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DESIGN AND CONSTRUCTION OF A GYROSCOPIC PROPULSION MECHANISM[1]

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Abstract: *This paper outlines the design and construction of a Gyroscopic Mechanism anticipated to create a thrust due to inertial forces generated by the rotation of unbalanced gyroscopes. The mechanism consists of four gyroscopic discs each carrying an offset mass. The gyroscopes are driven by a DC motor, which is powered by an external control and power supply unit. The rotation of the motor is transmitted via a reduction gear train and a synchronous belt drive to the first gyroscopic carrier. The latter converts its rotation through a bevel planetary gear train into a gyroscopic motion of two unbalanced discs mounted on it. Each disc carries an offset mass synchronised to that of the other disc by making discs as externally meshed spur gears. As a result, the discs rotate opposite to each other about their own axes and at the same time, they rotate about the axis of gyration of the carrier being perpendicular to the first and intersecting the discs axes. Therefore, the discs perform gyroscopic motion as they rotate about their individual points of intersection. Next, the rotation is transmitted from the first carrier through a synchronising gear train to a second carrier and planetary gear train and via another synchronous belt drive to a second pair of gyroscopic discs. The latter act alike those in the first disc carrier. In brief, the mechanism consists of four unbalanced gyroscopic discs generating variable inertial forces, which are expected to propel the system if appropriately synchronised. The trajectories of offset masses are found to be of figure-eight-shape located over the upper half of a spherical surface and therefore are not passing under the axes of the gyroscopic carriers.*

Keywords: *gyroscopic disc, planetary gear train, inertial propulsion, gyroscopic mechanism*

INTRODUCTION

For many years inventors from different countries have made numerous attempts to design and construct mechanisms that can propel themselves by using inertial forces without the help of friction forces. These mechanisms are known as Inertzoids. The most famous of them, which closely relate to the proposed gyroscopic propulsion mechanism discussed in this paper, is invented by Tolchin (1977), Shipov (2006), Provatidis (2010), and Provatidis (2014).

The Russian engineer Vladimir Tolchin, (1977) has invented a mechanism that creates an inertial propulsion force by employing two contra-rotating masses, spinning along a circular path and rotating about common axel in opposite directions. The masses rotate with variable velocity as per specially arranged phases of the rotation cycle. The self-motion of the mechanism does not require any friction forces between the wheels and the ground and hence it is a typical Inertzoid. Fig. 1(a) shows the pictorial view of the mechanism along with the schematic of phases illustrated in Fig. 1(b). The components of Tolchin's drive presented in Fig. 1(a) include: 1 - rotating masses designated as M1 and M2, 2 – a motor brake, 3 – supporting wheels and 4 - a spring motor. The rotation is arranged so that during Phase I (Fig. 1b) the masses M1 & M2 are accelerating, in Phase II they are slowing down and in Phase III they rotate uniformly. As a result a forward motion is achieved in the direction of Phase I with a minor reversed motion in Phase II. Under these

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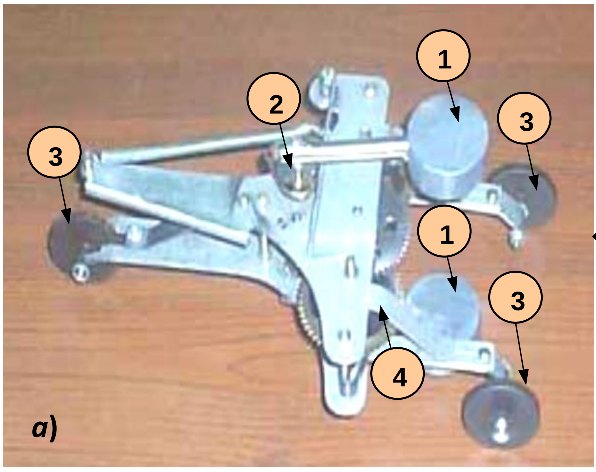
conditions the mass center of the mechanism receives a forward acceleration and hence it moves in forward direction.

