



## SPACE FLIGHTS AND ELECTROMAGNETIC FIELD MOMENTUM

Solomon Itskovich Khmelnik  
15302, Bene-Ayish, 0060860, Israel

### ABSTRACT

A new approach to the design of spacecraft for flights in space is proposed. The device for converting an electromagnetic pulse into a mechanical pulse is analyzed in detail. An experiment is described that demonstrates the existence of traction in the proposed device. It is shown that the specific thrust of this device is 1000 times greater than the specific thrust of a jet engine. The author offers cooperation for patenting in various countries and the development of devices for various purposes.

**Keywords:** Spacecraft engine, space rocket, space flights, specific momentum, specific thrust, electromagnetic momentum, law of conservation of momentum, static electromagnetic field.

### INTRODUCTION

The practice of the last half-century has shown that flights in outer space are a costly undertaking and in general require huge devices. It may be objected that today there are so many small satellites that they interfere with astronomical observations. However, these unmanaged and nonreturnable devices are the modern analog of cannonballs. The reason for this state of affairs is considered to be the law of conservation of momentum. More precisely, the law of conservation of a mechanical impulse, for the fulfillment of which tons of fuel is required for a flight in the free space (vacuum).

However, there is a more general law of conservation of momentum, in which a mechanical momentum and an electromagnetic momentum enter quantitatively on an equal footing. However, the possibility of movement under the influence of electromagnetic forces, as a rule, is rejected. A vivid example of this is the ongoing controversy surrounding EmDrive (Shawyer, 2016). In 2016, NASA team has also claimed 'impossible' space engine works here <http://news.nationalgeographic.com/2016/11/nasa-impossible-emdrive-physics-peer-review-space-science>. In 2017, China has also claimed on EmDrive here <https://futurism.com/china-claims-its-made-the-impossible-emdrive-possible>. This device can demonstrate very little force: critics are looking for some yet undetected forces.

Indeed, this criticism can be understood. The electromagnetic momentum density  $p$  is related to the electromagnetic energy flux density  $S$  by the formula  $J =$

$S/v^2$ , where  $v$  is the electromagnetic energy flux rate, i.e. the speed of light. When dividing by the speed of light squared, it is impossible to obtain an impulse value acceptable for the technique, and this fact convinces critics. It is also possible to mention that this work treats only speeds that cannot exceed the speed of light in a vacuum. Therefore, the possible faster speeds reviewed in (Zakharenko, 2020) because they can be also supported by a vacuum are not considered.

The movement speed of electromagnetic energy in electrodynamics is assumed to be equal to the speed of light. This statement has supplanted from scientific use cases when the speed of electromagnetic energy is less than the speed of light. However, such cases are known. There is no electromagnetic wave in a static electromagnetic field but there is a flow of electromagnetic energy, the speed of which can be arbitrarily low (Khmelnik, 2019). This means that there may be some when the electromagnetic momentum is comparable in magnitude with a mechanical pulse, and it is possible to design economical apparatus.

Such an apparatus is proposed in the patent by (Khmelnik, 2019) that is analyzed below. Some experiments are described in (Khmelnik and Triger, 2019). This device can move for a long time with continuous but limited acceleration and therefore travel for long distances in a short time. Below, for example, in Appendix 1, we consider the flight to the Moon. It is shown that the flight to the Moon will take by about 7 hours with a maximum acceleration of 5 G. At the same time, the device can have a simple gasoline engine and weigh 90 tons with the fuel, of which 50% is the weight of the fuel.

Jet engine performance indicators are specific impulse and specific thrust. The proposed theory will allow us to calculate these indicators for our apparatus. For it, in essence, these are the performance of the internal combustion engine used to rotate the disk. Example 6 below provides quantitative estimates, from which it follows that the **specific thrust of this device is 1000 times greater than the specific thrust of a jet engine.** This suggests that the proposed apparatus is a high economic engine for the spacecraft.

In general, the device features are the ability to move in airless space, the simplicity of design, reliability, noiselessness, the ability to move at low speed, and hovering. The device can be used for returning satellites, instead of helicopters, instead of construction cranes and, most importantly, for space flights. In the latter case, compared with a rocket, the device has the ability to rise and land at a low speed, low fuel consumption, no overload for the crew, lack of expensive thermal protection.

