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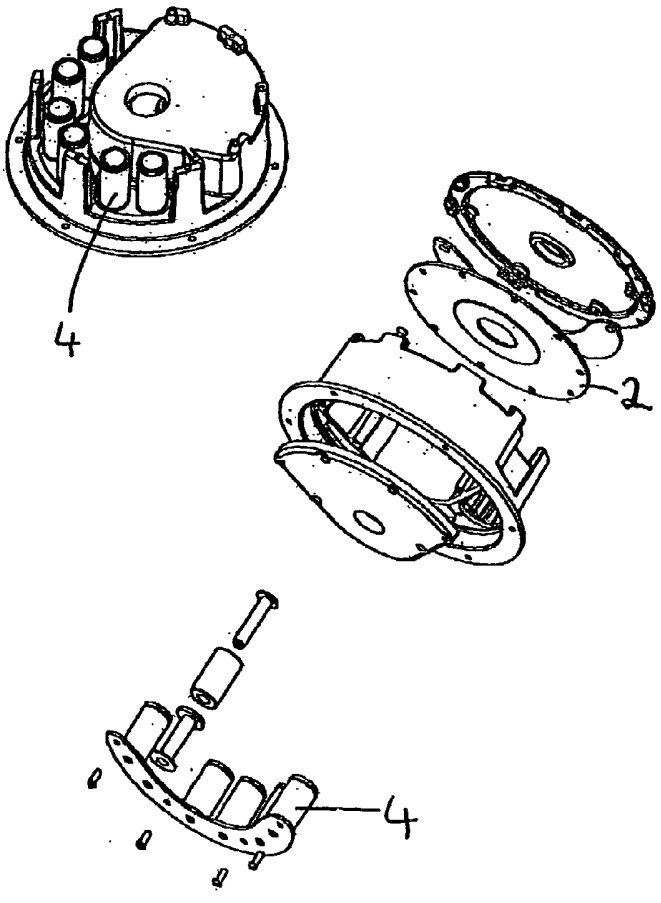
[Continued on next page]

(54) Title: LOAD APPLYING UNIT



(57) Abstract: A brake unit suitable for use in an exercise machine, wherein a rotating disk of the brake defines the outer diameter of the brake unit and wherein the electromagnetic assembly does not extend radially beyond that diameter, such that the unit is small and compact and leads to exercise equipment which is simple to maintain.

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Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

LOAD APPLYING UNIT

The present invention relates to a unit or system for applying a load and, thus, a braking effect in exercise apparatus or sports apparatus.

In many exercise machines, the user performs some form of activity, over a period of time, against the resistance of the machine. For example, a user may pedal an exercise cycle, perform a stepping motion on a stepper machine, a rowing motion on a rowing machine, etc.

Many exercise machines have adjustable resistance levels, thus allowing the user to increase the level of exercise as their fitness increases. This resistance is provided by means of a load applying device. Such devices are typically belt-friction brakes, using a band around a large flywheel, or electromagnetic eddy current brakes.

Typically, the human body exercises at a relatively low number of cycles per minute, generally in the region of 40 - 100 cycles per minute. Commonly used systems for offering resistance against an exerciser, in exercise machines, are only effective at a high number of revolutions per minute, e. g. in the range of 500 to 6000, or, torque needs to be amplified in order for the brake to be effective. Thus, for these systems to be useful in practice, the mechanism directly driven by the user, e. g. the rotation of pedals, the movement of steps, etc. causes rotation of a shaft, and this rotation is then stepped up to the higher rotation required to operate the braking mechanism by means of a gear mechanism using, for example, a chain or belt drive connecting the driven shaft with appropriate gear wheels.

Whilst such mechanisms are effective in operating the braking mechanism to provide the required resistance, the large belt or chain gearing mechanism is cumbersome and also requires a high level of maintenance in, for example, tensioning, greasing or re-fitting of various components. This high level maintenance is costly in terms of parts and time and means that the exercise machine is out of use during maintenance, which is clearly undesirable.

The present invention aims to solve the problems of the prior art by producing a braking unit which is small and compact and leads to exercise equipment that is simple to maintain.

