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Balanced hinged–lever mechanism

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Abstract

The article presents the principle when two forces applied from one side of the lever mechanism, for their mutual balancing, have one direction of their action. To implement this principle, it is necessary to bring the action of forces to their common support with the possibility of their movement in different directions relative to each other. The paper considers the case when two unidirectional forces compensate each other, since they have oppositely directed degrees of freedom. On this basis, a mechanism is proposed that belongs to flat hinged (lever) mechanisms, and which can be used in the design of industrial and lifting cranes. This principle will allow us to take a fresh look at dialectics, which will require presenting the struggle of two opposites as the summation of two one–sidedness (united actions) with diametrically opposed possibilities (rights freedoms, interests, ...).

Keywords: Energy, Technology, Gravity, Efficiency, Crane, Construction, Equilibrium, Kinematics, Law of conservation of energy, Dialectic.

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1. Introduction

The law formulated by Isaac Newton: Action always has an equal and opposite reaction, that is, two forces to balance each other have the opposite direction.

The same is true for a lever mechanism: The forces applied on one side of the support must be in the opposite direction.

The kinematics of the proposed mechanism ensures the synchronous movement of two points, with parallel forces applied to them. At the same time, when these points move, the work equal to zero is performed, that is, the work of the force on one point is equal to the work done when the second point moves. One of these work is negative relative to the other work. Therefore, their sum is zero.

Further, it was developed in dialectic: the struggle of two opposites is equivalent to the unity of two unidirectional phenomena with opposite possibilities.

1.1. History

In 1987, a patent application N 4130878/08 was filed for the mechanism, but the author received a refusal decision from the industry patent expertise of the USSR. It came to a meeting at the Patent Expert Control, but the experts had their kinematic calculations and traditional predictions about mechanics so strong that even the operation of the mechanism before their eyes did not seem convincing to them, because, in their opinion: "This cannot be."

Previously, the principle of the lever (see Figure 1a and Figure 1b) was used (1988) in balanced two–handed manipulators [6], the use of which is not always possible.

In 2003, the basics of this two–link mechanism were described in the book "Inventive Creativity" [7].

2. Methods

The basis of the work is kinematics and the Law of Conservation of Energy.

2.1 Description

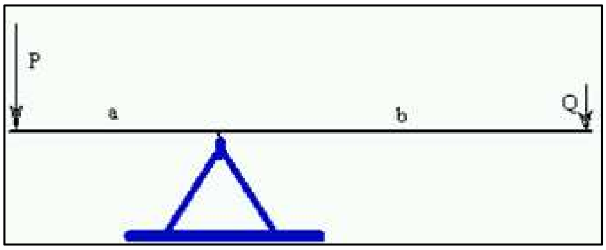
A lever is a well–known device in which a smaller force balances a large force. The lever has a pivot bearing and two points of force application.

The lever is in equilibrium if the vector sum of the moments of the forces acting on it is equal to zero:

$$Pa - Qb = 0$$

Here a and b are the arms (links) of the forces P and Q, respectively (see Figure 1a).

Figure 1a:

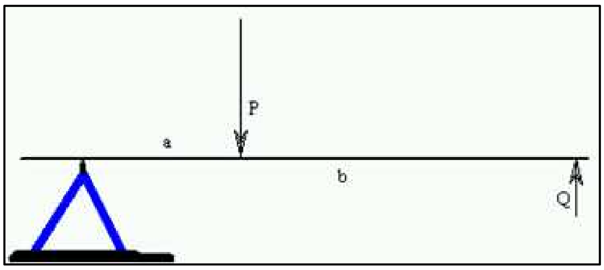


Source: Author**.**

In this case, the fulcrum of the lever is between the points of application of the forces P and Q acting on the lever.

If two forces P and Q are applied to the lever on one side of the support, then for their mutual equilibrium they must be directed in different directions (see Figure 1b).

Figure 1b:



Source: Author**.**

Forces applied on one side of the support can also be directed in one direction for mutual equilibrium. To do this, each force must have its own segment of the lever (its own arm) between the point of application and the support, and also on the support, the arms must be coupled through a transmission mechanism, for example, one stage of a gear mechanism with **ZM** wheels. In this case, the lever rule works (see Figure 2).

