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# A NEW MODEL OF INERTIAL PROPULSION FOR ELECTRIC VEHICLES

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## ABSTRACT

The article provides a description of the device, which is a system of four rotating imbalances that continuously rotate from 0 to 148 degrees and then back to 0 degrees. Two of the imbalances rotate in one direction, while the other two rotate in the opposite direction, thereby compensating for the horizontal projections of the centrifugal force on the X-axis of transport devices.

**Keywords** inertial · propulsion · centrifugal force · electric vehicle

## 1 Introduction

One of the first devices for obtaining thrust due to inertial forces was V. Tolchin's inertioïd, which he manufactured and tested in 1936. The principle of operation for the inertioïd is simple: two inertial weights rotate synchronously towards each other relative to the axis fixed on the trolley body. It functions as a straightforward inertial propulsion unit. The propulsion drive is facilitated by a motor-brake, with its device utilizing a method of dispersing unbalanced loads around the circumference at different angular speeds along the trajectory.

At the outset of each load's movement, the process of acceleration and achieving maximum speed occurs. Subsequently, the loads decelerate and return to the start of the trajectory with minimal velocity. This results in the emergence of a substantial centrifugal force of inertia in the section of the trajectory where the movement of the loads is faster. In contrast, the centrifugal force is significantly reduced in the area with slower movement, leading to unbalanced thrust in one direction of the cart's movement with imbalances.

In Tolchin's experiments the movement of his inertias was investigated on a surface moistened with engine oil to reduce friction between the surface and the wheels of the inertia cart [1]. The movement was undisturbed in a given direction. In contrast, a model car with a spring-wheel drive on the same surface started to rotate in place and could not move in the desired direction. This confirms the presence of unsupported thrust in Tolchin's inertia. The experiments also showed [1] two symmetrically mounted inertials at the ends of a rotating rocker, which was mounted on a fixed axle. The inertioïds generated thrust in a specific direction, creating a torque of rotation of the rocker that can be converted into electrical energy.

In his experiments, Tolchin demonstrated how a spring-driven toy truck was mounted on a light cart. When the truck started, due to the action of friction forces, the cart started moving backward, and the truck started moving forward. However, when Tolchin installed his inertioïd on this cart, it remained at rest. He also placed the inertioïd on the surface of the swing and set it into action, and the swing remained motionless.

These experiments confirm that the motion of the inertioïd is unsupported. The inertioïd model moved in jerks <sup>1</sup>, and for this reason, opponents argue that the movement is due to friction forces. However, as is known, the forces of inertia do not obey the third law of Newtonian mechanics, and Tolchin's inertioïd demonstrates this[1].

Although the inertial mover is alleged to contradict the law of conservation of momentum, official science does not recognize it. However, this has not deterred the creators of inertioïds from inventing and developing new operating

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<sup>1</sup><https://www.youtube.com/watch?app=desktopv=u9-wdV32hos>.

devices. These inventors put forth their theories using known laws of physics, while also taking into account the interaction with unknown environmental factors, such as the physical vacuum and gravitational fields[2].

The traditional explanation for the inertia force operation is that its movement is caused by frictional forces between the supporting surface and the inertia wheels during the forward and reverse half-cycles of the working cycle [3]. With dry friction, resistance to slow motion is greater than resistance to fast propulsion of the inertia. Therefore, movement of inertias in a vacuum is currently deemed impossible according to modern science. Despite this, the inventors of inertias have demonstrated that it is possible in practice [4].

A theoretical study was conducted on the effect of V. Tolchin's inertia based on the general theory of relativity and gravitational waves with gravitoelectric and gravitomagnetic components [4]. This resulted in the identification of Lawrence's gravitomagnetic force on the moving mass in the magnetic field. Therefore, the author believes that Newton's third law may be violated in the gravitational field of the Earth, as in the electromagnetic field. This supports the explanation and calculation of the functioning of V. Tolchin's inertia.

