PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
A47D 9/04, 9/02

A1

(11) International Publication Number: WO 98/17155

(43) International Publication Date: 30 April 1998 (30.04.98)

(21) International Application Number: PCT/GB97/02888

(22) International Filing Date: 20 October 1997 (20.10.97)

(30) Priority Data:
9621897.9 21 October 1996 (21.10.96) GB

(71) Applicant *(for all designated States except US)*: LOCUS TECHNOLOGY LIMITED [GB/GB]; Campus Ventures Centre, University of Manchester, Oxford Road, Manchester M13 9PL (GB).

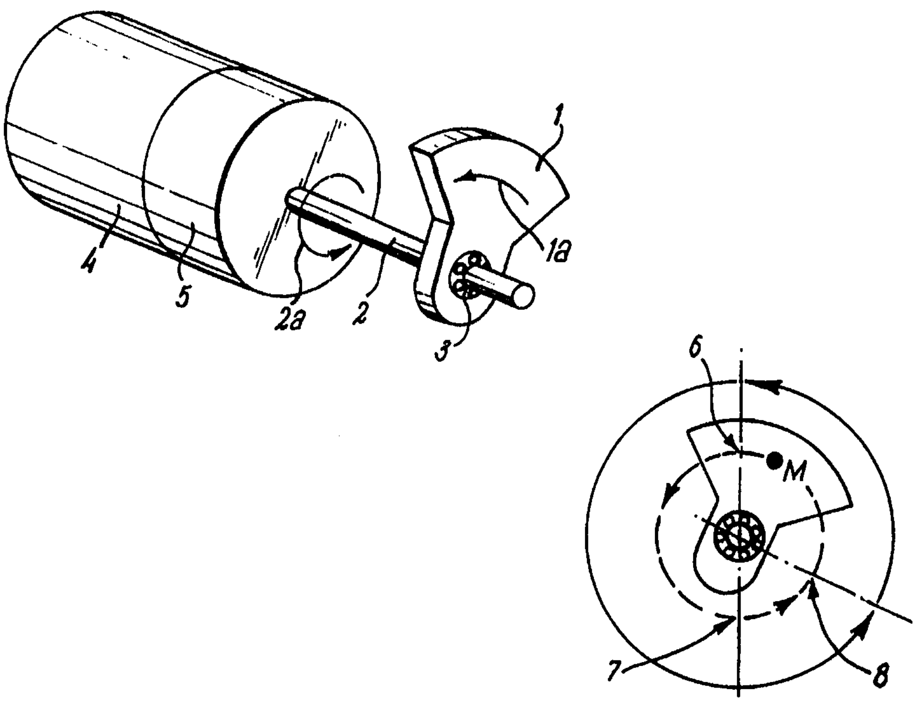
(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: BOWLES, Gary, Alexander [GB/GB]; Cabbage Row Cottage, 7 Back Blackburn Road, Egerton, Bolton BL7 9TL (GB). ROWORTH, Donald, Anthony, Acott [GB/GB]; Blake Lea House, Waters House, Marsden, Huddersfield HD7 6NG (GB).

(74) Agents: DOWNEY, William, Gerrard et al.; Wilson Gunn M'Caw., 41–51 Royal Exchange, Cross Street, Manchester M2 7BD (GB).

(81) Designated States: AU, CN, JP, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: VARIABLE SPEED ROTARY VIBRATOR



(57) Abstract

Apparatus and method for producing a varying force by the rotation of an unbalanced mass (1) at a non–constant angular velocity. The system may include an unbalanced mass (1) rotated by way of a uni–directional coupling (3). The apparatus is particularly directed to the rocking of a baby's seat, cot, pram or crib or a hammock for an adult or child.

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		

VARIABLE SPEED ROTARY VIBRATOR

The present invention relates to apparatus for producing a varying force and particularly, although not exclusively, to apparatus for rocking a baby's cradle or seat. The invention also has many other potential applications in diverse fields of engineering and product design including (by way of example) feed systems, vibrators, and therapy systems.

It is well known that a regular rocking motion can be very soothing for a fractious baby, especially if accompanied by pleasant and repetitive sounds which can include the mother's heartbeat. An early method of achieving rocking mechanically was a clockwork escapement mechanism applied to a swinging cradle. More recently, electrically-driven mechanisms using rigidly driven eccentric masses, rotated at a substantially constant angular velocity, have been available, generally designed to be attached to any item of baby equipment or nursery furniture which can be made to rock or otherwise oscillate.

It is well known that periodic forces are generated by an unbalanced rotating mass. If the rotating mass is circular, the forces may be felt by contact with the periphery, or (whether circular or not) they may be transmitted by an axle to a journal or bearing. For example, railway locomotive wheels impart an undesirable "hammer blow" to the track unless the whole system of the wheel and any coupled parts is carefully balanced.

The direction of the out-of-balance force (the centripetal force) generated by an unbalanced rotating system rotates at the angular velocity of the system (ω). The force resolved in any particular direction shows a sinusoidal variation.

The sinusoidally varying force can be resolved in any direction in the plane of rotation, but the phase alters with the direction chosen. Changing the rate of rotation alters the frequency of variation of the force and also alters its amplitude according to the square of the change in rotary speed.

There are many established applications where this effect is put to practical use to vibrate or oscillate a work-piece or load to which the mechanism is attached, but its capability has severe restrictions when applied to slow speed applications (for example, where the periodicity is of the order of seconds).