**The design**

The design of the proposed device has, for example, the form shown in Figure 1 (from the patent by Khmelnik (2019) and contains an energy source, an engine 110, a disk 120, and a plurality of permanent magnets 130 mounted on the disk 120. The motor rotates the disk and the magnets move at linear speed  $V$  denoted by 140 in Figure 1. The magnets 130 have ends of the north N and south S poles. The magnets 130 are located on the disk 120 so that the planes of their ends make up a certain angle with the trajectory of the end and with the plane of the platform in which this trajectory lies. Figure 2 shows the scan of a disc with magnets.

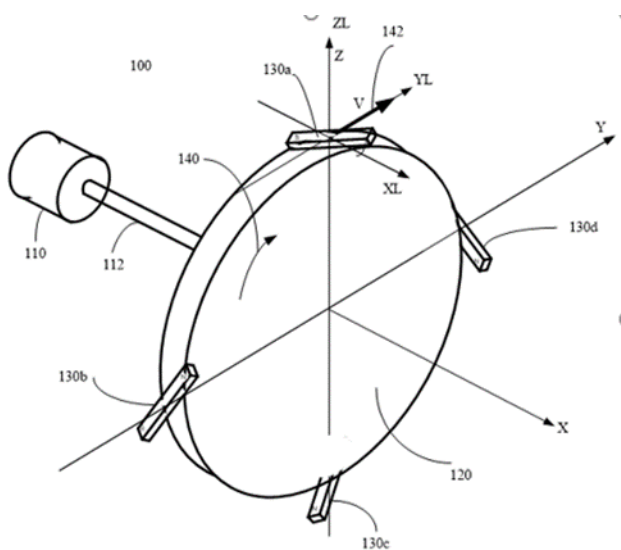


Fig. 1. The schematic diagram of the device.

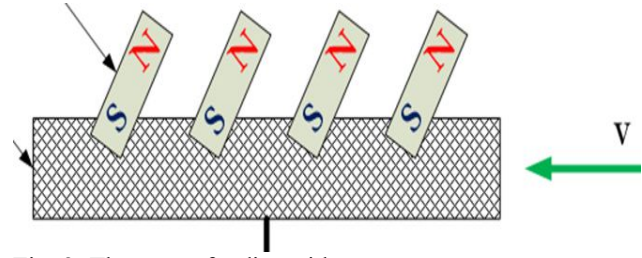


Fig. 2. The scan of a disc with magnets.

It is proved below that many magnets located on the platform moving with a certain speed create a total mechanical momentum directed perpendicular to the velocity vector. In Khmelnik and Triger (2019) many more variants of the arrangement of magnets are proposed, in which the same principle of the formation of a mechanical pulse is observed.

**Mathematical description of the design**

The Faraday unipolar induction law is widely known. It is natural to apply the law to a permanent magnet moving at a speed  $V$ :

$$E = V \times B \tag{1}$$

or

$$E = V \times \mu H \tag{2}$$

where  $B, E, H, \mu$  are the magnetic induction, electric and magnetic intensities, absolute magnetic permeability, respectively.

The density of the flow of electromagnetic energy flowing from the end of the magnet can be calculated with the following expression:

$$S = E \times H \tag{3}$$

Let us consider the application of these relations to our construction, see in Figure 3. In the cylindrical coordinates  $\{r, \varphi, z\}$ , the vectors under consideration have the following form  $H = [H_r, H_\varphi, H_z]$ . Moreover, taking into account (2), we obtain:

$$E = E_r \tag{4}$$

$$V = V_\varphi \tag{5}$$

Then

$$E = E_r = V\mu H_z \tag{6}$$

$$S_z = E_r H_\varphi \tag{7}$$

or

$$S_z = V \cdot \mu \cdot H_z \cdot H_\varphi \tag{8}$$

This value will be the greatest if

$$H_z = H_\varphi = H/\sqrt{2} \tag{9}$$

i.e. the magnet should be inclined to the plane at an angle of  $\pi/4$ . Then

$$S_z = 0.5V\mu H^2 = 0.5VB^2/\mu \tag{10}$$

or

$$S_z = 0.5V\mu H^2 = 0.5VHB \tag{11}$$

Similarly,

$$S_\varphi = 0.5VHB \tag{12}$$

The density of the entire energy flow is

$$S = \sqrt{|S_z|^2 + |S_\varphi|^2} = \frac{1}{\sqrt{2}} VHB \tag{13}$$

or

$$S = VW_m \sqrt{2} \tag{14}$$

where the magnetic energy density of the magnet is defined by

$$W_m = 0.5HB \tag{15}$$

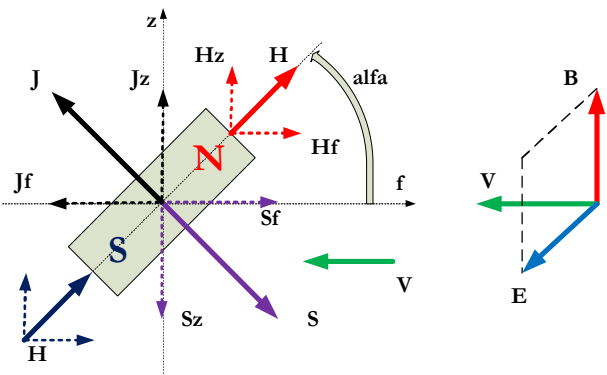


Fig. 3. The vectors acting in magnet.

Figure 4 shows a three-dimensional image of a magnet and the vectors acting on it. When moving, an electrically conductive magnet becomes an electret-magnet. Moreover, in it there are the following:

- the abcd plane is the north end of the magnet,
- the efgh plane is the south end of the magnet,
- the abge plane becomes the positive end of the electret,
- the cdhf plane becomes the negative end of the electret.

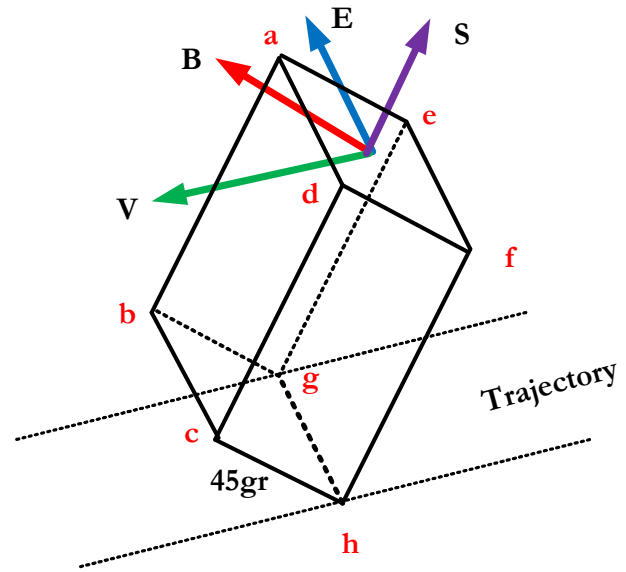


Fig. 4. The three-dimensional image of a magnet.

The energy source for the entire stream with density  $S$  is the energy of the energy source for the engine, and the stream with density  $S$  is the power of the engine. The magnet moves along the  $\varphi$  axis at a speed  $V$  and along the  $z$  axis at a speed  $V_{vert}$ , where  $V_{vert}$  is the vertical speed of the structure, **not** equal to  $V$ . The same speeds are the flow velocities  $S_z$  and  $S_\varphi$ , respectively. The density of the electromagnetic momentum is determined (as indicated above) by the formula  $J = S/v^2$ . Taking into account (12) and (13), we find that the momentum projections  $J_z$  and  $J_\varphi$  are equal to the following expressions:

$$J_\varphi = \frac{S_\varphi}{V^2} = \frac{HB}{2V} \tag{16}$$

$$J_z = \frac{S_z}{V_{vert}^2} = \frac{HBV}{2V_{vert}^2} \tag{17}$$

In accordance with the law of conservation of momentum, the electromagnetic momentum in total with the mechanical momentum of the magnet must be zero, since the latter was absent at the beginning of the motion.

Consequently, the magnet body acquires mechanical momenta such as

$$M_{m\varphi} = -\frac{HBQ}{2V} \quad (18)$$

$$M_{mz} = -\frac{HBVQ}{2V_{vert}^2} \quad (19)$$

where  $Q$  is the volume of the magnet.

This impulse of many magnets is the vertical impulse of the device. The powers consumed by the magnet for circular motion and for vertical motion are respectively equal to:

$$P_{m\varphi} = S_{\varphi} b \quad (20)$$

$$P_{mz} = S_z b \quad (21)$$

where  $b$  is the area of the end face of the magnet.