Analytically, it has been shown that the acceleration and deceleration version implemented by V. Tolchin in his inertia does indeed generate thrust in a given direction but is suboptimal. Using the proposed methodology, more effective intervals of acceleration and deceleration on the trajectory of movement of inertial imbalances were identified. This significantly enhances the inertial efficiency of propulsion through the timing diagram of motor brake switching on and off. In this case, the inertial motion is unsupported, as there is no opposing force for the Lorentz force. Although the Lorentz force does not perform work, the Lorentz gravitomagnetic forces create the conditions for transforming the energy of the internal engine into the kinetic energy of the mass of the platform of inertia.

G. Shipov reported [2] that in 1981, a group of eight scientists was established at the Faculty of Physics of Moscow State University. They commissioned Tupolev's firm to manufacture two samples of V. Tolchin's inertoids based on the drawings in his book [2]. The resulting inertoids were placed on an air cushion platform to minimize friction forces. The weight of each inertoid was 800 grams. The inertoid was turned on and moved along the guide together with the platform. Similar tests were conducted by G. Shipov and American physicists at Stanford in 2000. In the American experiment, a thin film was used to isolate the inertoid from the external environment and reduce aerodynamic effects. In this case, the inertial body moved steadily relative to the laboratory reference frame, periodically advancing 8 cm and then returning 2 cm.

In 1956, Norman L. Dean was granted a patent for his invention called the "System For Converting Rotary Motion Into Unidirectional Motion" [5]. The device comprises six pairs of inertoids, each having two counter-rotating imbalances that are suspended in the propeller body on an elastic spring. The pairs of imbalances, along with their drives, are mounted on a jumper that is connected to the body through springs.

During movement, the imbalances go through two half cycles - upper and lower - with a constant angular velocity of rotation, causing the jumpers to oscillate up and down. However, the total impulse of the force acting on the body is equal to zero for a constant oscillation time. To obtain a non-zero force impulse and to achieve movement of the body in one direction, Norman Dean included a movable transverse electromagnetic brake at the moment when the jumper is passing through the average vertical position. At this time, the system of rotating unbalance and the jumper become rigidly connected to the body.

During the first half-cycle of operation, the force impulse is transmitted to the body through an elastic connection without any loss. In the second half-cycle of work, a rigid connection is established between the system of rotating unbalance and the body, and most of the force impulse is converted into heat. As a result, a unidirectional total force is obtained on the body of the device. The use of six pairs of inertoids, which are shifted in phase by 60 degrees, allows for smoother unidirectional thrust.

The proposed inertial propulsion devices according to Thomson's patent [6] were registered in the USA and Canada. In his patent, imbalances move along the trajectory of a cardioid, which is realized by summing two motions - orbital and proper rotation. The inertial mechanism consists of two symmetrically located imbalances moving in opposite directions. During the rotation of the imbalances relative to the fixed center on the body, the radius of rotation of the imbalances is maintained constantly in the first half-cycle of the cycle, and in the second half-cycle, the radius begins to decrease, reaching a minimum in the middle of the second cycle of the half-cycle. This ensures the difference in the momentum of the force and the one-way movement of the mover. Tests of a boat with the proposed drive were carried out, confirming high efficiency slightly higher than that of a conventional outboard motor.

A more recent study [3] have examined the inertial motion of 8 hardened balls situated between two fixed plates and one holding plate. They derived the velocities and accelerations necessary for the balls to move in opposite directions, creating a resultant centrifugal force directed along the axis of motion. Additionally, they considered the dimensions of the balls that affect the parameters of the installation being studied.

Building on the limitations and challenges identified in previous research, this article presents a theoretical study of an inertial system that can generate a constant linear driving force through the rotation of four identical imbalances.

## 2 Research Model

The research was conducted using the Dynamic Simulation - Inventor 2021 program. The device comprises a rotational motor that rotates a gear 1 with a fixed axle 3 on which the imbalance is mounted. The trunnion 3 and the pusher 4 are located at the extreme position C, where the centrifugal force is zero. The axis of the drive system of the second imbalance (not shown in the diagram) is located on axis 3, rotated at an angle of  $1/2$  from the angle of the imbalance opening (see Figure 1). On gear 7 there are also drive units axis 8, trunnions 9 and pushers 10 of the third and fourth imbalance, the fourth imbalance is shifted relative to the third n  $1/2$  of the imbalance opening.