The magnitude of the out-of-balance force is dependent upon both the size of the out-of-balance mass and its rate of rotation. To increase the magnitude of the out-of-balance force for a given system requires either or both the mass or rate of rotation of the system to be increased.

Where an out-of-balance rotating mass is used to drive a periodic system, for example, a baby's cradle, it is preferable for the frequency of rotation of the mass to be equal to or a factor of the natural frequency of the driven system. This restricts the rate at which the out-of-balance mass may be rotated. Therefore, in order to generate a driving force of sufficient magnitude at a given frequency it is necessary to increase the mass of the out-of-balance mass. This is inconvenient as the heavier a particular mass the more expensive and difficult to handle it becomes. When a mass is attached to a cradle, for example, it is also important that it is not so heavy as to significantly unbalance the cradle.

As the natural period of oscillation of a typical baby+chair+rocker combination is low, being typically of the order of 2 seconds (i.e. 30 cycles per minute), a rigidly driven eccentric mass rocking system is ineffective for the reasons analysed above, and the amount of energy which it can transfer (and so the amplitude of movement which it can achieve) is severely limited. Attempts to increase this by making the rocker unit larger and heavier tend to be largely self-defeating because the increased weight further reduces the natural frequency of the rocker/chair/baby combination and may unbalance the system.

Another problem associated with the use of an unbalanced rotating mass to drive a periodic system is that the amplitude of the out-of-balance force is the same in all directions in its plane of rotation, so that, unless the load is constrained to move only in a plane it can be vibrated in a circular motion. For example, where a mechanism of this sort is applied to rock a baby seat, it would tend to impart a side-to-side motion to the seat as well as a vertical one. The sideways motion is undesirable and can be dangerous because it may cause the seat to "walk" from its original position.

Other systems for imparting a periodic force use reciprocating parts, for example, with a spring which is progressively compressed and then, when released, drives a mass in a straight line to an end stop. These are relatively complex and generally less reliable, require more maintenance, and are more noisy than simple out-of-balance rotating systems.

It is an object of the present invention to overcome, or at least mitigate some or all of the performance disadvantages of the simple rotary out-of-balance system, whilst retaining its simplicity and absence of reciprocating parts.

According to a first aspect of the present invention there is provided apparatus for producing a varying force comprising a rotatably mounted unbalanced mass and a means for rotating the unbalanced mass to produce an out-of-balance force wherein said means enables the mass to be rotated at a non-constant angular velocity.

By rotatably mounted unbalanced mass is to be understood a rotatably mounted mass the centre of mass of which is displaced from the axis of rotation.

Preferably the unbalanced mass is rotated so as to produce a substantially periodic force.

Preferably the means for rotating enables the angular velocity of the mass to be varied throughout a single revolution. More preferably the means for rotating the mass enables the angular velocity of the unbalanced mass to be varied in a predetermined manner, preferably in a repeatable manner. For example, to accelerate the rate of rotation of the unbalanced mass over a predetermined part of a revolution and then decelerate the rate of rotation over the remaining part of the revolution, so as to increase the out-of-balance force in a given direction.

By varying the rate of rotation of an unbalanced mass it is possible to increase the out-of-balance force in a given direction whilst maintaining a desired periodicity.

In one embodiment the means for rotating the mass comprises a motor which may rotate at constant angular velocity, connected to the mass by means of a uni-directional rotational coupling. The motor preferably rotates at a substantially constant angular velocity. The uni-directional coupling is preferably disposed so that the motor can drive the mass in one direction only and that the mass can overrun the motor, that is, rotate faster than the motor in the direction that it is driven. This embodiment is particularly addressed to applications when the plane of rotation of the unbalanced mass is other than horizontal.

Where the plane of rotation of the out-of-balance mass is not horizontal the rotation of the mass will tend to be accelerated by gravity during a part of its rotation, thus producing a non-constant angular velocity.

The motor preferably comprises an electric motor. The motor may drive the mass by way of a gearbox, belt, or any other suitable transmission means. The uni-directional coupling is preferably effected by a one way roller bearing although any other suitable means may be employed. It is preferable that the uni-directional coupling has a minimum of backlash.

Preferably there is also provided means to enable the overall periodicity of the out-of-balance mass system to be adjusted, to enable the system to be tuned to the natural frequency of the system to be driven. Where the drive means comprises a motor and uni-directional coupling the drive means preferably also comprises a means to vary the rate of rotation of the motor.

The apparatus is preferably self contained. Means for storing a battery to run the drive means are preferably provided on the apparatus. Rechargeable batteries may be employed.

There is also preferably provided a control means for controlling the drive means. The control means may comprise a timer to enable the drive means to operate for a predetermined period of time and then to stop automatically.

The control means may also include a means to automatically adjust the overall periodicity of the system to the natural frequency of the driven system. To achieve this the control means may include one or more sensing means.

The apparatus is preferably provided with a means to enable it to be secured to a child's seat, cot, cradle, hammock for use by adults or children or other object, this means preferably comprises a bracket, strap or straps. Alternatively the apparatus may be integrated with a child's seat, cot, cradle or other object.

When the apparatus is intended for rocking a baby's cradle, and indeed for other applications, it is desirable that the apparatus is balanced in order that it can be easily attached to the cot, cradle or other object. For instance, when the apparatus is suspended or secured at two points it is desirable that the centre of mass of the device lies substantially at the midpoint between the suspension points.