Fig. 2 shows the Shipov's mechanism which is an upgraded Tolchin's mechanism. Where: 1 - is a servomotor, 2 - rotating masses, 3 - wheels, 4 – a computer, 5 - the chassis of mechanism, 6 - motion sensors and 7 – position sensors. The mechanism weighs 1.5 kg and generates a trust of about 1.8 kgf. Recently both Tolchin and Shipov drives are considered to be 4D gyroscopes and their performances are explained by the torsion field theory created by Shipov, (2006).



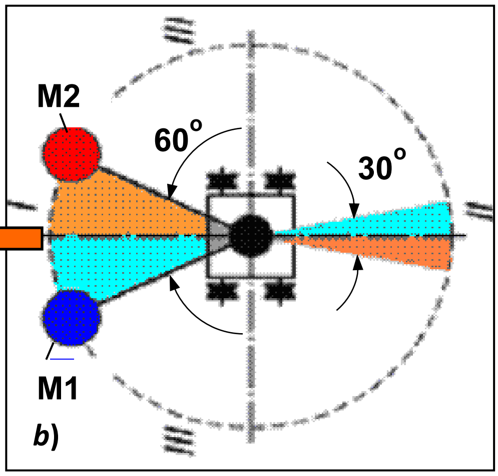


Fig. 1a shows Tolchin's drive while Fig.1b illustrates its phase diagram.

Lately, an inertial drive is developed and profoundly investigated by Provatidis, (2010). In fact, this mechanism uses two contra-rotating masses creating figure-eight-shape trajectories by spinning around the ***x*** and ***y*** axes (Fig.3a) at the same angular velocity. Moreover the masses are given an additional rotation about the vertical ***z*** – axis and as a result a net impulse is obtained in the vertical direction, producing a vertical thrust of about 8% from the weight of the mechanism. Fig. 3b depicts the trajectories of the rotating masses depending upon the presence of the additional rotation about the ***z*** axis. When $\omega_z = 0$ (Fig. 3b (a), the trajectories resemble the shape of figure eight drawn over the lower halve of a sphere, while for other ratios ω_z / ω_x they appear differently as seen in Figs. 3b (b), (c), and (d).

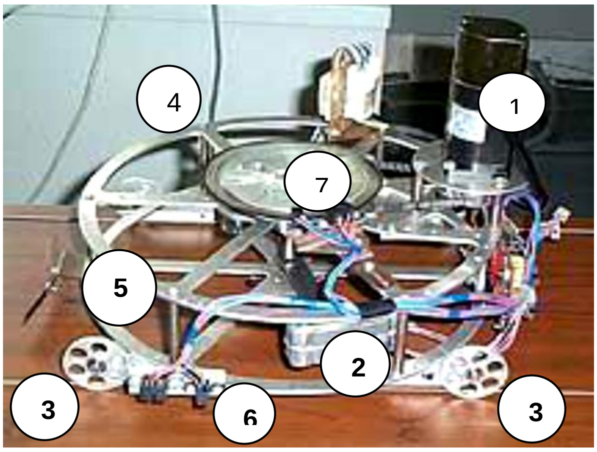
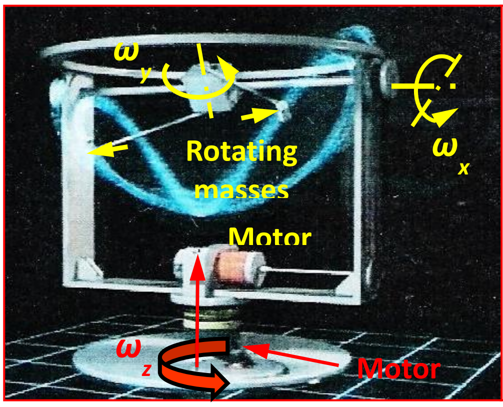