From (11), (12), (20), and (21) we find:

$$P_{mz} = P_{m\varphi} = 0.5VHBb \quad (22)$$

From (18), (19), and (22) we find:

$$M_{m\varphi} = \frac{HBQ}{2V} = \frac{2P_{m\varphi}Q}{2V^2b} = \frac{P_{m\varphi}L}{V^2} \quad (23)$$

$$M_{mvert} = M_{mz} = \frac{HBVQ}{2V_{vert}^2} = \frac{2P_{mz}Q}{2V_{vert}^2b} = \frac{P_{mz}L}{V_{vert}^2} \quad (24)$$

where the length of the magnet is expressed as follows:

$$L = \frac{Q}{b} \quad (25)$$

The magnet weight is

$$Z_{mag} = Q\rho \quad (26)$$

where  $\rho$  is the specific gravity of the magnetic material.

The mass of the device will be defined as

$$m = rZ_{mag}/G, \quad r = \frac{Gm}{\rho Q} \quad (27)$$

where  $G$  is the acceleration of gravity,  $r$  is the loading coefficient. The power consumed by the magnet for vertical movement is

$$P_{mz} = F_{vert} V_{vert} \quad (28)$$

where  $F_{vert}$  is the magnet traction force.

In addition, we have:

$$M_{mvert} = mV_{vert} \quad (29)$$

With (24) and (29), we find the speed of vertical movement as follows:

$$mV_{vert} = \frac{P_{mz}L}{V_{vert}^2} = \frac{HBVQ}{2V_{vert}^2} \quad (30)$$

or

$$V_{vert} = \sqrt[3]{\frac{HBVQ}{2m}} \quad (31)$$

We find the magnet traction force at a given speed  $V_{vert}$  from (28):

$$F_{vert} = P_{mz}/V_{vert} \quad (32)$$

With (31) and (32), we find

$$F_{vert} = \frac{HBVb}{2} / \sqrt[3]{\frac{HBVQ}{2m}} = b \sqrt[3]{\frac{(HBV)^2 m}{4Q}} \quad (33)$$

Considering also (27), we find:

$$F_{vert} = b \sqrt[3]{\frac{(HBV)^2 r \rho}{4G}} \quad (34)$$

From (34) we find

$$F_{vert} = bd \quad (35)$$

where

$$d = \sqrt[3]{\frac{(HBV)^2 m}{4Q}} = \sqrt[3]{\frac{(HBV)^2 r \rho}{4G}} \quad (36)$$

i.e.  $d$  is also **pressure**, and the traction force  $F_{vert}$  is also **pressure force**.

The obtained relations together with known external forces allow us to calculate the dynamics of flight. Obviously, the vertical in this case is the direction of the axis of rotation of the disk. Therefore, all of the above applies to fly in any direction.

With a known traction force at each moment of time, from (34) we can find the required linear velocity of the magnets:

$$V_{min} = \frac{1}{HB} \sqrt[3]{\frac{4GF_{vert}^3}{r\rho b^3}} \quad (37)$$

Khmelnik and Triger (2019) describe an experiment demonstrating the existence of traction in the proposed device. Together with the vertical flow of energy (11), there is a horizontal flow of energy (12) directed in a circle. Together with the flow (12), there is a co-directional electromechanical impulse and (due to the law of conservation of momentum) a mechanical impulse opposite to the energy flow (12), i.e. directed opposite to the speed  $V$ . Therefore, this impulse is inhibitory. Similar to (32), the braking force  $F_{br}$  can be found by the following formula:

$$F_{br} = P_m / V \tag{38}$$

Thus, the engine power is spent on lifting and braking during rotation. From (38) it follows that after acceleration, the braking force can be neglected.

**Examples of calculation**

**Example 1. Fixed and unsupported device.**

The design has a disk mounted with many magnets and has the following characteristics:

$$b = 0.015 \text{ m}^2, L = 0.005 \text{ m}, B = 1.35 \text{ T}, H = 50 \text{ A/m}, \\ \rho = 5 \times 10^4 \text{ N/m}^2, Z_{mag} = 3.75 \text{ N}.$$

Note that there can be many magnets and disks with magnets. Here  $b$  is the total area of all magnets. At a given speed,  $V = 43$  [m/s], according to the above formulas

$$F_{vert0} = 98 \text{ N}, r = 26, V_{vert} = 0.22 \text{ m/s}, P_{mz} = 22 \text{ W}, \\ \omega = 60V / (2\pi R) = 2780 \text{ rps}.$$

Figure 5 shows the functions  $V_{vert}(V)$  and  $P_{vert}(V)$  calculated with formulae (31) and (22), respectively, and  $\omega = 60V / (2\pi R)$ .