According to one aspect, the present invention provides an eddy current brake unit comprising a rotatable disk or ring, at least part of which is formed from an electrically conductive material; and an electromagnetic assembly arranged to introduce eddy currents into the disk or ring as it rotates; characterised in that the electromagnetic assembly and the rotatable disk or ring are arranged relative to each other such that the diameter of the disk or ring defines the outer diameter of the brake unit and the electromagnetic assembly does not extend radially beyond that diameter.

Preferably, the rotatable disk or ring is rotated by means of a drive shaft connected to the rotatable disk or ring by means of a gear mechanism to cause the rotatable disk or ring to rotate at a rate greater than the rate of rotation of the drive shaft, wherein the drive shaft, the gear mechanism, the rotatable disk and the electromagnetic assembly are all arranged in a unit having a maximum diameter corresponding to the diameter of the rotatable disk or ring.

In the most preferred embodiment, the drive shaft rotates around the same axis as the axis of rotation of the rotatable disk or ring. However, the drive shaft and rotatable disk or ring may also rotate about different axes, both being within the radial range defined by the outer circumference of the rotatable disk, and such an arrangement would still achieve the advantages of the present invention.

Different types of step-up or gearing mechanisms may, of course, be used, including, for example, a number of rotatable gear wheels connected by chains or belts. Again, all of these components are arranged such that they fit within a radially defined area defined by the outer circumference of the rotatable disk or ring.

The electromagnetic assembly preferably comprises one or more electromagnetic coils arranged, in an axial direction, on one side of the rotatable disk or ring and a ferric plate or ring arranged on the opposite side of the rotatable disk or ring such that magnetic flux is generated which is cut by rotation of the conductive disk or ring.

Preferably several coils are used and these are arranged around an arch of a circle, preferably in a semicircle, having a radius smaller than that of the rotatable disk or ring.

The entire brake unit is preferably arranged in a housing slightly larger than the diameter of the brake unit, i.e. slightly larger than the diameter of the conductive disk or ring. This self-contained unit within the housing can then be easily attached and removed from, for example, the exercise machine in which it finds application.

In accordance with another aspect of the invention, there is provided an exercise machine comprising a driven mechanism operated by the user and a brake unit as described above, wherein the rotatable disk or ring is caused to rotate in response to operation of the driven mechanism, and wherein the electromagnetic assembly introduces eddy currents into the disk which exert a braking force on the disk, the braking force being conveyed to the driven mechanism operated by the user to provide resistance to driving by the user.

The brake unit of the present invention finds application in a large range of leisure and exercise machines, in particular exercise cycles, stepping machines, rowing machines, skiing machines and the like.

The braking unit itself, incorporated into a housing, could be merely provided with pedals connected to a drive shaft for causing rotation of the rotatable disk or ring and can be connected, via control circuitry, into, for example, a home computer or games console, such that rotation of the pedals by a user interacts with software in the computer or games console.

In another aspect of the invention, there is provided a single interface control circuit between a data processing machine and the brake unit, comprising a programmable integrated circuit located between a microprocessor serial port and a load circuit of the brake system. Rotation of the rotatable disk or ring generates a tachometer signal which is communicated, via the PIC to a computer. A load command is then provided by the computer, in response to the tachometer signal received, which is then communicated, via the PIC to the control circuitry for applying current to the electromagnetic assembly, and thus, to control the

braking effect on the rotatable disk or ring.

As a safety feature, to prevent over-heating of the coils, the system can be arranged such that no current is supplied to the electromagnetic assembly when no motion is applied to the pedals, etc. to drive the rotatable disk or ring.

Preferred embodiments of the present invention will now be described, by way of example only, and with reference to the accompanying drawings.

Figure 1 shows a simple schematic view of a braking unit according to the present invention;

Figure 2 is a side sectional view of the braking unit; and

Figure 3 is an exploded view of the unit, but not showing the gears and shafts.

The drive unit comprises a driven axle 1 driven by the user, via e. g. pedals or by a rowing or stepping motion etc. The unit also comprises a conductive disk 2 or ring caused to rotate with the driven axle around the same axis. This conductive disk 2 or ring is preferably made of conductive aluminium but may also be made of copper, some other conductive alloy or a complex conductive configuration for example.

