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(51) INT CL:
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F16F 3/06 (2006.01)

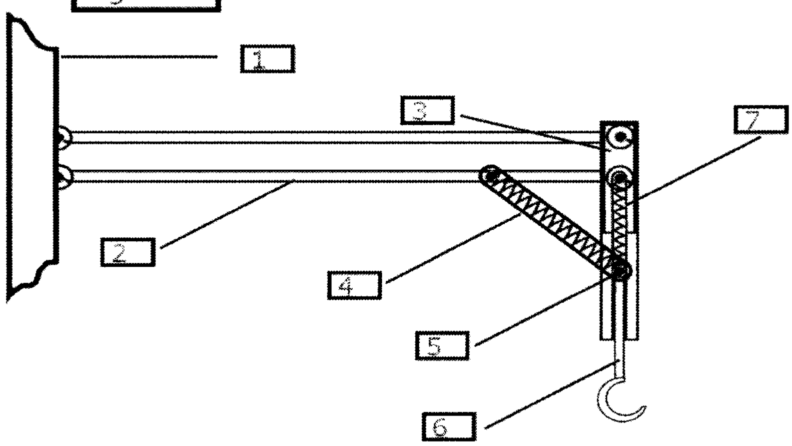
(56) Documents Cited:
GB 2495012 A **WO 2007/035096 A2**
DE 019742050 A1 **US 4883249 A**

(58) Field of Search:
INT CL **F16F, F16M**
Other: **WPI; EPODOC**

(54) Title of the Invention: **Automatically adjusting gravity-equilibrator**
Abstract Title: **An automatically adjusting spring to mass gravity-equalised support arm**

(57) A parallel support arm 2 is attached to a fixed structure 1. At the other end of the arm 2 there is a vertically sliding hook 6 which slides within a vertical end bar 3. The end bar remains vertical throughout the range of movement of the support arm 2 about the two fixed pivot points. The hook is held in place by a spring 7, attached to the end bar 3. One end of a zero-free-length spring 4 is attached to the underside of the support arm 2, and the other end of the zero-free-length spring 4 is attached to the sliding hook 6. With no supported mass attached, the spring 7 will fully retract the sliding hook 6, and the vertical attachment point of the zero-free-length spring 4 will be raised and the support arm 2 will be in balance. On picking up an object, the weight of the object will proportionally stretch the spring 7, which will, in turn, lower the effective vertical attachment point 5 of the zero-free-length spring 4 to maintain balance.