According to a second aspect of the present invention there is provided a method of producing a varying force comprising the steps of rotating an unbalanced mass to produce an out-of-balance force wherein said mass is rotated at a non-constant angular velocity.

By rotatably mounted unbalanced mass is to be understood a rotatably mounted mass the centre of mass of which is displaced from the axis of rotation.

Preferably the angular velocity of the mass is varied throughout a single rotation of the mass. More preferably the rate of rotation is varied in a predetermined and repeatable way throughout each revolution.

In order that the invention may be more clearly understood there are now described embodiments thereof, by way of example and with reference to the accompanying drawings in which:-

Figure 1a shows diagrammatically the manner in which a rotating out-of-balance mass generates a force;

Figure 1b shows a graph of the force generated by the mass illustrated in Fig.1a, resolved in a particular direction;

Figure 2a shows a perspective view of a first embodiment of the invention;

Figure 2b shows an end elevation of the embodiment illustrated in Fig.2a;

Figure 3 shows an embodiment of the invention mounted on a baby carriage;

Figure 4 shows an embodiment of the invention mounted on a baby's chair;

Figure 5 shows an embodiment of the invention mounted on a baby's rocking chair, the chair is resting on a carpeted surface;

Figure 6a shows a part perspective view of a further embodiment of the present invention;

Figure 6b shows a side elevational view of the embodiment illustrated in Figure 6a, hidden detail is shown by way of dashed lines;

Figure 7a shows a part cross-section of a third embodiment of the invention;

Figure 7b shows an end view of the embodiment illustrated in Figure 7a, secured to a part of a baby chair;

Figure 8 shows a part cross-sectional view of a still further embodiment of the invention;

Figure 9a shows a side elevation of a rocking chair mounted on runners; and

Figure 9b shows a part cross-sectional view of a runner illustrated in Figure 9a.

Referring to Figure 1a, when mass M is constrained to travel in a circular path force f is generated as follows:-

$$f = m\omega^2 r \text{ Newtons}$$

where	f	is the force acting radially
	ω	is the angular velocity in radians/sec
	m	the effective unbalanced mass in kg
and	r	the effective radius of rotation of the mass in m.

Figure 1b shows a graph of the force produced by the mass m of Figure 1a resolved in a particular direction, plotted with respect to the angular position θ of the mass m. The force varies sinusoidally with maximum and minimum values of $m\omega^2 r$ and $-m\omega^2 r$.

From the above it can be seen that the amplitude of the radial force generated by a rotating out-of-balance mass is dependent upon the frequency of rotation and that to generate a significant force requires a large unbalanced mass and/or a large radius, especially at slow rotational speed. For very slow rotation the force becomes minimal, even with a substantial rotating mass, because of the square law relationship between force and angular velocity

Referring to Figures 2a and 2b the apparatus comprises an out-of-balance mass rotor 1 mounted on a shaft 2 by way of a one way roller bearing 3. The shaft 2 is connected to motor 4 by way of reduction gearbox 5. The one way roller bearing allows the rotor 1 to rotate in the direction of arrow 1a, relative to the shaft 2. The intended direction of rotation of shaft 2 is shown by the arrow 2a.

The motor 4 and gearbox 5 enable the shaft 2 to be driven at a low, say between 10 and 100 revolutions per minute, but adjustable and substantially constant rate of rotation.

The mode of operation of the device is as follows: Consider the rotor 1 initially to have its centre of mass M rising, being raised slowly but steadily by the rotation of the output shaft 2 via the locked one-way roller bearing 3. As the centre of mass M passes its highest point 6, it will fall forward as it over-runs the shaft and is no longer restrained by the one-way roller bearing 3. The rotor will accelerate under gravity, and will reach its maximum angular velocity when M passes the lowest point 7, imparting a significant impulse vertically downwards as it does so. As it continues to rotate further, the rotor 1 will slow down as its centre of mass M rises, reducing angular velocity until it is again locked onto the shaft by the one-way roller bearing 3 at about point 8 when the rates of rotation of the shaft 2 and rotor 1 coincide.

In effect the rotor is coupled to the shaft only for a portion of the rising part of the cycle. For the rest of each cycle it is free to rotate, spending approximately the first 180° falling under gravity and a part of the next 180° decelerating under gravity until the constant rotation of the shaft "catches" it.

The exact proportion of the cycle for which the rotor is driven by the shaft will depend upon the rate of rotation of the shaft and the amount of energy which is imparted to the load during the impulse around its lowest point. The smaller the part of the cycle for which the bearing is locked, the higher the impulse rate for a given shaft speed.

In this embodiment it will be seen that (i) the effective rate of rotation of the rotor is greater than that of the shaft (ii) the force exerted on the load is impulsive, not sinusoidal (iii) the impulse is always downwards (iv) for slow rates of rotation, the amplitude and shape of the impulse are fixed and independent of the rate of rotation.

It can be shown that the maximum impulse force F_A exerted by the freely-rotating unbalanced rotor (i.e. at the point where its centre of mass is vertically below the axle) is given by

$$F_A = m\omega^2 r + 4mg$$

where g is the acceleration due to gravity (i.e. 9.81 m/s^2) and the other variables are as defined before, whereas for a fixed drive rotor the force F_B at the same position is given by

$$F_B = m\omega^2 r$$

The ratio of the "free-fall" force to the "fixed" force for a given set of parameters is thus

$$F_A/F_B = 1 + (4g/\omega^2 r)$$

Taking a typical rotational speed of the shaft as 60 revolutions per minute and the radius of rotation of an unbalanced mass of 0.1 kg as 25 mm, it can be calculated from the above that the downwards impulse imparted to the load as the freely rotating centre of mass passes its lowest point is approximately 40 times greater than that obtained from the same weight and size of rotor if the rotor were permanently fixed to the shaft. The downwards momentum imparted to the load is (as required) much greater than the upwards or transverse momentum.