The driven axle 1 causes the disk 2 or ring to rotate via a gear mechanism. The gear mechanism preferably comprises a number of different sized gear wheels 3 positioned on different axles or a plurality of step-up stages connected by small belts. In the preferred embodiment, the gear ratio is approximately 1:45. The ratio is preferably between 1:40 and 1:60 although other

ratios may be used, according to the particular application and requirements of the apparatus.

A plurality, preferably six, magnetic coils 4 are located inside the outer circumference of the disk or ring, but spaced from its inner circumference. The axes of the coils 4 are normal to the plane of the disk 2.

These coils are arranged around half of the inner circumference of the disk 2, in such a way that their pole faces adjacent the inner surface of the disk or ring alternate from coil to coil, i. e. the first coil may have a north face adjacent the ring; the next coil its south face; the next coil its north face, etc.

On the other side of the disk is provided a ferric ring. This ring, together with the alternating north, south, north etc. faces of the coils 4 on the opposite side of the conductive disk 2 forms a complete magnetic circuit.

The gap between the ferric ring and the faces of the coils is approximately 5mm, in a preferred arrangement and the conductive disk ring rotates within this gap.

Because the coils 4 are spaced around the circumference of a semi-circle, thus describing part of a ring having an outer diameter just slightly smaller than the diameter of the conductive disk or ring 2, the conductive disk cuts the magnetic flux generated by the electromagnets at the largest possible diameter within this compact arrangement.

The remaining space within the area defined by the circumference of the conductive disk is taken up by the gearing arrangement 3 described above.

The fact that all of the components are arranged within

the area of the conductive disk 2 means that the brake unit is as compact as possible.

In the preferred arrangement, the unit has a 20cm diameter and is in the form of a 10cm high cylinder.

As mentioned above, the preferred gear ratio is between 1:40 and 1:60, i. e. one revolution of the pedal crank or crank driven by the rowing or stepping motion, etc. produces up to 60 revolutions of the conductive disk. This can be achieved with a number of step-up stages or gear components such as 1:4, 1:4, 1:2 and 1:2. Such a configuration would give a total step-up of 1:64. In one preferred construction, the ratios selected are 1:4, 1:4, 1:1,94 and 1:2, giving an overall step-up of 1:62.1.

In the preferred embodiment, the step-up stages are fixed steel gears 3. However, other types of gear mechanism can also be used, for example toothed belts or chains and a combination of steel gears and toothed belts or chains. In one embodiment, a combination of steel gears and toothed belts is used, providing an overall step-up ratio of 1:45.

In the preferred example, where the braking unit is used in combination with an exercise bicycle, pedalling at say, 60 revolutions per minute turns the pedal cranks and this causes the conductive disk or ring to spin at 3726 revolutions per minute, with the preferred step-up ratio.

Preferably, the conductive disk is 200mm in diameter. The centre line of the ring or disk apparent to the pole faces of the electromagnetic coils is of radius 85mm. The conductive disk, apparent to the centre line of the magnetic field generated in the coils, therefore travels

at an equivalent linear speed of approximately 33m/s.

Preferably, the coils contain 7000 turns of copper wire around a soft iron core (relative permeability mu =7000). This will allow a current of approximately 100mA per coil.

Eddy currents are induced in the conductive disk as it cuts the perpendicular magnetic field. According to Lenz's law, which states that an induced emf will tend to cause a current to flow in such a direction as to oppose the cause of the induced emf, a force is apparent on the disk to oppose the generation of the eddy currents, i. e. a braking force.

In the particular example described herein, when the user pedals at 60 revolutions per minute, the brake will sink approximately 500 Watts of input power. This power is converted to heat in the aluminium disk through joule heating by the eddy currents. The heat is dissipated away from the disk by airflow stimulated by detailing on the aluminium disk.

The electromagnetic coils are driven by a circuit which may apply a fixed current level or a number of fixed current levels, for example zero, medium and high. A control circuit then switches these current levels on and off in order to achieve the appropriate average current. In this way, the system can be programmed to control the level of braking since changing the average current level across the coils changes the magnetic field generated by the coils, which changes the power sunk by the brake.