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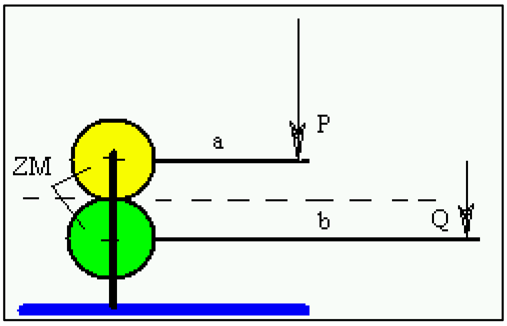
Figure 2:

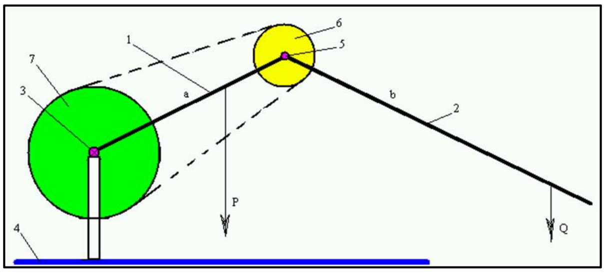


Source: Author.

In this case, the gear mechanism **ZM** must have a gear ratio equal to one, as well as the angles between the arms a and b and the direction of the forces P and Q, respectively, equal to each other.

The new mechanism has been proposed in which forces P and Q are applied to a two-link lever with links 1 and 2 (see Figure 3).

Figure 3:



Source: Author.

The first link (lever) 1 of the lever with shoulder a for force P rotates freely on hinge (joint) 3 of support 4. The second link 2 of the lever with shoulder b for force Q rotates on hinge 5 of the free end of link (lever) 1. Gear wheel 6 rotates on the same axis with hinge (joint) 5, to which link (lever) 2 is attached. Pulley (wheel) 6 is connected by the belt (cord) to pulley (wheel) 7, motionless (without the possibility of rotation) fixed on the support 4 on the same axis with the hinge 3.

The diameter of wheel 7 is twice the diameter of wheel 6. The length of lever arm 2 is twice the length of link 1. Link of lever 1 forms an angle α with the horizontal. Link of lever 2 forms an angle β with the horizontal. Their sum is $\alpha + \beta = 90°$. These conditions ensure the balance of forces P and Q, if they are equal, despite the fact that they are directed in the same direction and applied on the same side of the support.

The trajectory of the point of application of force Q is an ellipse.

A feature of the mechanism in Figure 3, compared to the lever mechanism in Figure 2, is that the forces, being on one side of the support and heading in the same direction, balance each other. In the proposed new mechanism, one of the arms is attached not to the base, but to the point of application of the force of the other arm (the action of the transmission mechanism is preserved). Then we have a kind of balanced lever, in which the forces have one direction and are applied on one side of the hinge placed on the support. From the point of view of common sense, this is impossible, but the mechanism turns out to be simple.

The proposed mechanism can be used in the design of manipulators.

The efficiency of such a manipulator tends to be 100%. The losses are due to friction in hinges 3 and 5. For horizontal movement, there is no need to expend work on lifting and lowering links 1 and 2, since they are mutually balanced.

3. Exemplifications

3.1. Analogy of the lever and the proposed mechanism

3.1.1. Placement of the mass in the midpoint of the lever and the mechanism

Here are the positions of the lever: turning the lever counterclockwise (see Photo 1), horizontal position of the lever (see Photo 2), and turning the lever clockwise (see Photo 3).

Photo 1 [1, p. 1]. Turning the lever counterclockwise.

Source: Author.

Photo 2 [1, p. 2]. Horizontal lever placement.

Source: Author**.**

Photo 3 [1, p. 3]. Turning the lever clockwise.

Source: Author**.**

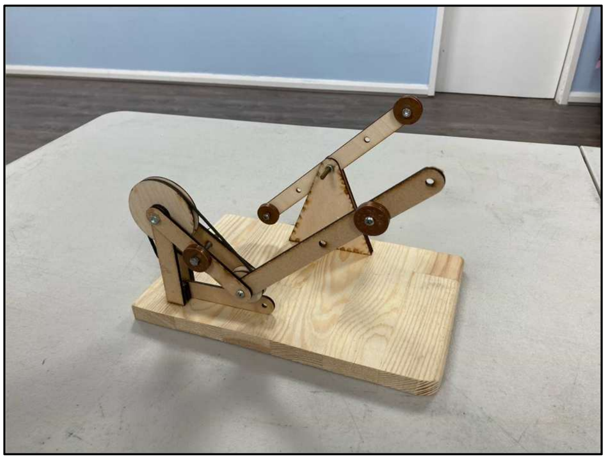
Here are the positions of the two levers: one is a traditional single-link lever with a rotation axis on the base (in the background) (see Figure 1a), and the second (in the foreground) is the proposed two-link mechanism (see Figure 3), with the rotation axis located in the middle of the movable link (lever) 2. This provides, during the rotation of the lever, a constant value of the potential energy of the load that creates the force P (or Q).