At low rates of revolution, changing the shaft speed has very little effect on the amplitude of the impulse, but its frequency will change and can be simply adjusted to be close to resonance with the natural frequency of the load. Because of the non-sinusoidal force waveform, the impulsive force has a wider spectrum and will continue to impart significant energy to the load even if somewhat away from synchronism.

Compared with the established method of rotating an out-of-balance rotor at a constant angular velocity by a rigid drive, it can be seen that this invention enables the same effect to be obtained with a much reduced weight, especially when the periodicity is low. This gives a considerable improvement in safety, the reduced weight being much less likely to destabilise the load or to cause damage should it become detached.

It is known that to obtain the maximum transfer of energy between two coupled oscillating systems they need to be operating at the same frequency but out of phase. Thus to obtain the maximum effect when an out-of-balance rotating mass is applied to a load (for example, to rock a chair), the periodicity of rotation must be adjusted to match the natural period of oscillation of the chair. This may simply be achieved by a manual adjustment to the voltage applied to the drive motor (for example, by means of a potentiometer), but if there is no feedback means to maintain synchronicity under changing load or drive characteristics coupling efficiency will be lost and the effect on the load will diminish. The present invention shows a significant advantage over a simple rigid drive system in this respect, because it has an inherent degree of self-adjustment to the natural period of oscillation of the load. This arises from the free-wheeling effect of the one-way coupling: the angle through which the rotor turns freely before being "caught" by the coupling is greater if the drive is lagging the load and less if the drive is tending to lead the load, due to the relative movement of the free rotor and the load. Thus the effective periodicity of the drive will reduce in the former case and increase in the latter case, tending to correct for unequal periodicities of drive and load. Because this process is effective in providing such stabilising negative feedback over only a limited range either side of the "correct" periodicity, it requires the user initially to set the drive to approximately the correct speed. However, once set it is effective in maintaining a closer synchronism than the conventional fixed-rotor approach where there is no such feedback mechanism.

Referring to Figures 3 to 5 there are illustrated a number of possible mounting positions for embodiments of the present invention, indicated as 9 in each Figure. In Figure 3 the rocker 9 is attached by straps 11 to the handle of a baby carriage 10 which it causes to oscillate on its springs. A second example is shown in Figure 4, where a baby chair 12 having a springy frame 13 has the rocker 9 attached to the top of the chair by adaptor 14.

In general to obtain the maximum effect, it is necessary to place the rocker as far as possible from the pivot point to obtain the maximum leverage. This is achieved with the baby carriage 10 by attaching the rocker to the handle, and with the chair 12 by attachment to the top of the frame.

When the load to be driven is lossy, as shown in Figure 5, where a baby chair with integral rockers 15 is placed on a soft carpet 16 which absorbs energy as the chair rocks, there is no opportunity for the amplitude of oscillation to build up from a small sinusoidal driving input, and a fixed-drive rocker with its low energy output can be ineffective.

Referring to Figures 6a and 6b, a further embodiment of the invention is illustrated comprising an eccentric rotor which is formed from a shaped disc 17 of material, rotated on its axis by a motor/gearbox combination 18 to which it is coupled. The drive between gearbox and disc is turned through 90° by means of a bevel gear or spur gear set 19, resulting in a compact unit.

The disc is coupled to the drive by means of uni-directional coupling 21. Alternatively the gearbox may be so constructed that one of the gears disengages under reverse torque, a technique well established in clockwork mechanisms to allow winding without disconnection from the load.

Referring to Figures 7a and 7b there is illustrated a further embodiment, contained in a substantially cylindrical housing 31, which may be attached to the handle 51 of a baby chair by (for example) straps 22.

This embodiment employs an electric motor/gearbox combination 23 controlled by a switch 25 and speed control potentiometer 24 to enable the rate of rotation of the motor to be adjusted.

The motor/gearbox 23 drives out-of-balance mass 26 via shaft 27 and one way roller bearing coupling 28. The out-of-balance mass 26 is cast or machined from a substance of high density such as steel or cast iron, and is linked to shaft 27 by one-way coupling 28.

Bearings 29 support the motor shaft and the rotor, and must be of sufficient strength to withstand the out-of-balance forces as the rotor rotates.

The cast or moulded housing 21 may be designed so that it is made from two identical halves (to minimise tooling cost), each of which may incorporate ears 30 for the attachment of straps or clips by which the unit is secured to the load. The housing is preferably produced from a plastics material.

The embodiment of Figure 7 gives a long slim unit ideally suited to attachment to the handle of a pram or push-chair.

The motor 23 is preferably a dc, permanent magnet electric motor. The power supply may be external although preferably there is made provision for the storage of batteries on the body 31 of the apparatus (not shown).