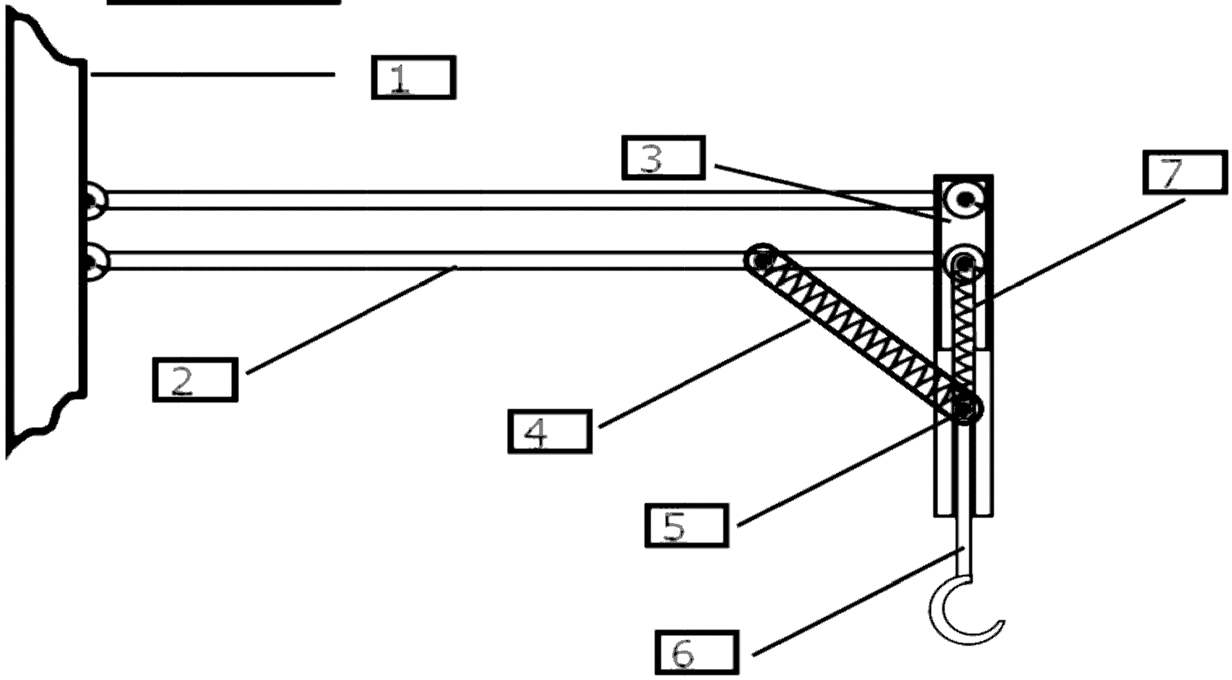
Fig. 1



GB 2501418 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig. 1



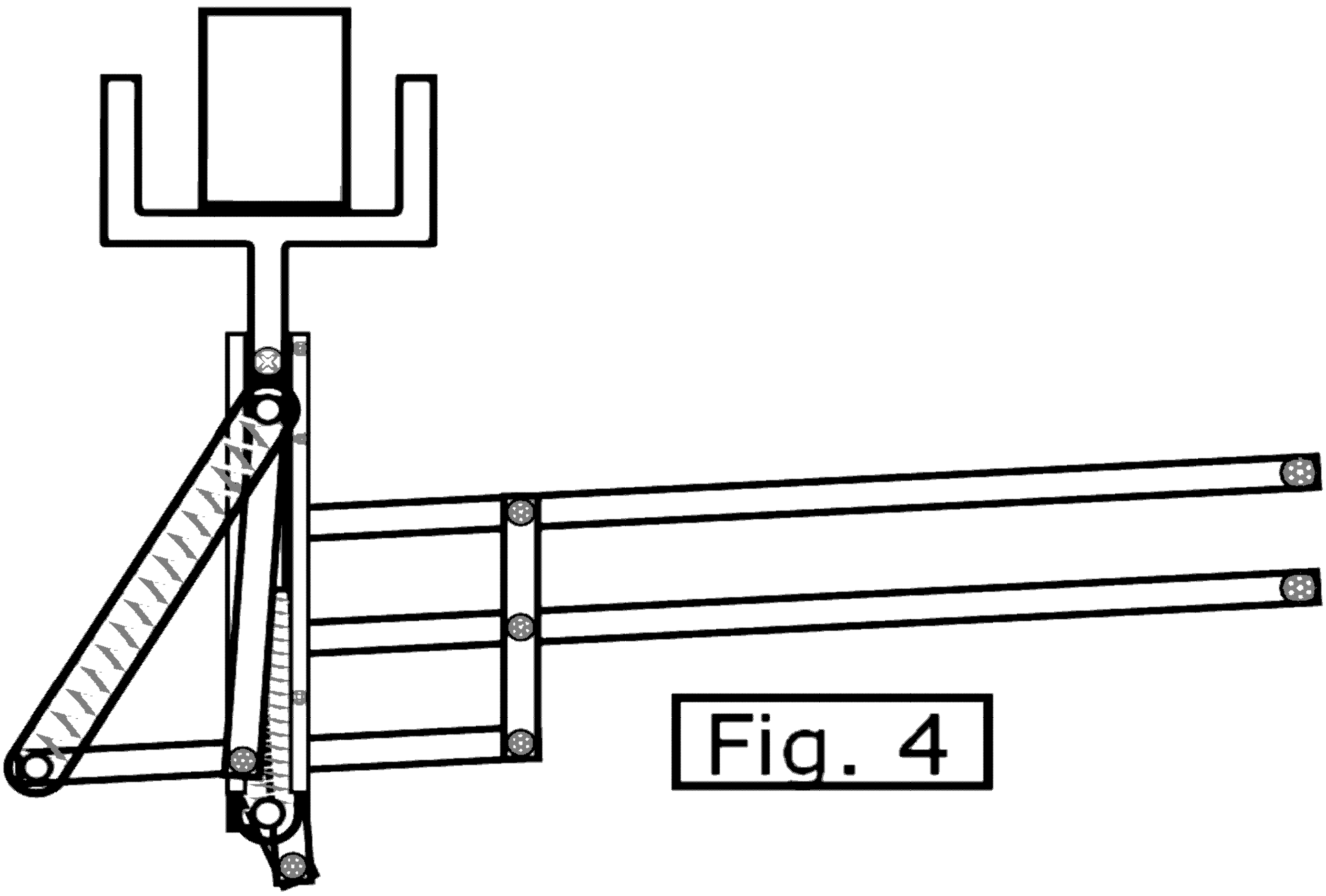


Fig. 4

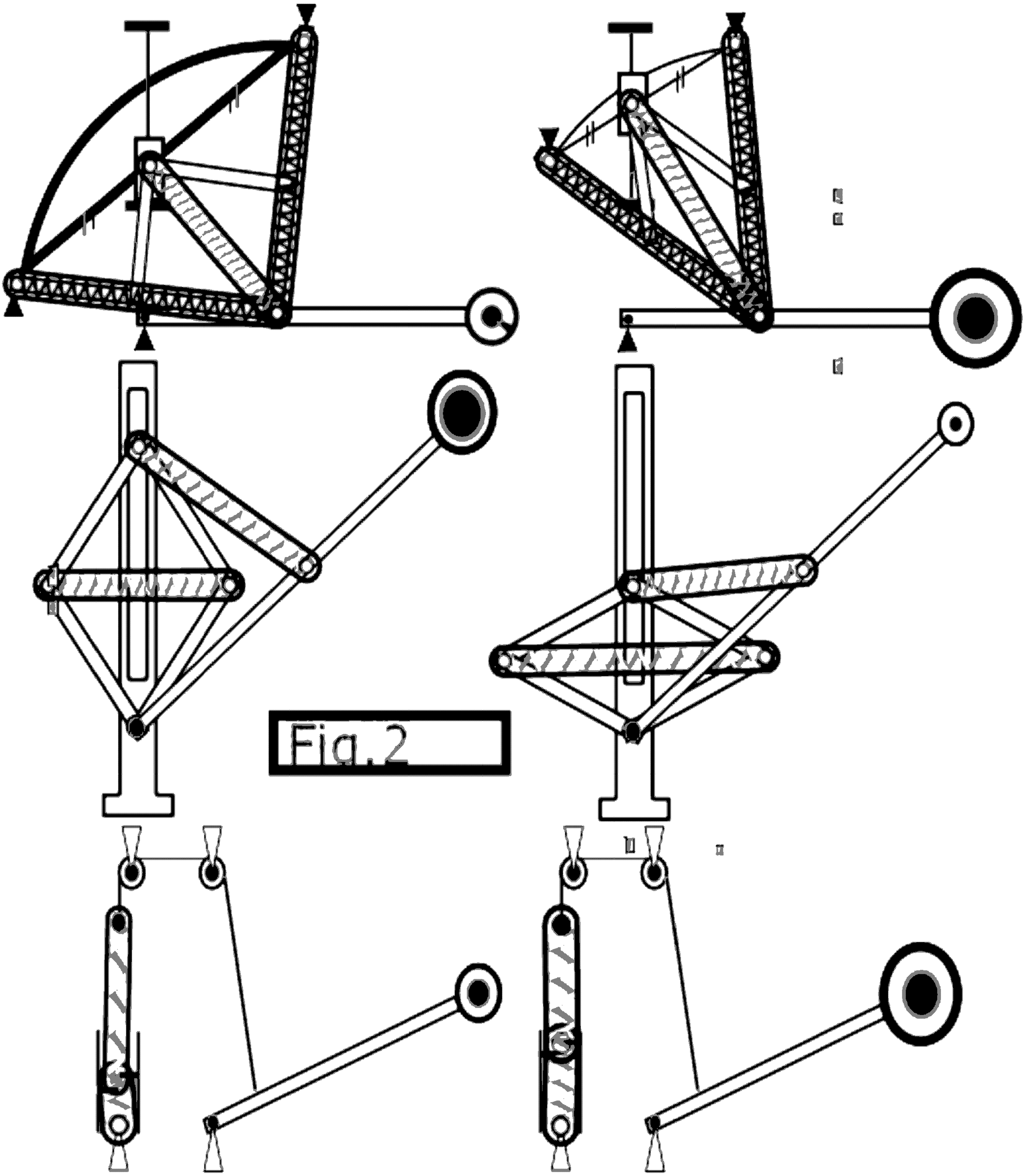


Fig.2

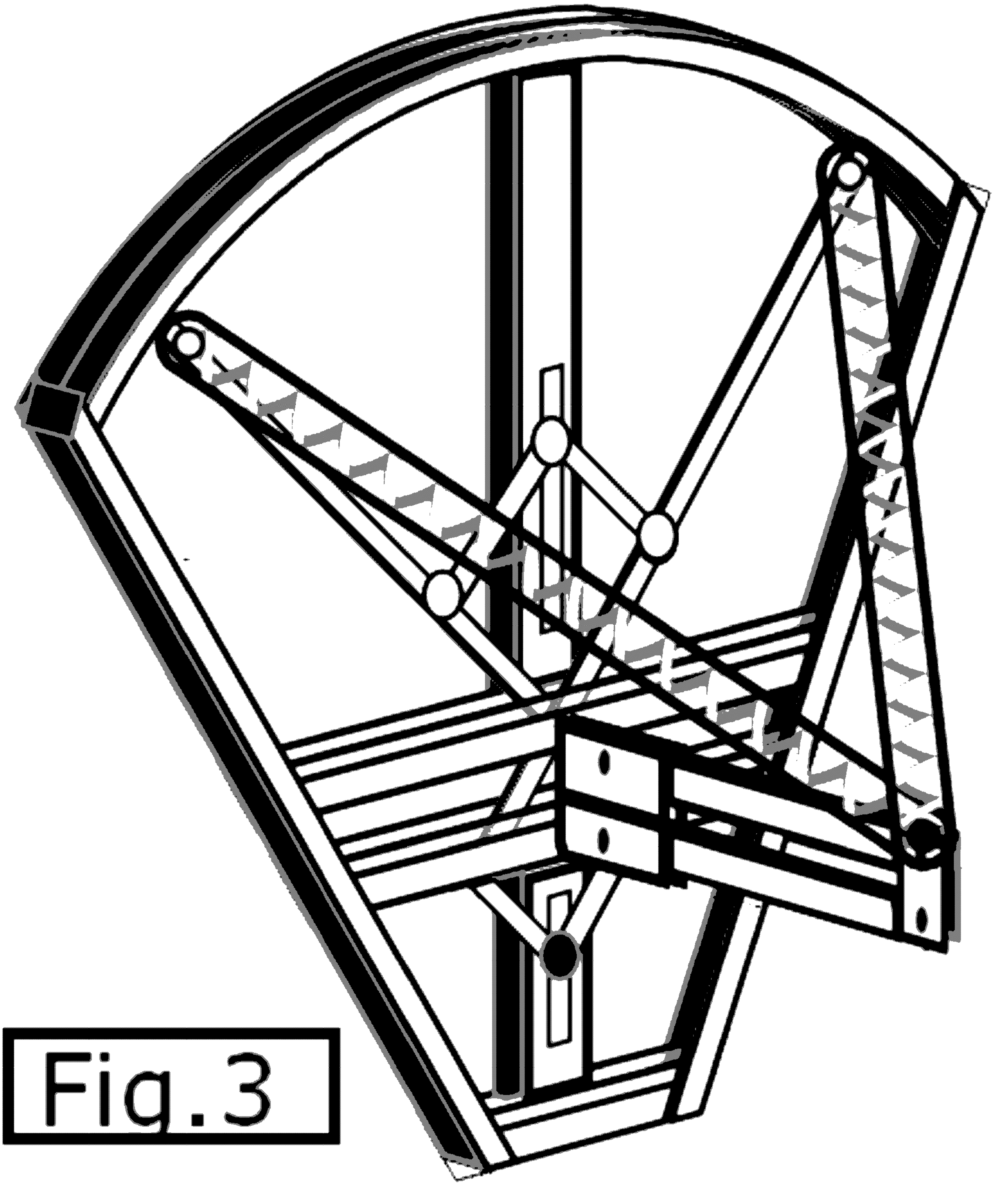


Fig.3

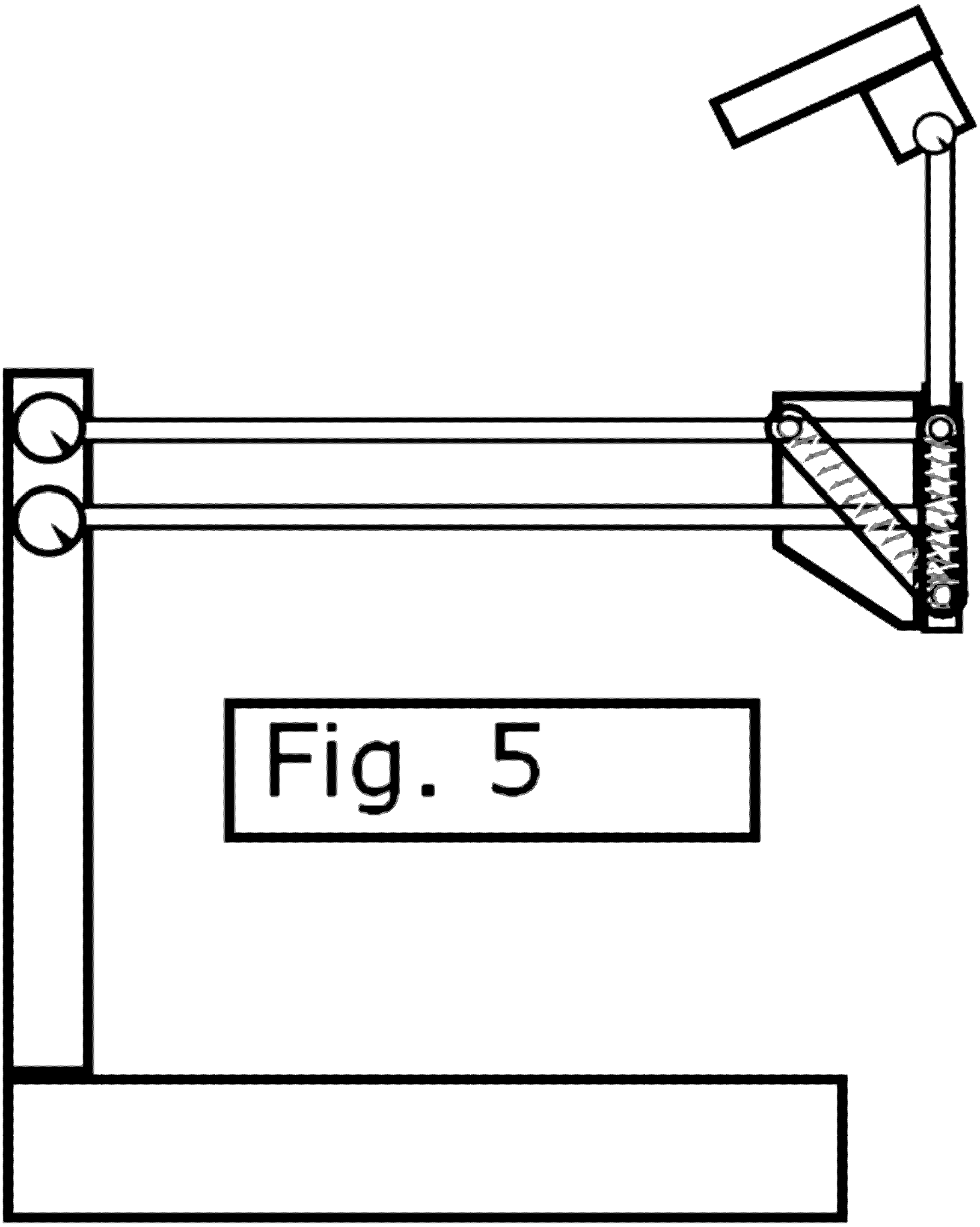


Fig. 5

Description

Background-

In general terms, when a system is said to be perfectly neutrally-statically-balanced, a supported mass is said to have a *constant potential energy (PE)* throughout its range of movement. That range of movement is determined by the pivoted nature of the mass's support arm and other countenance factors.

This countenance to the supported mass's weight is often achieved through the use of *springs* and/or *counterweights*. Invariably, the springs used are said to be zero-free length springs, meaning they are pre-tensioned to such a degree that their tension *k* is proportional to their *length*, in lieu of their elongation.