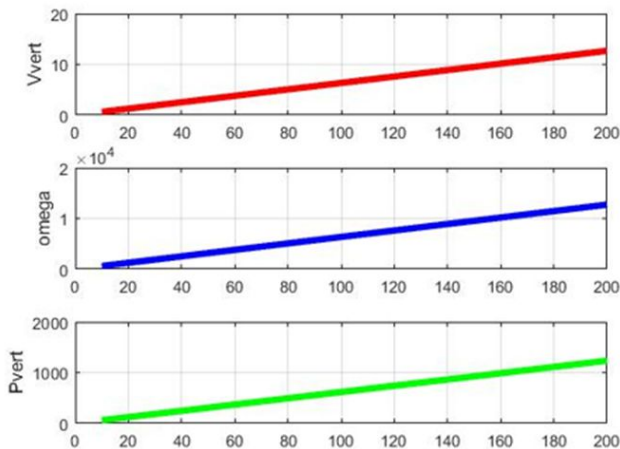


Fig. 5. The functions  $V_{vert}(V)$ ,  $\omega(V)$ , and  $P_{vert}(V)$ .

**Example 2. Counteraction to the impulse of force.**

Suppose that under the conditions of Example 1, an additional force of **150 N**. Find a new traction force

$$F_{vert2} = F_{vert} + 50 = 148 \text{ N}$$

By (41) we find a new linear velocity of the magnets  $V = 108$  [m/s]. Find the new vertical speed from (32):  $V_{vert} = 0.3$  [m/s]. We also find the power required for this by (29):  $P_m = 75$  [W].

**Example 3. Flying with acceleration in the absence of resistance**

Consider a flight in the absence of resistance (for example, in zero gravity). Since the disk rotates, it consumes energy (20, 21) and creates a torque (29). On the other hand

$$F_{vert} = am \tag{39}$$

where  $a$  is the acceleration created by this force.

With (39) and (29), we find

$$P_{mz} = F_{vert} V_{vert} = amM_{mvert}/m = aM_{mvert} \tag{40}$$

or

$$\alpha = \frac{P_{mz}}{M_{mvert}} \tag{41}$$

With (41) and (24), we find

$$\alpha = \frac{V_{vert}^2}{L} \tag{42}$$

Hence,

$$\frac{dU_{vert}}{dt} = \alpha \tag{43}$$

and the rate of change of momenta can be obtained with the following formula:

$$\frac{dM_{mvert}}{dt} = m \frac{dU_{vert}}{dt} = m\alpha = \frac{mV_{vert}^2}{L} \tag{44}$$

Considering also (31), we find:

$$\frac{dM_{mvert}}{dt} = \frac{m}{L} \sqrt{\left(\frac{QHbV}{2m}\right)^2} = \frac{1}{L} \sqrt{m(0.5QHbV)^2} \tag{45}$$

or taking into account (21) we finally find

$$\frac{dM_{mvert}}{dt} = \frac{1}{L} \sqrt{m \left(\frac{P_m}{b} Q\right)^2} = \sqrt{\frac{m}{L} P_m^2} \tag{46}$$

When the direction of rotation of the disk changes, the acceleration changes its sign. Thus, the rate of change of momentum (46) can accelerate or slow down the device.

It follows from (39) and (44) that

$$F = ma = \frac{dM_{\text{vert}}}{dt} \quad (47)$$

#### Example 4. Flying with acceleration in the presence of a drag force

Consider a flight with acceleration in the presence of resistance force  $F_T$ . In this case, formula (39) takes the form:

$$P_m = (F - F_T)V_{\text{vert}} = amV_{\text{vert}} \quad (48)$$

where  $F$  is, as before, the force created by a rotating disk in the direction of the axis of rotation. All formulas of Example 3 are preserved in this case, with the exception of formula (47), which here takes the following form:

$$F_{\text{vert}} = F_T + ma = F_T + \frac{dM_{\text{vert}}}{dt} \quad (49)$$

#### Example 5. The specific momentum and specific thrust

We find the energy required in order to pass a certain momentum to the device. From (46) we find:

$$M_{\text{vert}} = \int_0^T \frac{dM_{\text{vert}}}{dt} dt = \int_0^T \left( \sqrt[3]{\frac{m}{L} P_m^2} \right) dt \quad (50)$$

where  $T$  is the momentum duration.