Figure 8 shows a still further embodiment, in which the rotor is in effect folded back to rotate around the motor. The cylindrical case 32 is again cast or moulded from two identical halves and incorporates ears 33 for attachment purposes. The motor/gearbox combination 34 is supported at the rear end of the motor by a moulding (or pair of split mouldings) 35 which have a key into the motor casing to prevent it rotating under torque. Moulding 35 is itself supported firmly by ribs 36 in the case into which it is fitted when the case is assembled. An axial hole 37 in moulding 35 permits the wiring from the potentiometer 38 and power socket 39 to reach the motor.

Moulding 35 is so formed that a portion of its outside face forms a cylindrical bearing surface for an extension 40 to the rotor 41. The extension may be a moulding or a casting, and is designed to be clipped or screwed to rotor 41 during assembly, one end of moulding 35 being not greater in diameter than the bearing area to permit the circular bearing aperture in extension 33 to pass along it to its correct position during assembly. Although the bearing thus formed has a relatively large diameter, friction levels may be kept low by the use of self-lubricating plastic for one or both parts. The other end of rotor 41 is supported by a one-way roller bearing 42 carried on the gearbox output shaft 43, which is extended to a plain bearing 44 supported by ribs 45. This bearing provides the support for the other end of motor/gearbox 34 and must withstand and convey the eccentric impulse from one end of rotor 41 as it rotates. This approach approximately halves the overall length of the unit for a small increase in diameter, and achieves a centrally-balanced impulse to the load.

A cavity 46 formed between the case halves provides space for electronics, if required, for versions of the product with added features, which may include a soothing sound generator and/or automatic activation. The sound generator may be designed to produce soothing music or an approximate simulation of maternal heartbeat. The automatic activation may be designed to turn the rocking on and off at predetermined or random intervals, or by the use of sensors may respond to movement or sound from the baby.

An alternative version of the compact design of Figure 8 may be achieved by eliminating the eccentric mass and using the motor itself as the eccentric mass. Most reduction gearboxes applied to small motors have the output shaft offset from the motor axis. By clamping the shaft so that it cannot rotate, and supporting the remote end of the motor in a suitable eccentric bearing, the motor will rotate in such a way that its centre of mass rises and falls. If the gearbox incorporates a gear which disengages under reverse torque, the motor will describe an impulsive eccentric path producing an effect similar to that from an out-of-balance rotor. Special steps must be taken to convey power to the rotating motor, and this may be achieved (for example) by slip rings, by inverting the motor construction so that the coils surround the permanent magnet and are stationary while the magnets rotate, or by introducing electrical isolation between the motor and the gearbox output shaft so that an electrical circuit may be obtained via the two bearings.

The embodiment of Figure 8 is so designed that its centre of mass lies approximately half way between ears 33 to enable it to be conveniently attached to a chair or pram or other rockable item without the rocking action causing the chair to walk.

Referring to Figures 5 and 9, even with the greater impulsive drive to the load obtained by the application of a one-way drive to the rotor, effective rocking results cannot be obtained when there is much energy loss due to a soft carpet as exemplified in Figure 5. Such a problem may be simply overcome by interposing a hard surface, such as a sheet of hardboard, between the chair rockers and the carpet. A more compact and convenient solution, which has the added advantages of lower cost and inhibiting "creeping" of the load across the floor as it rocks, may be achieved by the use of short lengths of appropriately shaped aluminium or plastic extrusion 47 as shown in Figure 9. The cross-section of the extrusion is such that if the rocker 48 is tending to run off line there is a self-centring action due to the "valley" shape 49. Ridges 50 on the underside lock the extrusion into the carpet and prevent it from moving, while those on the topside act as a safety barrier to prevent the rocker falling off the extrusion under extreme misalignment. The extrusion cross-section is reversible so that the user need not be concerned with placing it the right way up.

The above embodiments are described by way of example only and many variations are possible without departing from the invention.

CLAIMS

1. Apparatus for producing a varying force comprising a rotatably mounted unbalanced mass and a means for rotating the unbalanced mass to produce an out-of-balance force wherein said means enables the mass to be rotated at a non-constant angular velocity.

2. Apparatus as claimed in claim 1, wherein the means for rotating enables the angular velocity of the unbalanced mass to be varied throughout a single revolution.

3. Apparatus as claimed in any preceding claim, wherein the means for rotating the mass enables the angular velocity of the unbalanced mass to be varied in a predetermined manner.

4. Apparatus as claimed in any preceding claim, wherein the apparatus is arranged to produce a substantially periodic force.

5. Apparatus as claimed in any preceding claim, wherein the means for rotating the mass comprises a uni-directional coupling.

6. Apparatus as claimed in any preceding claim, wherein the means for rotating the mass comprises a motor.

7. Apparatus as claimed in any preceding claim, wherein there is also provided means to enable the overall periodicity of the rotation of unbalanced mass to be adjusted.

8. Apparatus as claimed in claim 7, when appendant to claim 6, wherein said means to enable the overall periodicity of the unbalanced mass system to be adjusted comprises a means for controlling the rate of rotation of the motor.

9. Apparatus as claimed in any preceding claim, wherein there is also provided a control means for controlling the drive means operative to stop the drive means automatically after a predetermined period of time.

10. Apparatus as claimed in any preceding claim, wherein there is also provided a control means adapted to automatically adjust the periodicity of the unbalanced mass system to the natural frequency of any article driven by the apparatus.

11. Apparatus as claimed in any preceding claim, wherein there is provided on the apparatus a means for storing an electric battery.

12. Apparatus as claimed in any preceding claim, wherein means are provided to enable the apparatus to be mounted onto an object to which it is desired to apply a force.