In a preferred embodiment, the brake unit contains a fixed position tachometer which generates a signal related to disk speed by reflecting a beam, preferably

an infrared beam onto the disk and detecting reflection of the beam from the disk. The disk is provided with markings or pits etc. which interrupt the reflection of the beam and the reflection pattern is converted into an electronic signal used by the control circuitry of the system.

The brake unit is particularly reliable because of the design of the fixed gear box which contains a number of highly reliable individual components, assembled to precision engineering standards in factory conditions, with appropriate life-wear characteristics on each of these components and, where necessary, lubrication sealed in appropriate places.

As the brake unit is comprised in a single compact unit, maintenance is greatly simplified since the unit can be removed in its entirety and replaced with a new unit without affecting the rest of the exercise machine, and thus minimising downtime of the machine.

The control electronics and remaining structure of the machine are not integrated with the brake unit and are thus not affected by removal of the unit.

As mentioned above, a tachometer can be incorporated into the brake unit and the control circuitry for the brake, in the preferred embodiment, is also novel.

In this particular preferred arrangement, the brake unit is controlled by means of a Programmable Integrated Circuit (PIC) chip located between a microprocessor serial port and the circuit which delivers the current supply to the coils in the brake unit. The PIC reads the tachometer signal and sends it to a controlling computer. The PIC acts as a serial interface and receives a load word from the computer and applies an

appropriate pulse width modulated signal to the circuit which applies current to the coils.

Preferably, in order to prevent the coil control circuit from overheating and burning out, the load current is only applied if there is rotary motion indicated from the tachometer.

Claims

1. An eddy current brake unit comprising a rotatable disk or ring, at least part of which is formed from an electrically conductive material; and an electromagnetic assembly arranged to introduce eddy currents into the disk or ring as it rotates;

characterised in that the electromagnetic assembly and the rotatable disk or ring are arranged relative to each other such that the diameter of the disk or ring defines the outer diameter of the brake unit and the electromagnetic assembly does not extend radially beyond that diameter.

2. An eddy current brake unit as claimed in claim 1 further comprising a drive shaft and a gear mechanism connected to the rotatable disk or ring configured so as to cause the rotatable disk or ring to rotate at a rate greater than the rate of rotation of the drive shaft.

3. An eddy current brake unit as claimed in claim 2 wherein the drive shaft, the gear mechanism, the rotatable disk, and the electromagnetic assembly are all arranged in said unit, said unit having a maximum diameter corresponding to the diameter of the rotatable disk or ring.

4. An eddy current brake unit as claimed in claims 2 or 3, wherein said drive shaft rotates around the same axis as the axis of rotation of the rotatable disk or ring.

5. An eddy current brake unit as claimed in any preceding claim wherein said electromagnetic assembly comprises one or more electromagnetic coils on one side of the rotatable disk or ring and further comprising a ferric plate or ring arranged on the opposite side of

the rotatable disk or ring.

6. An eddy current brake as claimed in claim 5 wherein said electromagnetic coils are arranged in an arch of a circle having a radius smaller than that of the rotatable disk or ring.

7. An eddy current brake unit as claimed in any preceding claim further comprising means for connection to control circuitry, said control circuitry adapted for connection to a data processing machine such that rotation of the rotatable disk or ring interacts with software in the data processing machine.

8. An eddy current brake unit as claimed in claim 7, wherein said data processing machine is a home computer or games console.

9. An eddy current brake unit as claimed in any preceding claim wherein said brake unit further comprises

a tachometer arranged to provide a signal representative of the rotational speed of the rotatable disk or ring and;

a load control circuit configured to control the load applied by the electromagnetic assembly in response to a load control signal.

10. An eddy current brake unit as claimed in claim 9, wherein said load control circuit is configured to control the load applied by said electromagnetic assembly in response to said load control signal which has been pulse width modulated.

11. An exercise machine comprising a driven mechanism operated by the user and an eddy current brake unit as claimed in any preceding claim, wherein the rotatable

disk or ring is caused to rotate in response to operation of the driven mechanism, and wherein the electromagnetic assembly introduces eddy currents into the disk which exert a braking force on the disk, the braking force being conveyed to the driven mechanism operated by the user to provide resistance to driving by the user.

12. An exercise machine as claimed in claim 11 wherein said driven mechanism is a cardiovascular exercise machine mechanism.