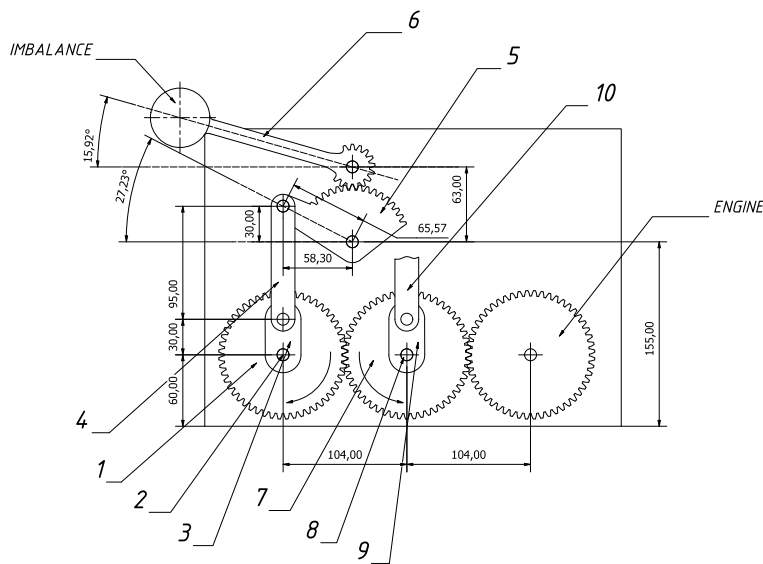


Figure 1: Imbalance position to the left of rotation.

The clockwise rotation of the gear results in an increase in angular velocity (as shown on Figure 3), which reaches  $7.23 \text{ [rad s}^{-1}\text{]}$  in the top position at a speed of 50 rpm (position A in Figure 2). As the imbalance continues to rotate, the angular velocity decreases and becomes zero in a certain position. With further rotation, the angular velocity reaches a maximum value of  $-6.58 \text{ [rad s}^{-1}\text{]}$  (Figure 3). The maximum value between points A and B explains the power supply value between the actuator's position at these points (as depicted in Figure 3).

The projection of centrifugal forces on the Y axis, acting on each of the 4 imbalances, are determined by the formula:

$$F(y) = m \cdot w^2 \cdot R_i \cdot \sin \alpha \quad (1)$$

where:

- $F(y) \text{ [N]}$  – projection of the centrifugal force acting on the imbalance on the Y axis;
- $m \text{ [kg]}$  – mass of the imbalance;
- $w \text{ [rad s}^{-1}\text{]}$  – angular velocity;
- $R_i \text{ [m]}$  – trajectory radius of the unbalance;
- $\sin \alpha$  – is the angle between the centrifugal force vector and the Y axis (the direction of the longitudinal force).

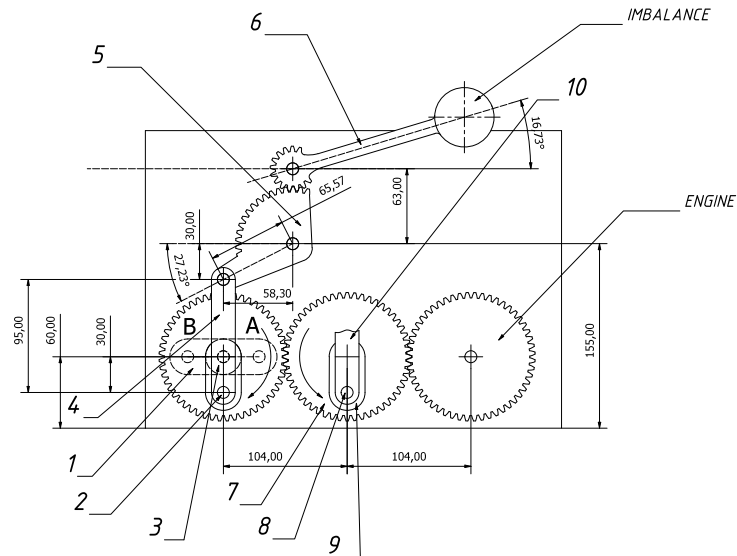


Figure 2: Imbalance position to the right of rotation.