In all these cases, the movement of the lever, the load always remains at the same level relative to the horizon, and work is not performed.

3.1.2. Symmetrical placement of weights (of equal weight) on the first and second levers of the mechanism

Here are the positions of the lever: turning the lever counterclockwise (see Photo 4), horizontal position of the lever (see Photo 5), and turning the lever clockwise (see Photo 6).

Photo 4 [2, p. 1]. Turning the lever counterclockwise.



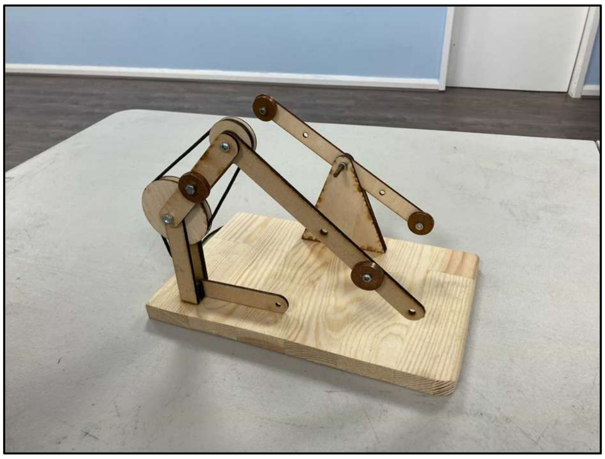
Source: Author**.**

Here are the positions of the two levers: one is a traditional single-link lever with a rotation axis on the base (in the background) (see Figure 1a), and the second (in the foreground) is the proposed two-link mechanism (see Figure 3), with the rotation axis located in the middle of the movable link (lever) 2.

Photo 5 [2, p. 2]. Horizontal lever placement.

Source: Author**.**

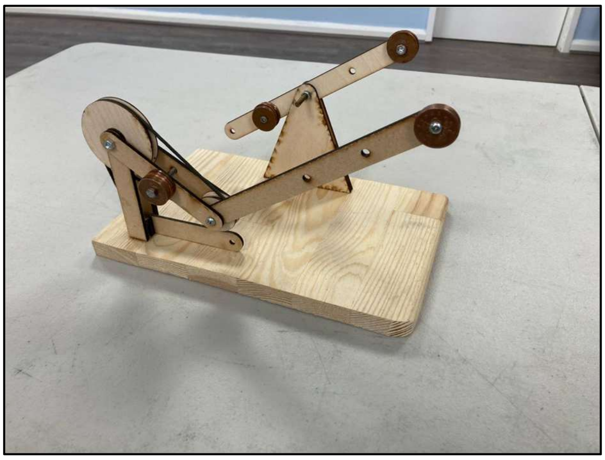
Photo 6 [2, p. 3]. Turning the lever clockwise.



Source: Author**.**

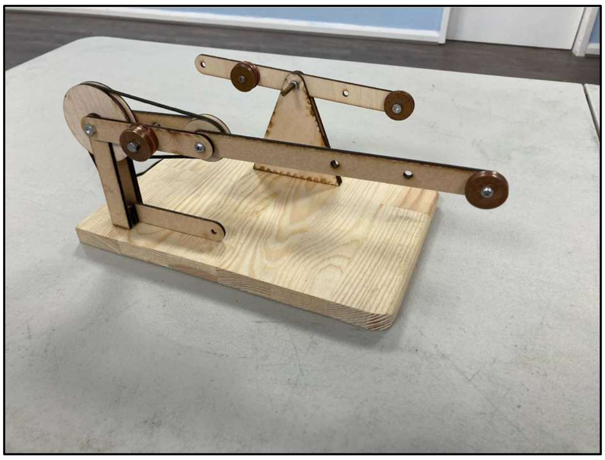
3.1.3. Asymmetric placement of loads

Photo 7 [3, p. 1]. Turning the lever counterclockwise.