13. An apparatus comprising an eddy current brake unit as claimed in any of claims 1 to 10, a data processing machine and an interface control unit connected between said eddy current brake and said data processing machine, wherein

said interface control unit comprises a programmable integrated circuit connected between a microprocessor serial port and a load control circuit of the eddy current brake unit.

14. An apparatus as claimed in claim 13, wherein

rotation of the rotatable disk or ring generates a tachometer signal which is communicated to the data processing machine via said programmable integrated circuit; and

a load control signal is generated by said data processing machine in response to the tachometer signal and is communicated via said programmable integrated circuit to said load control circuit for applying current to the electromagnetic assembly so as to control the braking effect on the rotatable disk or ring.

15. An apparatus as claimed in claim 14, wherein said load control circuit is configured to control the load applied by said electromagnetic assembly in response to

said load control signal which has been pulse width modulated.

16. An apparatus as claimed in claim 13 or 14 wherein said data processing machine is a home computer or games console.

17. An eddy current brake unit as hereinbefore described with reference to the drawings.

FIG. 2

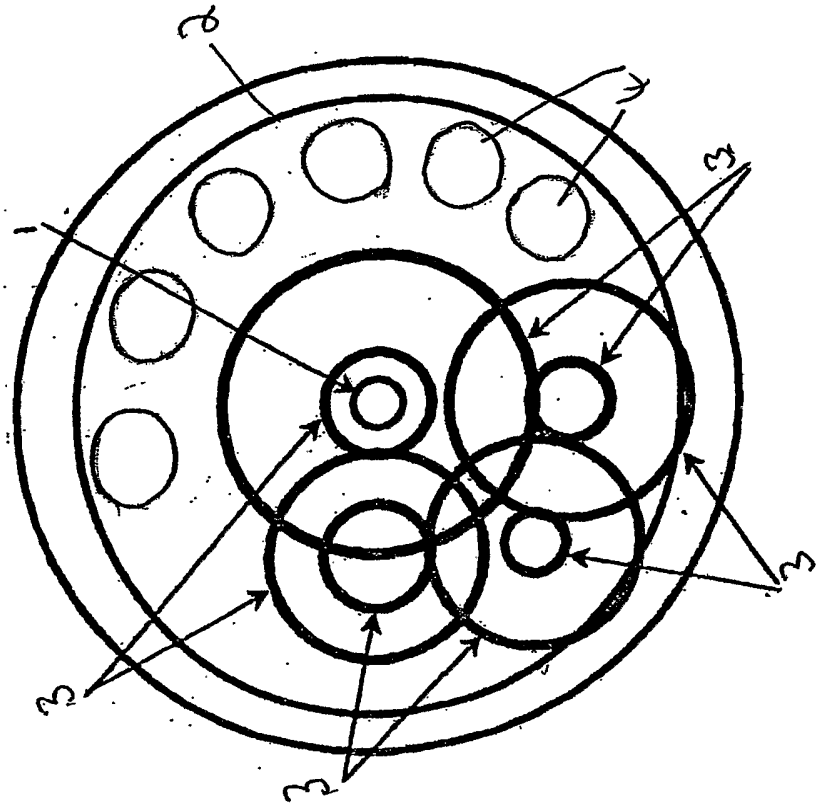

FIG. 1

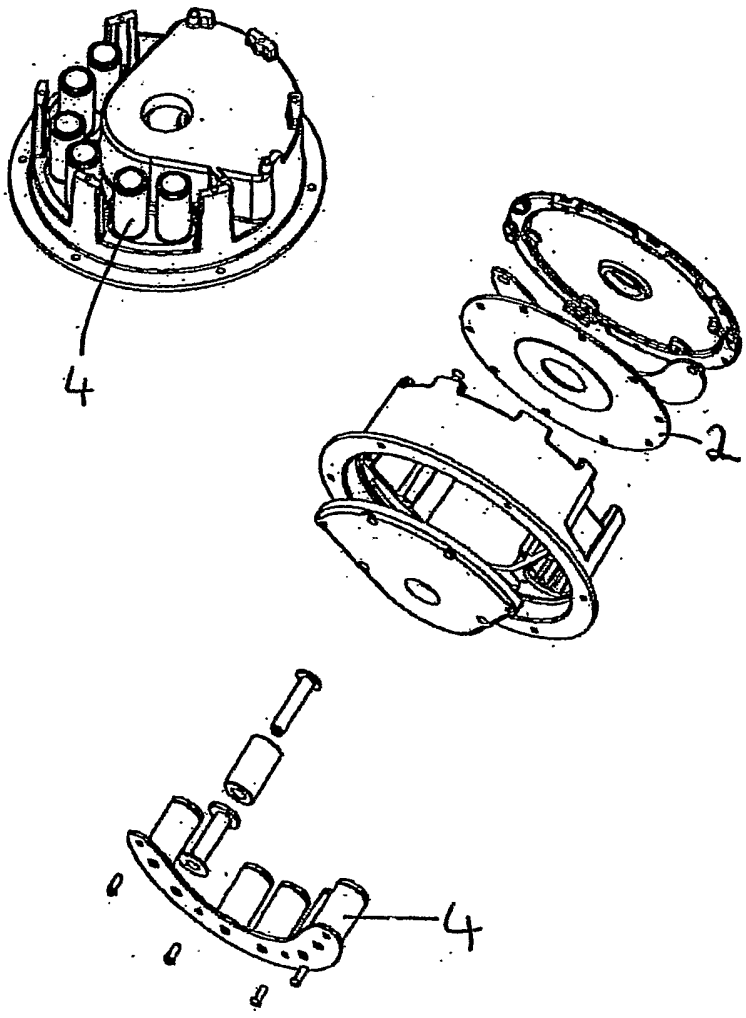

FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 02/11012

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02K49/04 A63B21/005

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 A63B H02K

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)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 116 294 A (FINDLAY NATHANIAL B) 26 May 1992 (1992-05-26)	1-4,11, 12
A	column 3, line 58 -column 4, line 36 column 5, line 36 - line 61; figure 2	5
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A	column 4, line 1 - line 32; figures 1,2 column 4, line 48 - line 53 column 5, line 36 - line 46 column 7, line 39 - line 47; figures 11A,11B	5,6,10, 13-16
X	US 5 072 930 A (SUN PAUL) 17 December 1991 (1991-12-17)	1,11,12
A	column 2, line 26 -column 3, line 46; figures 1-4	2-4