13. Apparatus as claimed in any preceding claim, wherein the apparatus is adapted to be integrated into an object to which it is desired to apply a force.

14. A method of producing a varying force comprising the steps of rotating an unbalanced mass to produce an out-of-balance force, wherein said mass is rotated at a non-constant angular velocity.

15. A method as claimed in claim 14, wherein the angular velocity of the mass is varied throughout a single revolution.

16. A method as claimed in either claim 14 or 15, wherein the angular velocity of the mass is varied in a predetermined manner.

17. A method as claimed in any of claims 14 to 16, wherein the mass is so rotated to produce a substantially periodic force.

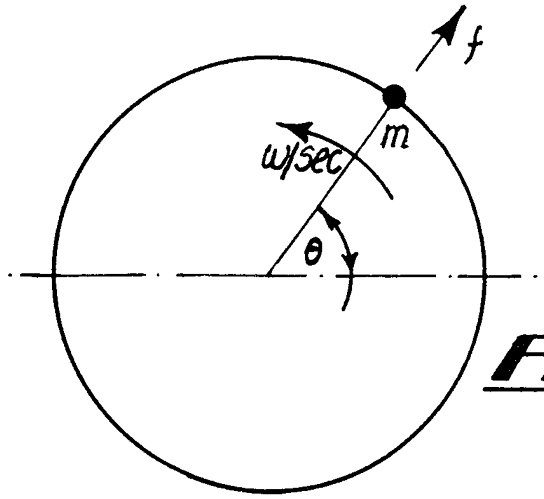