Source: Author.

Photo 8 [3, p. 2]. Horizontal lever placement.



Source: Author**.**

Photo 9 [3, p. 3]. Turning the lever clockwise.

Source: Author**.**

Asymmetric placement of loads (of different weights: in a ratio of one to two) on the lever and on the mechanism (at a distance with a difference of two times)

Here are the positions of the lever: turning the lever counterclockwise (see Photo 7), horizontal position of the lever (see Photo 8), and turning the lever clockwise (see Photo 9).

4.1.4. Placement of weights on the second arm of the mechanism on either side of the center

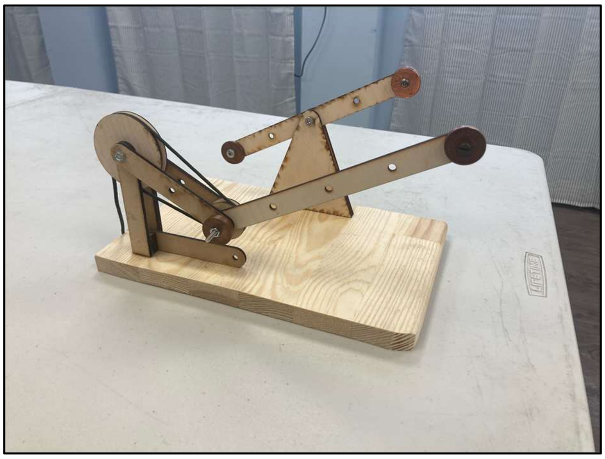
The center (axis of rotation) of the lever 2 is shown in Photos 1, 2 and 3 in the form of cargo placement.

Here is the position of the lever 2, with the rotation axis located in the middle of the movable link (lever) 2. Two identical weights are placed symmetrically with respect to the middle of link 2 (see Photos 10 and 11). In Photo 12, there are two loads of different weights: one is twice as large as the other.

Here are the positions of the lever: turning the lever counterclockwise (see Photo 10 and 12), horizontal position of the lever (see Photo 11).

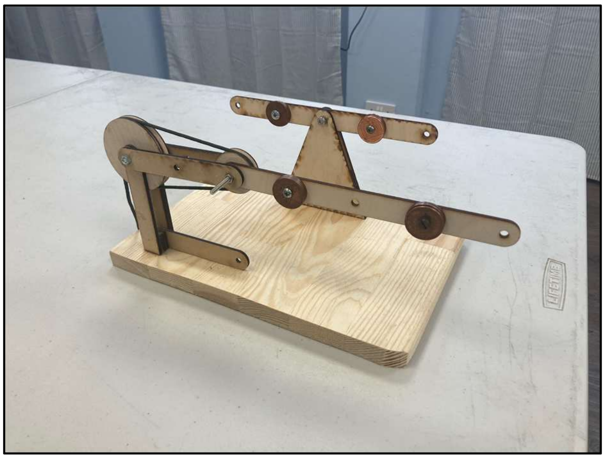
The weight on the left is divided into two weights: one on link (lever) 1 and the other on link (lever) 2 (see Photo 13).

Photo 10 [4, p. 1]. Turning the lever counterclockwise.



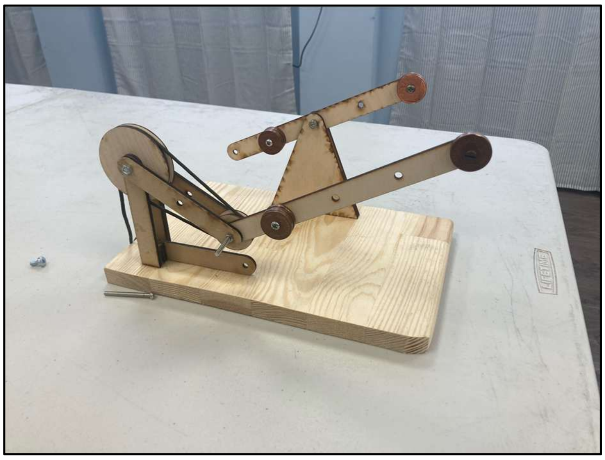
Source: Author**.**

Photo 11 [4, p. 2]. Horizontal position of the lever.



Source: Author.

