1982 (1982-03-24) page 6, line 16 -page 7, line 14 figures 1,2	1,5-8
A	US 4 221 324 A (R.FREY) 9 September 1980 (1980-09-09) abstract; figures	1,3,4,6
A	GB 1 243 944 A (G. EBERLE) 25 August 1971 (1971-08-25)	
P,X	DE 198 07 668 A (KENDRO LABORATORY PROD.) 25 March 1999 (1999-03-25) the whole document	8

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 00/00401

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-7, 9-12

   Sample carrier for centrifuge rotor

2. Claims: 8-12

   Sealing for centrifuge rotor housing B

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern ıal Application No
PCT/GB 00/00401

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2233584 A	16-01-1991	NONE	
US 3877634 A	15-04-1975	CA 1007213 A	22-03-1977
		DE 2425165 A	12-12-1974
		GB 1470806 A	21-04-1977
		JP 1116239 C	15-10-1982
		JP 50022693 A	11-03-1975
		JP 57010776 B	27-02-1982
US 3361343 A	02-01-1968	NONE	
EP 47840 A	24-03-1982	AT 12024 T	15-03-1985
		JP 1431076 C	24-03-1988
		JP 57110352 A	09-07-1982
		JP 62039014 B	20-08-1987
		US 4391710 A	05-07-1983
US 4221324 A	09-09-1980	CA 1084460 A	26-08-1980
		DE 7835727 U	12-04-1979
		EP 0002270 A	13-06-1979
GB 1243944 A	25-08-1971	DE 1966274 A	15-06-1972
		FR 2094303 A	04-02-1972
		DE 1912322 A	10-12-1970
		US 3674198 A	04-07-1972
DE 19807668 A	25-03-1999	NONE	