Because the supported mass, or P*ayload*, can be said to have *constant PE*, no energy is required to move or elevate the mass. The mass, in the context of a statically balanced system, is said to be weightless. This type of system is said to be *Gravity Equalised*.

Moreover, when the support arm and attached mass is released after elevation or repositioning, the mechanism, as a whole, will not move as there is *no preferred rest-position* within the arc of movement of the device's balance arm.

A classic example of a Gravity Equalised Device in use today is the *Anglepoise Lamp*

Other applications that currently use Neutral-Stability principles are assembly-line robotic-arms and personal assistive devices. The common principle behind all these examples of industrial use remains the same, that being any fixed payload is perfectly counter-balanced by any opposing equal-force, so that the operating energy requirement is minimal.

Problem 1:

As a rule of thumb, most gravity equalised structures support a constant load. The downside to this is that if the supported and perfectly countered load is changed, the equitable state of the system is lost, so requiring adjustment.

Problem 2:

That *Change of Payload* adjustment often takes large amounts of input energy effort, resulting in larger actuators for robotic arm manipulators, and with an increase in running costs also. In the case of orthopaedic arm supports, the wearers will simply not have the muscle strength to carry-out this adjustment.

Therefore, there is a need to reduce that adjustment energy requirement down to a minimum -read *energy free adjustment*.

Generally, an adjustment of a gravity-equilibrator- spring to mass balance arm- for a change of payload requires some form of external intervention and input, whether that be from an electrical or hydraulic power source or, in the case of energy-free adjustment mechanisms, the locking off of some part of the arm by the operative