Fig. 2 illustrates the Shipov Inertzoid



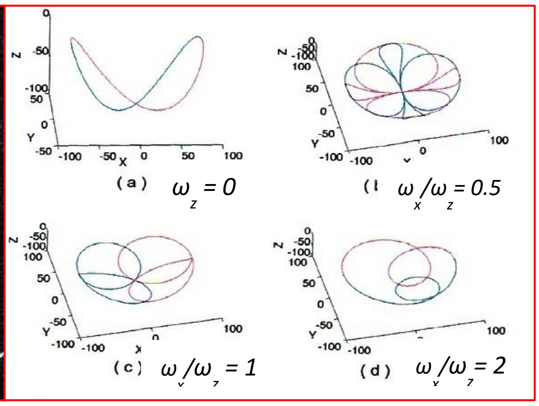


Fig. 3a The Provaditis drive Fig. 3b The trajectories of rotating masses

After the analysis of schematics of above mechanisms it is decided to design and construct a gyroscopic mechanism capable of propelling itself. It should be also stated that the proposed mechanism is designed, build and tested before the Provatidis, (2010) mechanism is published. The image of the proposed mechanism is published for the first time as a means of driving vibration-driven robots, vibrating pimps etc. (Loukanov, 2014) but not discussed in details.

EXPOSITION

Design and construction of the gyroscopic propulsion mechanism

A gyroscope is a disc rotating concurrently about two mutually perpendicular axes at high speed. The design of proposed mechanism (Fig. 4) consists of four discs operating in pairs and rotating in opposite directions. Each pair of discs, being a pair of meshing gears, is supported and driven by an individual carrier, which in turn rotates opposite to another carrier. Thus, each disc rotates about the point of intersection of the two axes and hence is considered a gyroscope. To avoid the turning effect of the gyroscopic moments it is assumed that the gyroscopic pairs have to rotate opposite to each other. In fact, the proposed design is accomplished by employing two separate carriers each carrying a planetary gear train composed of a single pair of bevel gears. By means of two synchronous belt drives, the gear train drives the first disc and hereafter the second one. To achieve an opposite rotations of the two carriers a set of four gears is employed.