In our first experiment we investigated the impulse of the vertical force of the 1st imbalance per one revolution of the drive rotating with angular velocity 5 sec<sup>-1</sup> and unbalance with a mass of 0.3 kg (Figure 4). The difference between the maximum of the first swing to the right and to the left is explained by the presence of a maximum of angular velocities at points A and B (Figure 2). In our second experiment we investigated the impulse of the vertical force of the 2nd imbalance per one revolution of the drive rotating at a angular velocity of 5 sec<sup>-1</sup> (Figure 4). Next, the pulse period was shifted by one quarter of the pulse period. This was done because by adding with a period of 1, we tear off the value from the zero value (Figure 5). After, to remove the horizontal component from the centrifugal force, we rotated two imbalances 3F and 4F in opposite directions (Figure 6 and 7). Note that the graph of the joints is directed in the positive direction from the zero position. (Figure 7). Finally, by adding the oscillatory impulses (newtons) of the four imbalances, we obtained graphs of joint oscillations (Figure 8).

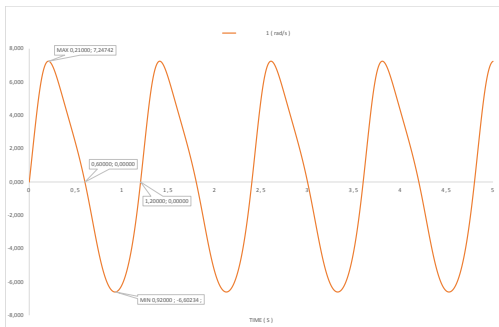


Figure 3: Graph of angular speeds

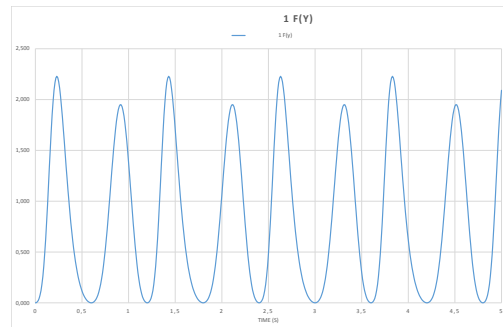


Figure 4: Projection of centrifugal force 1F(Y) on the axis Y

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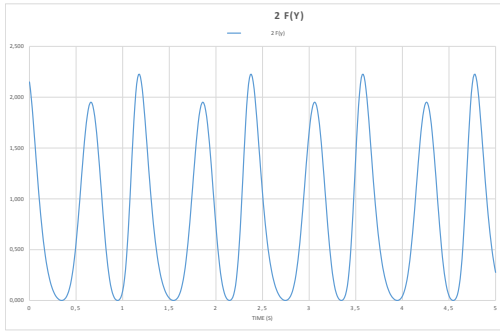