prior to that adjustment. This is clearly time-consuming and problematic, especially for the unskilled or physically impaired when the principles are embodied in to limb supports.

Various existing designs use a combination of zero-free-length spring(s)- and standard extension springs- to create Gravity-Equalised support arms that are capable of supporting changeable payload weights. Examples of these are: *– Figure 2 (Patent: US 2008/0210842) & Figure 3 (Patent Pending: GB 2495012)*. As stated, the drawback with all is that the adjustment and balancing mechanisms, for all intents and purposes, are distinct and separate, creating a pause in usability, which is a less than satisfactory situation.

This invention embodies a new way to automatically carryout this adjustment for a change in supported payload by altering the length / attachment points of the countenance spring(s) by using the supported masses' weight – Figure 1- without any other intervention, and bar the energy exchange between the supported masses' weight and system spring(s), the adjustment can be said to be '*energy-free*'.

Referring to Figure 1, in this embodiment, we have:

A parallelogram support arm(2) attached and pivoted to a fixed structure (1). At the other end of the arm there is a vertically sliding hook (6) which slides within the vertical end bar (3). This end bar remains vertical throughout the range of movement of the support arm (2) about the two fixed pivot points.

The hook is held in place by a standard spring (7) which is attached to the vertical end bar (3) also.

To the underside of the support arm, a zero-free-length spring is attached (4). This, in turn, is attached to the sliding hook assembly (6).

With no supported mass attached, the standard spring will fully retract the sliding hook assembly (6), and the vertical attachment point for the zero-free length spring will be raised. The support arm, without a load, can be said to be in balance.