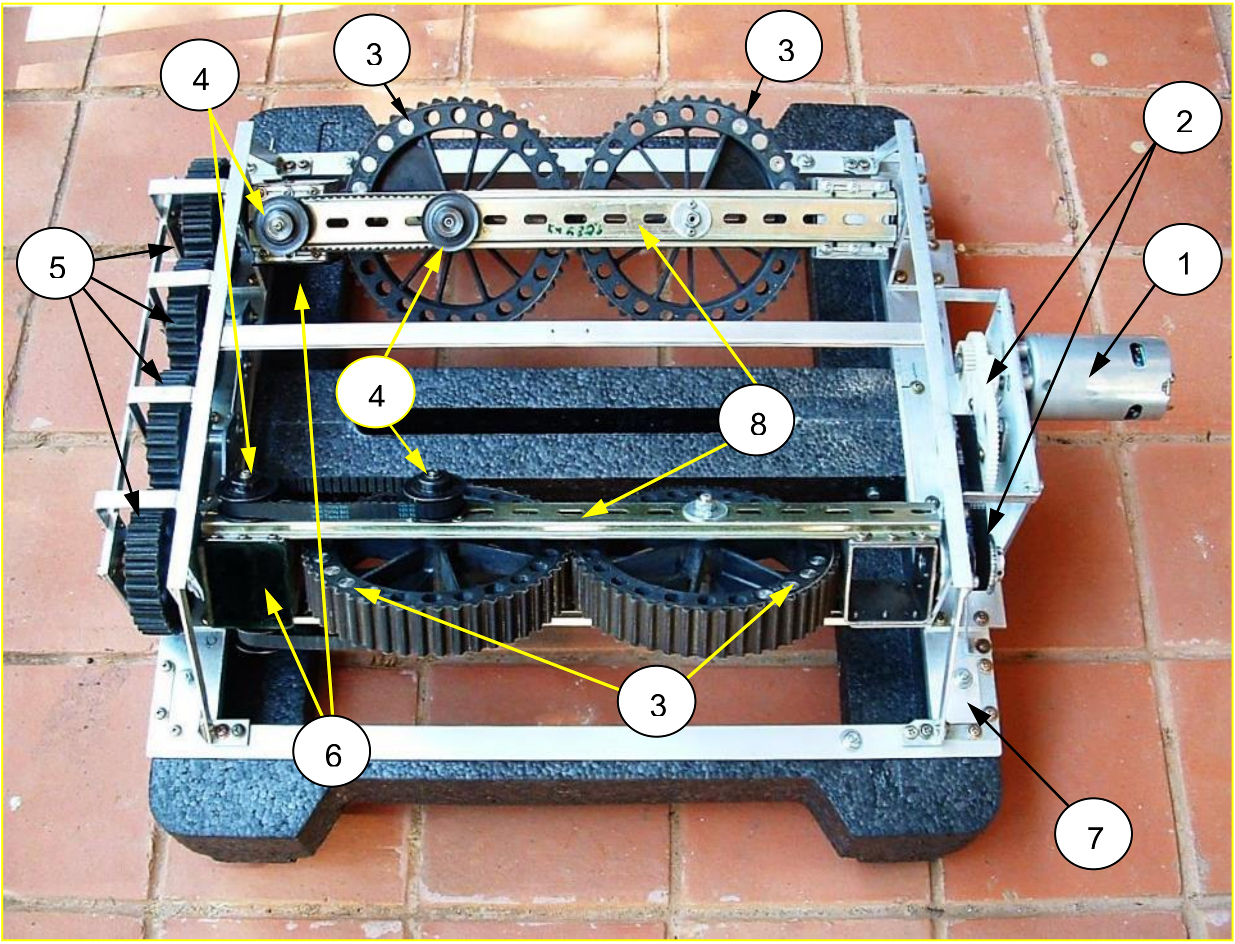


Fig. 4 Shows the proposed mechanism design illustrating its particulars.

The description numerals used in Fig.4 stand for the following sub-systems or components:

1 – DC motor,
2 – Motor reduction spur-gear train,
3 – Rotating offset masses,
4 – Synchronous belt drives,
5 – Synchronizing gear train,
6 – Planetary gear trains,
7 – Chasses,
8 – Individual gyroscopic carrier.

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The technical data of the proposed gyroscopic mechanism are listed in Table 1 bellow. These are detailed values measured either experimentally, determined by calculations or listed according to manufacturer's specifications.

Table 1. Values of mechanical parameters of the gyroscopic mechanism

№	Type of parameter	Values	Units
1	Transmission ratio of motor gear train	4.615	dimensionless
2	Individual rotating mases	0.068	kg
3	Total mass of rotating masses	0.272	kg
4	Transmission ratio of synchronous belt drives	1.00	dimensionless
5	Transmission ratio of planetary gear trains	1.00	dimensionless
6	Total mass of the gyroscopic mechanism	6.6	kg
7	DC motor, 12V, 4000 rev/min	480	Watt

In this paper, the gyroscopes are titled unbalanced since they carry offset masses (Fig. 4, numerals 3) attached to the periphery of each gyroscopic disc. The purpose of these masses is to generate inertial forces when they are spinning along special trajectories. Initially it is thought that when masses do not pass under the axes of the gyroscopic carriers they will generate unidirectional inertial forces, which will be directed only in one direction. In the actual setup of this mechanism, inertial forces were presumed to act vertically only. Unfortunately, this assumption appears to be incorrect as the direction of inertial force depends upon the curvature of its trajectory and the location of centre of rotation of the mass at that instant.