FIG. 1a

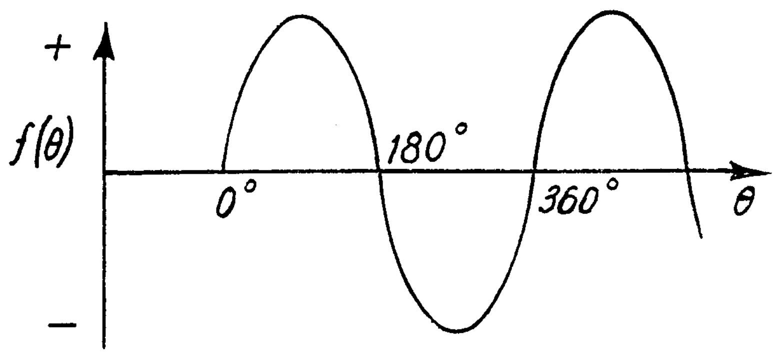


FIG. 1b

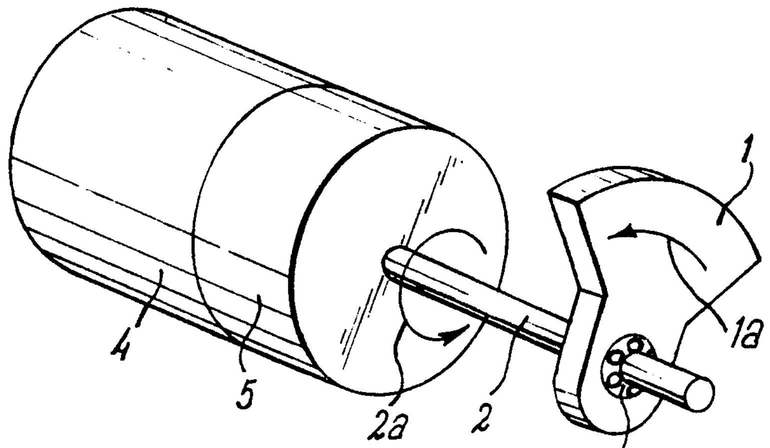


FIG. 2a

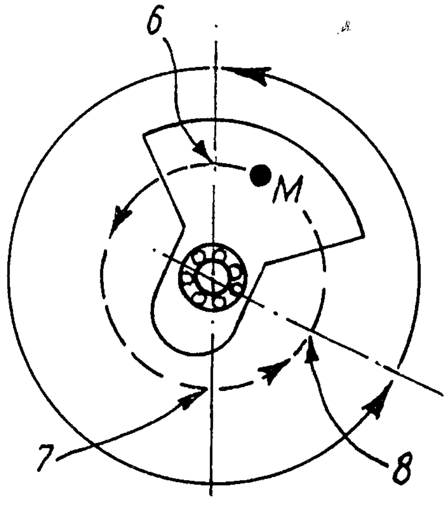


FIG. 2b

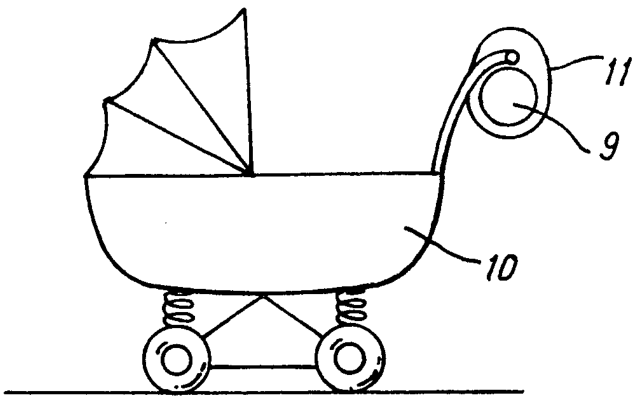


FIG. 3

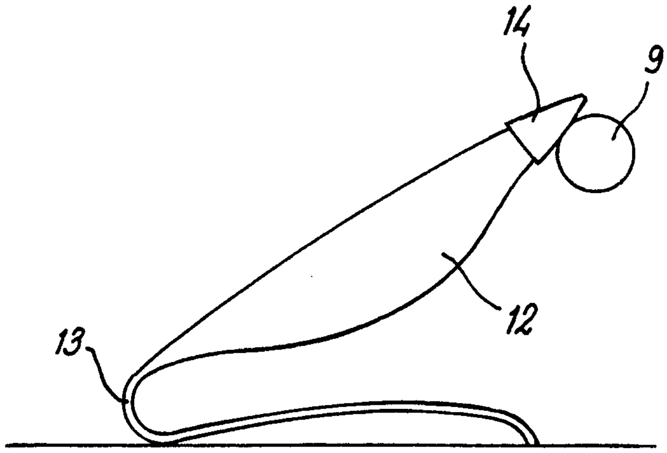


FIG. 4

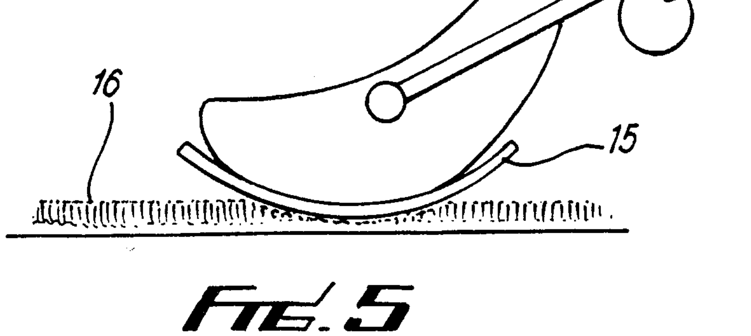


FIG. 5

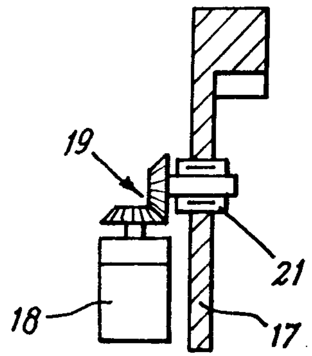


FIG. 6a

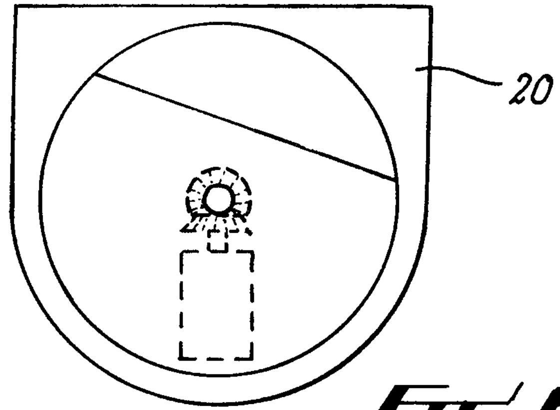


FIG. 6b

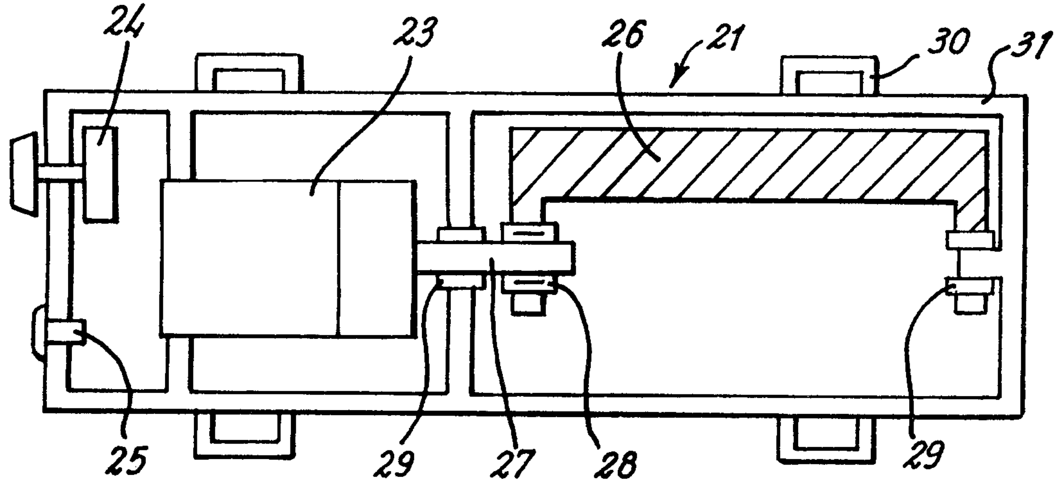


FIG. 7a

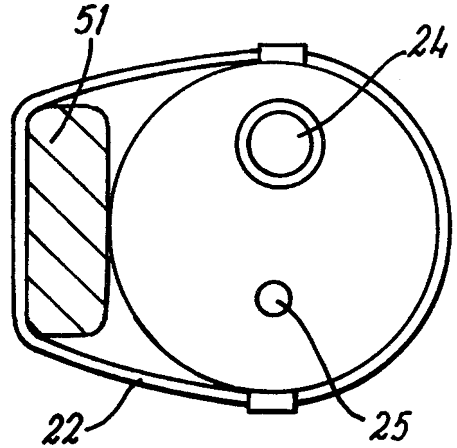


FIG. 7b

PCT/GB97/02888

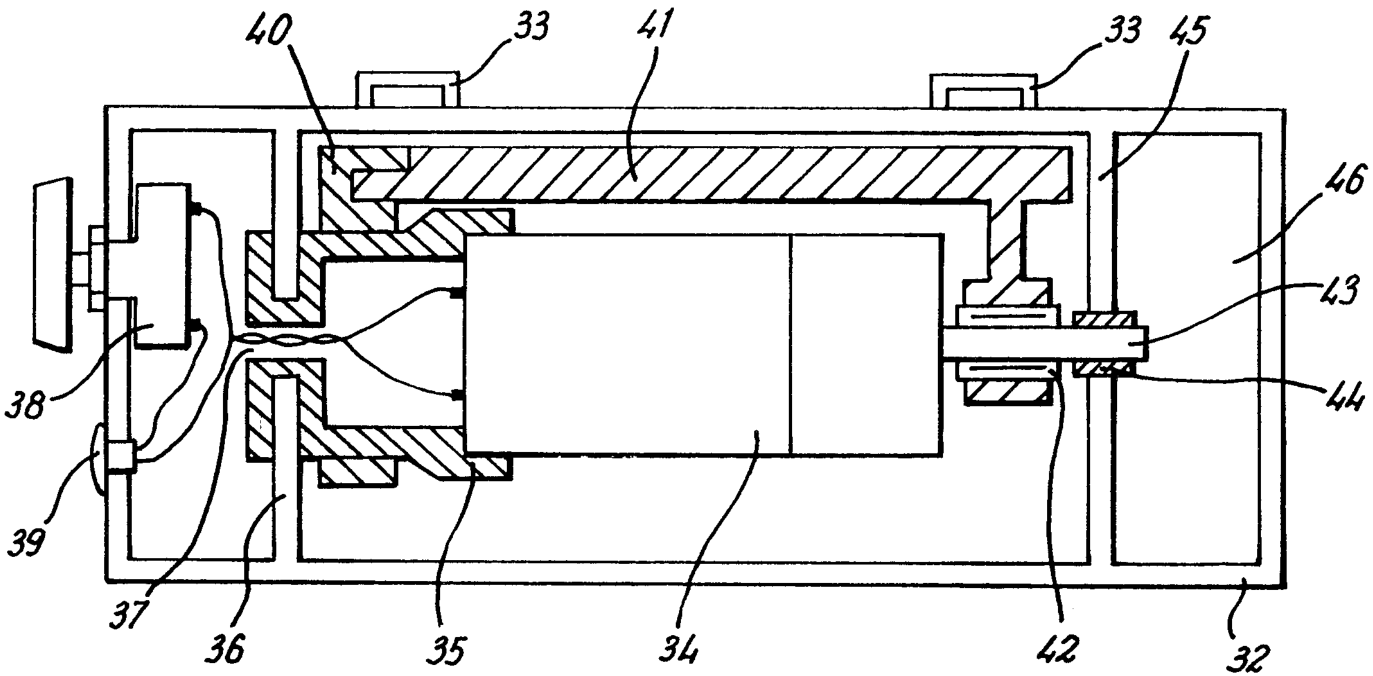


FIG. 8

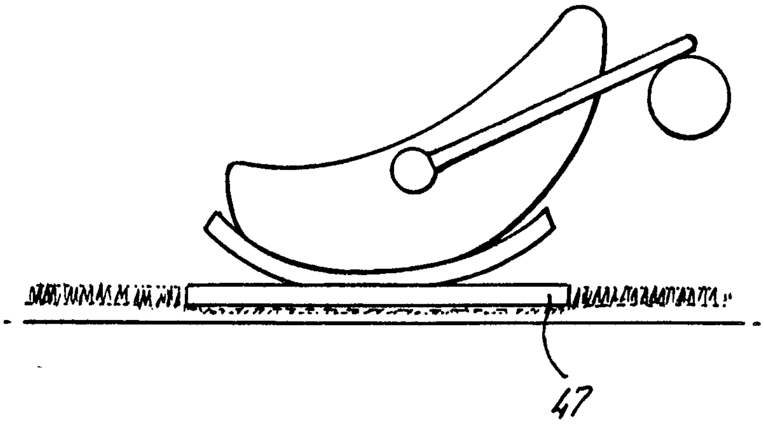


FIG. 9a

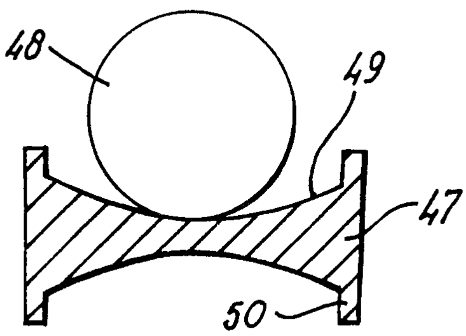


FIG. 9b

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 97/02888

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A47D9/04 A47D9/02

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 6 A47D

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.
A	DE 41 40 809 A (HERMANUSSEN) 9 June 1993 see the whole document ---	1,3,4, 6-13,16, 17
A	US 3 311 935 A (PETTY) 4 April 1967 -----	

☐ Further documents are listed in the continuation of box C.

☒ 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 1998	19/02/1998

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	VandeVondele, J

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter. ...nal Application No
PCT/GB 97/02888

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 4140809 A	09-06-93	NONE	
US 3311935 A	04-04-67	NONE	