On picking up a object, the weight of that object will proportionally stretch the standard spring (7).

This, in turn, will lower the effective vertical attachment point of the zero-free-length spring (5).

When the mass is fully supported, the sliding attachment point will remain stationary relative to the vertical end bar, and with the zero-free length spring's vertical attachment point altered, the system is once again in a gravity-equalised state. The support arm can now raise the changed payload in an energy free manner.

Upon release of the supported mass, the automated mechanical adjustment reverses, thus re-establishing a balanced state. Therefore, it can be said that, for any payload picked up (within a given range from Zero), adjustment is automatic and energy-free.

Further embodiments of this method of carryout this automatic adjustment can be seen in:

Fig.4- Pan Tray Support

Fig.5- Limb Support.

Also, this invention would be well suited for pick and place robotic arms, physical therapy centres where you have a large patient through-put (there would be no need to adjust the support apparatus for individual body masses)

1. An automatically-adjusting spring to mass, gravity equalised support arm, whereby the energy required to carry-out any adjustment of said support arm, is derived from the weight of a mass being supported.
2. An automatically-adjusting spring to mass, gravity equalised support arm according to claim 1, wherein the supporting elements are non-rigid.
3. An automatically-adjusting spring to mass, gravity equalised support arm according to claim 1 or 2, wherein the support element exhibits zero-free length behaviour in use irrespective of load (within a pre-determined weight range starting from zero).
4. An automatically-adjusting spring to mass, gravity equalised support arm according to claim 1 where the standard spring and zero-free length spring, or equivalent, are both located at the non-fixed end of the balance arm so as to adjust the length and / or attachment points of both in unison.
5. An automatically adjusting spring to mass, gravity equalised support arm according to claims 1-4, whereby all supporting and adjusting elements are so arranged as to provide static equilibrium of the support arm at any position within the range of movement of the support arm.
6. An automatically-adjusting spring to mass, gravity equalised support arm according to claim 1 whereby the repositioned spring attachment points (after adjustment) remain stationary, relative to the beam end's vertical plane, during movement of the support arm as a whole.

Amendments to the claims have been filed as follows:

Claims

1. An automatically adjusting spring to mass, gravity equalised support arm, the support arm comprising: a balance arm; and a vertically moveable load bearing portion located at a distal end of the balance arm, the vertical movement of which is controlled by two supporting elements, whereby the energy required to carry out any adjustment of the support arm is derived from the weight of the mass being supported.

2. An automatically-adjusting spring to mass, gravity equalised support arm according to claim 1, wherein the supporting elements are non-rigid.

3. An automatically adjusting spring to mass, gravity equalised support arm according to either of claims 1 and 2, wherein the support elements comprise a first standard spring , the second spring exhibiting zero-free length behaviour irrespective of load within a predetermined weight range.

4. An automatically-adjusting spring to mass, gravity equalised support arm according to claim 1 where the standard spring and zero-free length spring, or equivalent, are both located at the non-fixed end of the balance arm so as to adjust the length and / or attachment points of both in unison.

5. An automatically adjusting spring to mass, gravity equalised support arm according to claims 1-4, whereby all supporting and adjusting elements are so arranged as to provide static equilibrium of the support arm at any position within the range of movement of the support arm.

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Application No: GB1312408.6 **Examiner:** Mr Kevin Hewitt

Claims searched: ALL **Date of search:** 28 August 2013

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	GB 2495012 A (HARPER-MEARS) See whole document.
A	-	US 4883249 A (GARLAND) See especially the Abstract; and all Figures.
A	-	WO 2007/035096 A2 (TECHNISCHE UNIVERSITEIT DELFT) See especially the Abstract, and all Figures.
A	-	DE 19742050 A1 (CARL ZEISS) See especially the WPI Abstract Accession Number 1999-206046; and all Figures.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

F16F; F16M

The following online and other databases have been used in the preparation of this search report

WPI; EPODOC

International Classification:

Subclass	Subgroup	Valid From
F16F	0003/02	01/01/2006
F16F	0003/04	01/01/2006
F16F	0003/06	01/01/2006