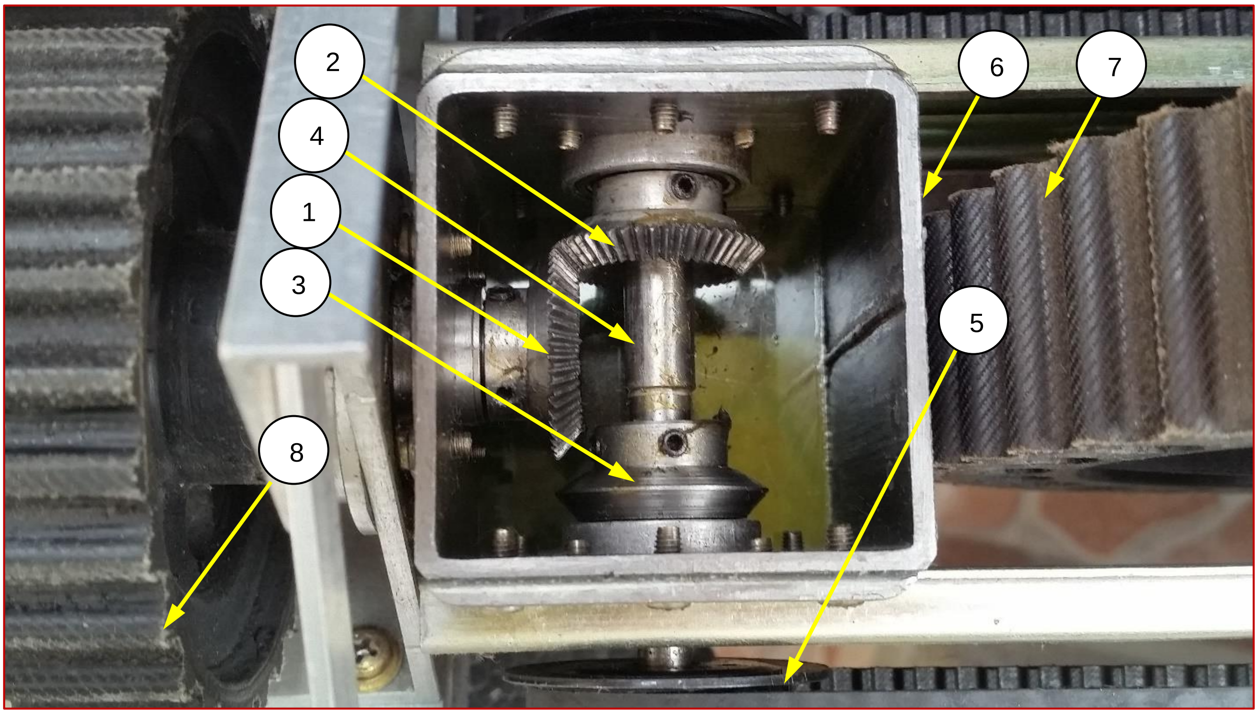

Fig.5 shows a close view of the first planetary gear train

As shown in Fig. 4, there are two planetary gear trains used in this mechanism, each one of them attached to the respective gyroscopic carrier. Both gear trains are identical in terms of their gear train ratio, being unity. As seen in Fig. 5 the first planetary gear train is composed of two bevel gears having same numbers of teeth. One of them is the planet gear – 1 and the other one is the satellite gear – 2 mounted on a shaft and ball bearings installed in housing - 6. To balance the inertial force generated by the mass of the satellite gear during the carrier rotation a counterweight – 3 is added. In the proposed design, the planet gear is motionless and is fixed to the chassis of the mechanism, while the satellite gear orbits the planet forcing the shaft - 4 to rotate about the gear train housing - 6 and via two synchronous belt drives - 5 turning first disc - 7 about its own axis.

Then, disc - 7 drives the second disc (seen in Fig. 4) and being spur gears in external mesh it rotates in opposite direction to the first one. This appears to be the relative rotation of the discs, while the rotation of their carrier is a rotation about an axis perpendicular to that of the discs axes. Therefore, the discs rotate concurrently about two mutually perpendicular axes, so the resultant motion of each disc is a rotation about the point of intersection of the respected axes. As a result, the discs are rotating about fixed points and therefore performing as gyroscopes. In addition, the first carrier rotation, which is also the rotation of the gear train housing, is transmitted by means of gear – 8 through a synchronizing gear train to a second carrier, forcing it to rotate in opposite direction to the first carrier. By this design arrangement, the generated gyroscopic moments by the four gyros are fully balanced and are not transmitted to the chassis, hence preventing any turning effects on the mechanism.