Photo 12 [4, p. 3]. Turning the lever counterclockwise



Source: Author.

Photo 13 [4, p. 3]. The weight on the left is divided into two weights.

Source: Author**.**

3.2 Analogy of the proposed two–link mechanism and its development: four link mechanism

On Photos 1, 2 and 3 in the proposed two–link mechanism (in the foreground) a movable center is indicated, in which any load is in equilibrium when it moves along the horizontal. If we place the proposed two–link mechanism (see Figure 3 and Photo 8, 9 and 13) with kinematic reduction of links to the base on this center, then we will get a four–link mechanism with two degrees of freedom.

The Photos 14, 15, 16 and 17 show the four extreme positions of the proposed four–link mechanism. Photos 18 and 19 show two middle positions of the proposed four–link mechanism.

Photo 14 [5, p. 1]

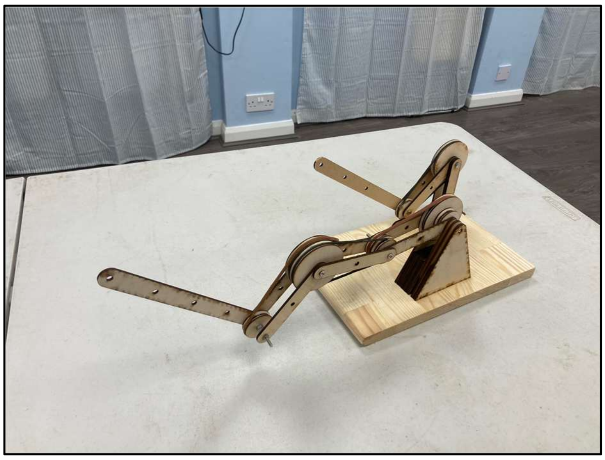


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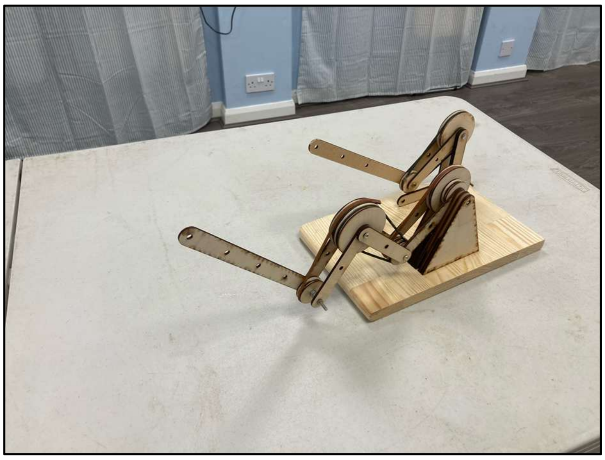
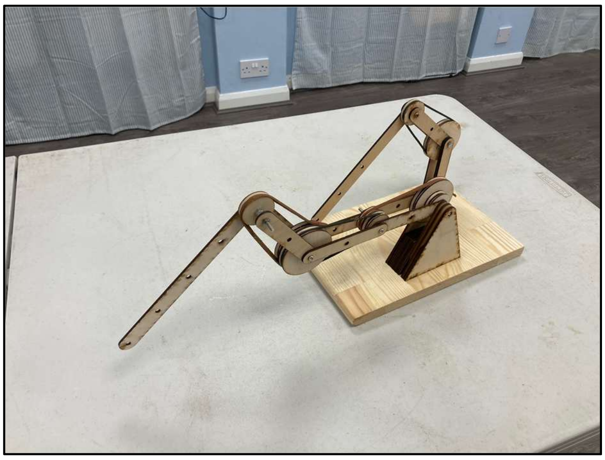
Photo 15 [5, p. 2]



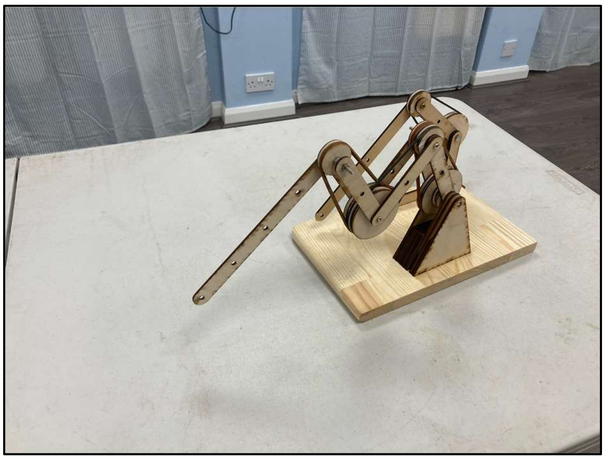
Source: Author**.**

Photo 16 [5, p. 3]