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[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
12 February 2003	19/02/2003

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	Levert, C

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

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 02/11012

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 656 001 A (BAATZ WILFRIED) 12 August 1997 (1997-08-12)	1,11,12
A	column 4, line 66 -column 5, line 53; figures 1-4	5,6
A	US 4 984 986 A (VOHNOUT VINCENT J) 15 January 1991 (1991-01-15) column 13, line 28 -column 15, line 63; figures 7,8,10	1,7-10, 13-16
A	US 4 828 257 A (RABENBERG BERLE E ET AL) 9 May 1989 (1989-05-09) column 7, line 36 -column 8, line 34; figures 2,3 column 11, line 33 -column 14, line 20; figures 6,7	1,7-10, 13-16
A	GB 906 635 A (ENGLISH ELECTRIC CO LTD) 26 September 1962 (1962-09-26) page 2, line 71 - line 101; figure 1	1,5
A	DE 26 50 147 A (FROUDE ENG LTD) 3 May 1978 (1978-05-03) page 8, line 13 -page 9, line 25; figure 1	1,5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP 02/11012

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. [X] Claims Nos.: 17
because they relate to subject matter not required to be searched by this Authority, namely:

Claim 17: Rule 6.2 (a) PCT - Reference to the drawings

2. [X] Claims Nos.: 1-16 (all in part)
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:

see FURTHER INFORMATION sheet PCT/ISA/210

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:

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

Continuation of Box I.2

Claims Nos.: 1-16 (all in part)

Present claims 1-16 relate to an extremely large number of possible apparatus. Support within the meaning of Article 6 PCT and/or disclosure within the meaning of Article 5 PCT is to be found, however, for only a very small proportion of the apparatus claimed. In the present case, the claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible. Consequently, the search has been carried out for those parts of the claims which appear to be supported and disclosed, namely those parts relating to an exercise apparatus or sports apparatus comprising an eddy current brake unit for applying a braking effect.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 02/11012

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