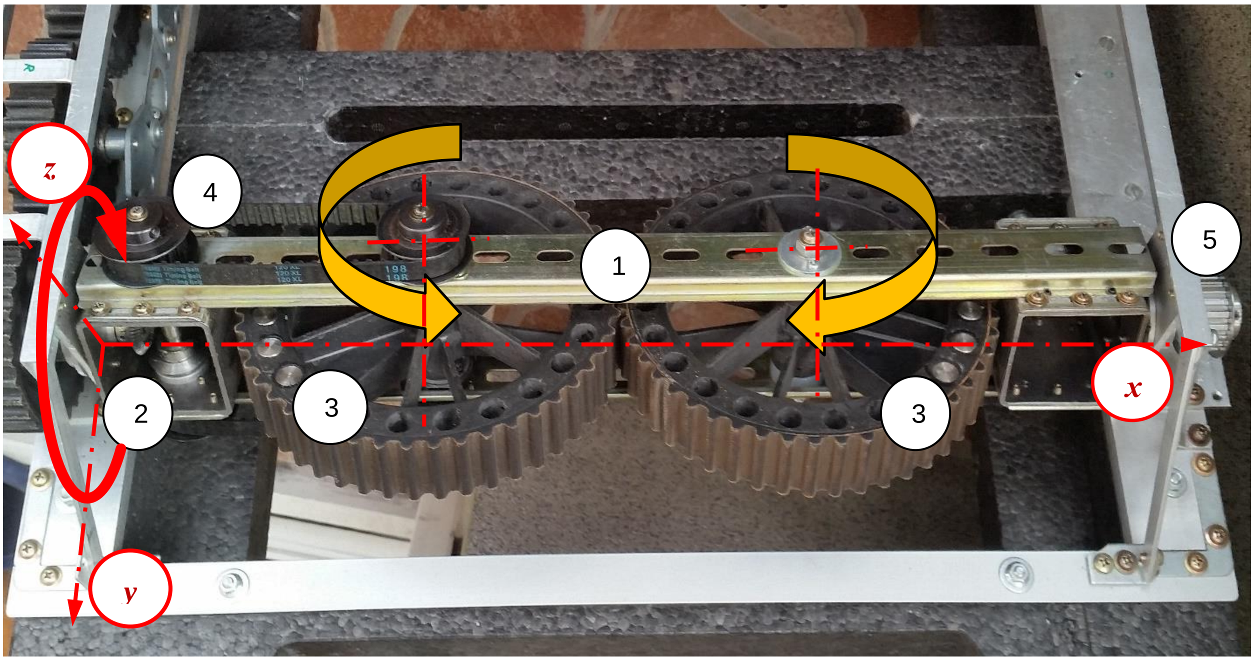

Fig. 6 displays carrier 1, planetary gear train 2, gyros 3, synchronous belt drive 4, and pulley 5.

From Fig. 6 it is seen that the two gyros rotate opposite to each other and the offset masses 3 are located on the axis - ***x*** of the carrier 1. Therefore, both masses will ascent into their individual trajectories. At this instant, the gyros are in the horizontal ***x-y*** plane. The input belt pulley 5 receives motion from the motor gear train, seen in Fig. 4, and drives the first carrier.

At later stage of this study, it is found that the shape of the trajectories of rotating masses resembles the figure-eight-shape positioned above the top surface of a sphere having the same radius as that identifying the position of offset masses. It appears that the shape of figure eight trajectories obtained by the rotating masses of this mechanism is opposite to the shape of trajectories obtained by Provatidis, (2010) mechanism as illustrated in Fig. 3b (a) when $\omega_z = 0$. It should be noted that the same trajectories as that found by Provatidis might be obtained either by appropriate setting of the mechanism or by simply turning up side down the mechanism.

Moreover, since the trajectories are continuous lines and the masses spin with constant velocity, there will be no resultant inertial force acting upright. Provatidis, (2010) also came to the same conclusion. In order to get a propulsion force he suggesting that his mechanism has to rotate in addition about the vertical ***z***-axis. Since our mechanism is not designed to rotate about the vertical ***z***-axis, in order to develop a propulsion force, it is necessary to either employ the Tolchin or Shipov's approach forcing the offset masses to rotate none uniformly along their trajectories. It is for this reason; an introduction of special setup is required, introducing either a cam mechanism with an electrical brake or using infrared sensors and electronic control system, to arrange an uneven rotation of unbalanced masses. The idea is to impart acceleration to the mass centre of the

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mechanism as done by Tolchin, (1977) and later by Shipov, (2006). Since that is not the objective of this paper, it is left for future improvement and additional studies.