Figure 5: Projection of centrifugal force 2F(Y) on the axis Y

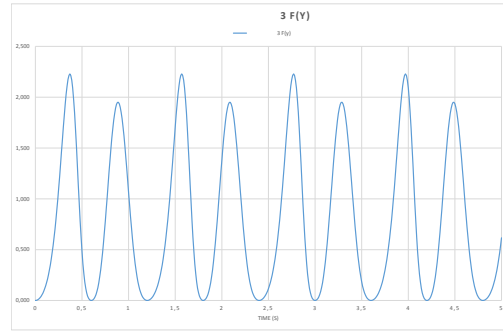


Figure 6: Projection of centrifugal force 3F(Y) on the axis Y

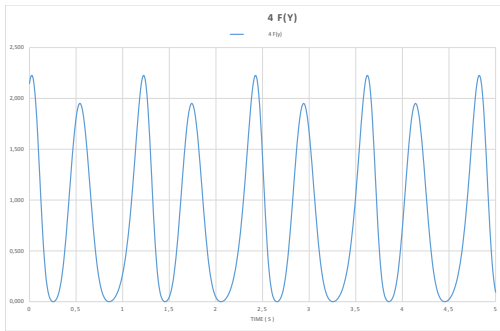


Figure 7: Projection of centrifugal force 4F(Y) on the axis Y

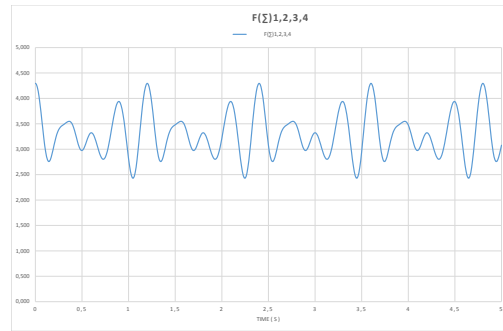


Figure 8: Graphs of joint oscillations

Note that the joint graph is directed away from the zero position (Figure 8). We selected the average value of the graph of joint oscillations of 4 imbalances equal to 3 Newtons and determined that the average value of the angular acceleration per rotation was 1 unit of angular acceleration (Figure 8). Next, we calculated how much resistance the moving car experiences.

Some manufacturers list the car's effective drag area in their specifications:

$$C_{\text{eff}} = c_x \cdot S = c_x \cdot 0.5 = 0.35 \cdot 0.5 = 0.175 \quad (2)$$

where:

- $C_{\text{eff}}[\text{m}^2]$  – car's effective drag area;
- $c_x$  – the drag coefficient of modern mass-produced passenger cars ranges from 0.2 to 0.35 per square meter of transverse area;
- $S[\text{m}^2]$  – the area of the flat plate oriented perpendicular to the oncoming flow.

The effective area is defined as the area of a thin, flat plate that is perpendicular to the oncoming flow and experiences the same drag force as a car moving at the same speed. The value of the effective area depends not only on the shape, but also on the size of the car, specifically the area of its midsection. For modern mass-produced passenger cars, the effective area typically ranges from  $0.5 \text{ m}^2$ . Under the standard atmosphere of the International Union of Pure and Applied Chemistry (temperature  $0^\circ \text{C}$ , pressure 100 kPa, zero humidity), the air density is  $1.2754 \text{ kg/m}^3$ ; at  $20^\circ \text{C}$ , 101.325 kPa and dry air, the density of the atmosphere is  $1.2041 \text{ kg/m}^3$ .

$$F = C_{\text{eff}} \cdot \rho \cdot \frac{v^2}{2} \cdot S = 0.1275 \cdot 1.2041 \cdot \frac{v^2}{2} = 0.1v^2 \quad (3)$$

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(we accept that  $v = \frac{250 \text{ km/h}}{3600 \text{ sec}} \cdot 1000 \text{ m} = 69.4 \text{ m/s}$ .)

where:

- $F[\text{N}]$  – drag force of the car;
- $C_{\text{eff}}[\text{m}^2]$  – car's effective drag area;
- $v[\text{m/s}]$  – velocity;
- $p [1, 2041 \text{ kg/m}^3]$  – density of the atmosphere;
- $S[\text{m}^2]$  – the area of the flat plate oriented perpendicular to the oncoming flow.

$$v = \sqrt{\frac{F}{0.1}} = 3.16 \cdot \sqrt{F_1 \cdot x^2} = 3.16 \cdot \sqrt{0.12 \cdot x^2} = 3.16 \cdot 0.35 \cdot x = 69.4 \text{ m/s} \quad (4)$$

where:

- $v[\text{m/s}]$  – velocity;
- $F[\text{N}]$  – drag force of the car;
- $x[\text{s}^{-1}]$  – angular velocity;
- $F_1[\text{N}]$  – force with an angular velocity of  $1 \text{ s}^{-1}$  ( $\frac{3}{25} = 0.12 \text{ N}$ ).<sup>2</sup>

$$(3.16 * 0.35 * x = 69.4, x = 63.7 \text{ s}^{-1}).$$

For example, let's calculate the power reserve of the Tesla model from the previous paragraph. The battery capacity is 100 kWh, energy consumption is 15.8 kWh per 100 km. Thus, the autonomous run range is:  $100/15.8 * 100 = 633 \text{ km}$ . In our case, a trip of 100 km takes 1 hour and the driving motor has a power of 2 kW and consumes energy of 2 kWh and 100 km consumes  $100/2 * 100 = 5,000 \text{ km}$ , which is  $5000 / 633 = 7.9$  times more.

### 3 Discussion

Readers are reminded that the main purpose of the study was to obtain projections of the centrifugal force of each unbalance onto the OY axis  $F(y)$  and summary graph(SUM) for 4 imbalances. These projections ensure smooth forward movement of the entire mechanism. To solve this problem, a digital prototype of a simplified model was created, an inertial engine, taking into account the kinematic scheme of the mechanism, initial design characteristics, and detailed design. In particular, cylindrical gears were calculated for engagement of 3 drive wheels, triangle, and unbalance. Values received for center distances, number of teeth, gear ratios, modules, gears, diameters of dividing circles, etc. The calculation of these parameters made it possible to create a virtual motion model in Autodesk Inventor 2021 for the imbalance, which is a presumed harmonic oscillatory system under external constant influence. Next, a dynamic analysis of the mechanism was carried out. Dynamic modeling provides an opportunity to determine how effectively the designed system will function in real conditions. All interactions between parts, as well as previously obtained parameters for gear engagement, were taken into account. Each connection is described by some kind of equality showing the degrees of freedom of the kinematic pair, axis, and coordinates that must be combined at the parts to obtain the correct connection.

To get correct results when creating a dynamic model, the system also needs to take into account the forces acting on the mechanism, moments, and inertia. In the process of dynamic simulation, small design changes and the kinematic diagram of the device were considered. As a result of dynamic calculations, numerical values were determined for angular speeds, accelerations, and forces arising in the nodes of the mechanism during movement. Based on this data, graphs of changes in the angle of rotation, angular velocity, and projections of centrifugal force on the y-axis for each imbalance were created. The final result of the research is a summary graph of projections of centrifugal forces on the OY axis for 4 imbalances, in which the function takes only positive values.

The main goal of the study is to create an electric vehicle capable of moving without recharging existing (standard batteries) over much longer distances compared to modern electric vehicles. The result of the research is the elucidation of the dependencies of the translational movement of the mechanism on the angular velocity of movement (rotation)

<sup>2</sup>It should be recalled that on all graphs  $F(y) = 3$  (newton) of the force were obtained at an angular velocity of  $5 \text{ s}^{-1}$  and in order to get the force per unit  $\text{s}^{-1}$ , the force formula  $F(Y)$  should be divided by the square of the angular velocity:  $F1 = 3 / 25 = 0.12$  (newton)

of the masses and masses of the rotating parts of the inertial propulsion device. It was found that a new translational motion of the trolley occurs smoothly, without jerks and rolling back, which is the difference between our development and Tolchin's mechanism.

There are some problems that need to be investigated, such as the limits (upper, lower) of the change in the angular velocity and mass imbalances at different speeds. Further research is needed to prototype electric vehicle propulsion and investigate not only the dynamics of the "electric vehicle movement" forward but also backward and upward if possible. It has been established that the resulting power fixed on the rotating mechanism and connected to a generator will produce electricity sufficient for movement, engine rotation, and battery recharging, which should be confirmed by further research.

## 4 Conclusion

Our model has shown that linear motion of an object without braking is possible, and we have found that the resulting force depends on the unbalanced mass and angular velocity.

Our research also has shown that the principle of unsupported movement, without braking the motion, is possible and can be used as an engine for an electric car.

Future studies should explore the possibility of generating electricity inside the vehicle and demonstrate the limits of using unsupported movement for other modes of transport, including space flights.

## Acknowledgments

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