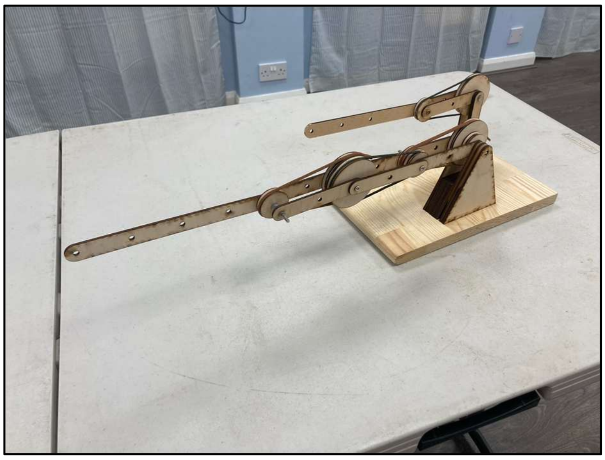
Source: Author**.**

Photo 17 [5, p. 4]



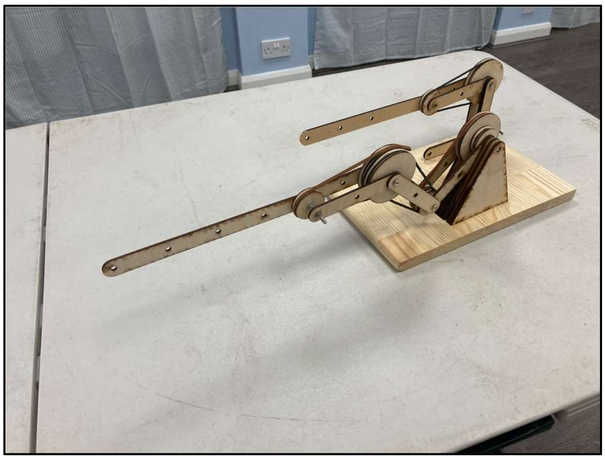
Source: Author**.**

Photo 18 [5, p. 5]



Source: Author**.**

Photo 19 [5, p. 6]



Source: Author.

4.3. Result

The Photos (1-19) shows the mechanisms in equilibrium. At the same time: in Photos (1-3) with one weight, in Photos (4-12) with two weights, in Photos 13 with three weights.

5. Perspectives

5.1 Manipulators

Mechanisms of this type will increase the efficiency of "one–armed" manipulators. In them, energy will be expended only on overcoming the forces of friction in the hinges and on doing useful work.

Manipulators, working according to the principle shown in Photos 1–13, have an arcuate trajectory of the executive movement. In Photos 14–19 (four link mechanism) indicate the principle of the trajectory of the executive movement in the form of a plane.

5.2 Dialectics

Hegel's dialectic in one of its manifestations is the law of unity and struggle of opposites, which always exclude each other. The proposed principle: "The summation of processes in which unidirectional forces in one system compensate each other", allows you to take a fresh look at dialectics, improve it or even abandon it.

6. Conclusions

If the dimensions of the proposed mechanism (see Fig. 3) with two applied forces P and Q tend to zero, then the distance between these two forces (P and Q) will also tend to zero. In this case, the forces P and Q will tend to merge into one force ($P + Q$). This resulting force ($P + Q$) will tend to zero in magnitude. So two unidirectional forces (parallel forces) merging into one force can compensate each other, that is, their sum will tend to zero.

Both of these forces ($P + Q$) have a kinematic connection with the base in the form of a point of application.

On this basis, a mechanism is proposed that belongs to flat hinged (lever) mechanisms, and which can be used in the design of industrial and lifting cranes. This principle will allow us to take a fresh look at dialectics, which will require presenting the struggle of two opposites as the summation of two one–sidedness (united actions) with diametrically opposed possibilities (rights freedoms, interests, ...).

Acknowledgment

The author is grateful to Maker Space in Newcastle upon Tyne[2] and personally to Maker Space member Mr. Iain Yarnall for making it possible to fabricate parts of the mechanism.

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