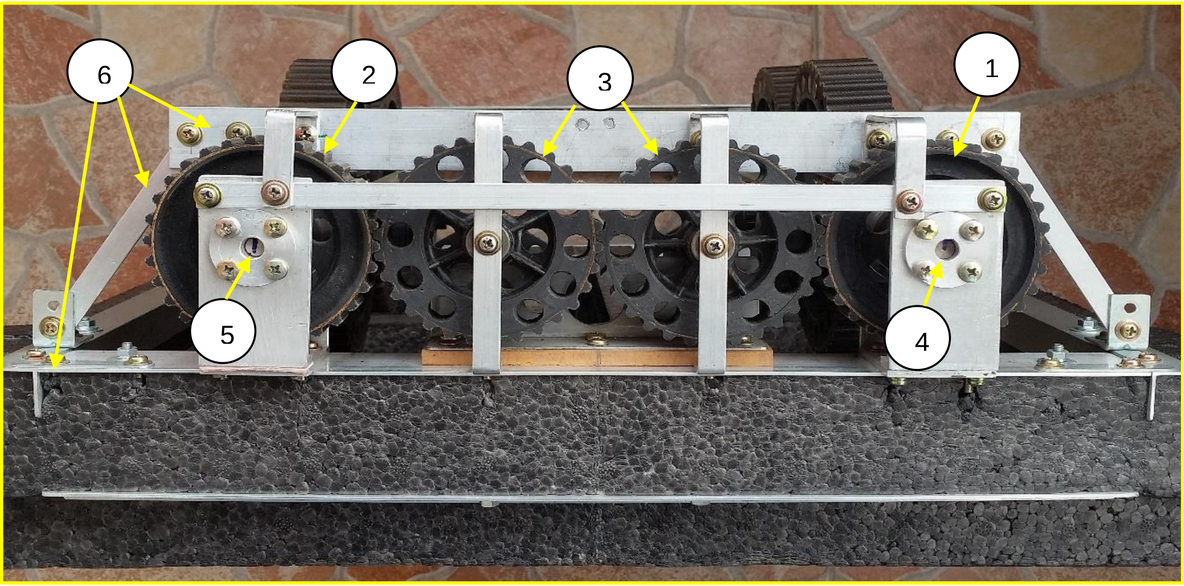

Fig. 7 shows the synchronizing gear train connecting the first to the second carrier of the gyros.

To synchronize the rotations of the first and second gyroscopic carriers a special gear train is employed consisting of four equal spur gears. The gear 1 is fixed to the first carrier while gear 2 is secured to the second carrier. To achieve synchronized but opposite rotation of the gyroscopic carriers two identical idler gears 3 are used. As stated previously the planet gears are stationary, and now their shafts are shown fixed to the chassis 6 by means of flanges 4 and 5. Similarly, here setscrews are employed to fix the planet gears to their respective shafts (Fig. 5 and Fig. 8) as well as their shafts to be secured to the flanges 4 and 5.

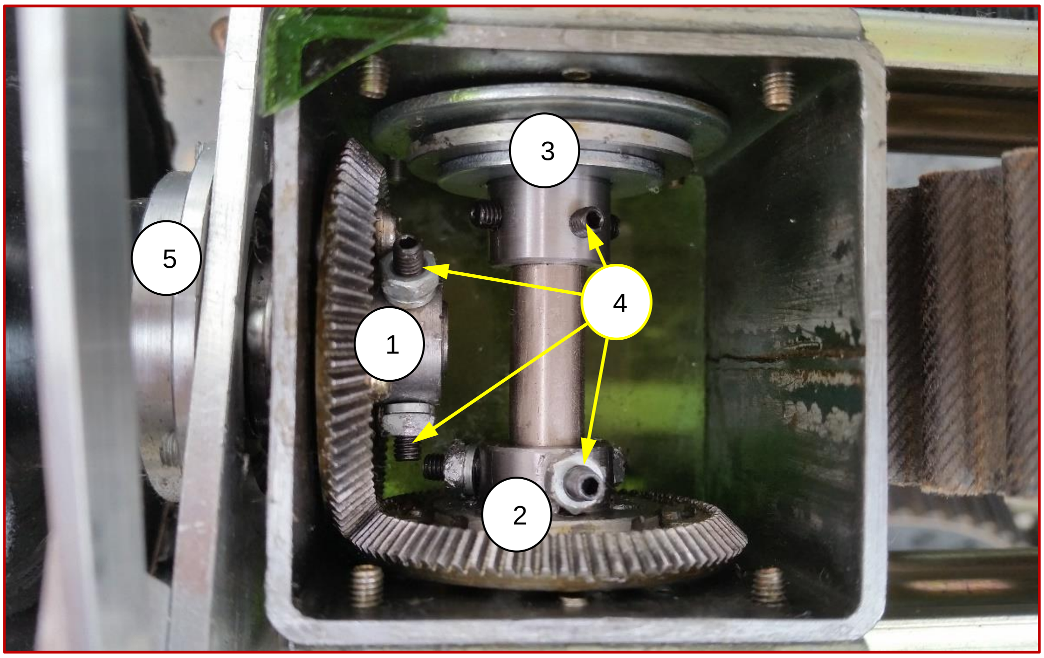

Fig. 8 displays the second planetary gear train also having a gear ratio unity

Although, the size of the bevel gears used in constructing the second planetary gear train are with larger number of teeth it has the same gear ratio as that of first gear train. More importantly, is the fact that it has the gear ratio of unity in achieving the gyroscopic performance of the discs installed on the second carrier. In fact, the timing pulleys used to transmit motion from the planetary gear train to the first gyroscopic disc of the pairs of gyros installed on the respective carriers are also fixed to their shafts by means of two setscrews. All setscrews are positioned at 75 degrees from each other making sure the transmission of a maximum turning moment. In Fig. 8 gear 1 is the fixed planet gear, 2 is the satellite gear, 3 is a counterbalance mass, 4 displays the setscrews and fixing nuts, while 5 stands for the housing of the left supporting bearing of the carrier. The right supporting bearing is not sawn in this picture but it is seen in Fig. 4. It should be noted that both carries are supported by ball bearings located at their ends. In addition, ball bearings are integrated in the carriers to support each gyroscopic disc.

Investigation of the mechanism performance and analyses of the design

After assembling, the gyroscopic mechanism is tested at different speed of rotation of the gyroscopic discs. A specially designed and build power supply unit was used for this purpose generating 500 Watt DC power output having a voltage control from zero to 12 V to achieve the necessary power supply. It was found that when tested on a hard and friction supply surface at moderate speed, the mechanism tends to propel itself with a modest speed of sliding. However, tested on a soft and elastic surface it is jumping above the surface with the same frequency as that of the rotating offset masses. The last observation is also appreciated when tested on a hard surface but it appears at much higher speed of rotation of the gyroscopic discs. In addition, this phenomenon is accompanied with heavy impacts between the mechanism and the contacting surface, indicating that there is a separation between them. The mechanism was also tested as a pendulum with the hope to notice any propulsion effect, but none is appreciated. During all tests, it is found that the setup of the mechanism is changed accidentally and the synchronization of the gyroscopic discs is lost. This certainly comes from some loose set-crews failing to keep the components firmly secured together. Surely, these problems require improving the components connections to shafts, pulleys and gears in order to avoid any problem with the original setup.

CONCLUSION

This paper provides details in relation to the design and construction of a gyroscopic propulsion mechanism. Analysing the problem encountered during tests it is found that an asymetric alteration of the mechanism original setup occurs. To solve the problem it is decided to undertake some changes of the connections among the components in order to achieve better performance and avoid the undesired desynchronization. Since it is clear that a propulsion effect with uniform rotation of the unbalanced gyroscopes is not possible, it necessitates furnishing the gyroscopic mechanism with a cam and electric brake mechanisms. These are intended to set and control the rotation cycle of gyroscopes by using micro-electric contacts, electric brake and the power supply unit. It is our believe that by this improvement we can achieve non-uniform rotation cycle following the Tolchin (1977) approach and hence gaining a self-propulsion effect by the gyroscopic mechanism.

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