Suppose that the power  $P_m$  for increasing the momentum remains constant over the entire period  $T$  of the increase in momentum. Then from (50), we find:

$$M_{\text{vert}} = T \sqrt[3]{\frac{m}{L} P_m^2} \quad (51)$$

The energy spent to get the momentum is

$$W_m = TP_m \quad (52)$$

From (51) and (52) we find:

$$M_{\text{vert}} = \sqrt[3]{\frac{m}{L} TW_m^2} \quad (53)$$

Consider the specific momentum of our apparatus, completely analogous to the specific momentum of a jet engine that is equal to the ratio of momentum to fuel consumption:

$$I_m = \frac{M_{\text{vert}}}{W_m/D} \quad (54)$$

where  $D$  is the specific fuel consumption for an engine rotating a disk with magnets. From (53) and (54) we find:

$$I_m = D \sqrt[3]{\frac{mT}{LW_m}} = D \sqrt[3]{\frac{m}{LE_m}} \quad (55)$$

It follows that the specific momentum increases with an increase in the mass of the device and a decrease in the engine power. A calculation using this formula (see example 1 below) shows that the **specific momentum of the proposed device significantly exceeds the specific momentum of a jet engine**.

Consider the specific thrust of our apparatus, completely similar to the specific thrust of a jet engine and equal to the ratio of thrust to fuel consumption:

$$\Psi_m = \frac{F_{\text{vert}}/G}{W_m/D} \quad (56)$$

It is possible to write (56) more strictly:

$$\Psi_m = F_{\text{vert}} dt / (GP_m dt/D) \quad (57)$$

or, taking into account (47),

$$\Psi_m = \frac{dM_{\text{vert}}}{dt} dt / (GP_m dt/D) \quad (58)$$

or

$$\Psi_m = D \frac{dM_{\text{vert}}}{dt} / (GP_m) \quad (59)$$

With (46), we obtain

$$\Psi_m = D \sqrt[3]{\frac{m}{L} P_m^2} / (GP_m) = \frac{D}{G} \sqrt[3]{\frac{m}{P_m L}} \quad (60)$$

With (55), we finally obtain

$$\Psi_m = \frac{I_m}{G} \quad (61)$$

It can be seen that the **specific thrust of the proposed apparatus significantly exceeds the specific thrust of the jet engine**.

#### Example 6.

For example, if our apparatus is a gasoline engine, then  $D = 4,262,400$  [J/kg]. Let also  $\frac{m}{P_m} = 0.5$ ,  $L = 0.005$  m.

Then by (54) and (61), we find:

$$I_m \approx 5 \times 10^6, \Psi_m \approx 5 \times 10^5.$$

Table 1. The specific impulse and specific thrust for the rocket engines and apparatus.

Engine	Specific momentum [m/s]	Specific thrust [s]
Gas turbine engine	30,000	3,000
Liquid engine	5,000	500
Solid fuel engine	3,000	300
Electric Rocket Engine	50,000	5,000
Ion Engine	30,000	3,000
Plasma Engine	300,000	30,000
Hypothetical photonic rocket	300,000,000	30,000,000
<b>Apparatus</b>	<b>5,000,000</b>	<b>500,000</b>

Table 1 shows the values of specific impulse and specific thrust for known rocket engines ([https://en.wikipedia.org/wiki/Specific\\_impulse](https://en.wikipedia.org/wiki/Specific_impulse)) and for the proposed apparatus. It can be seen that the specific impulse and specific thrust of the proposed apparatus significantly exceed the corresponding values for known jet engines. This suggests that the proposed apparatus is an economical engine for the spacecraft.

**The calculated ratio**

The design parameters are:

- the radius of the disk  $R$ ,
- induction at the end of magnet  $B$ ,
- coercive intensity  $H$ ,
- the number of magnets  $k$ ,
- the area of the end face of the magnet  $b$ ,
- magnet length  $L$ ,
- specific fuel consumption for the engine rotating the disk,  $D$
- the density of the magnet material is  $\rho$ .

It is important to note that the efficiency of the apparatus substantially depends on the length of the magnet and increases with decreasing the length. Therefore, it is advisable to use thin flat magnets. Currently, film magnets exist and are being improved that are extremely effective in this application.

The calculated parameters are:

- apparatus weight  $m$
- disk rotation speed  $n$ ,
- engine power  $P_m$ ,
- the speed of the apparatus (linear velocity of the apparatus along the axis of rotation of the disk)

$$V_{vert}$$

- the speed of the magnets (linear velocity on the disk circumference)  $V$ ,
- traction force  $F_{vert}$ ,
- specific thrust  $\Psi_m$ ,
- momentum  $M_{mvert}$ ,
- specific momentum  $I_m$ .

It should be ensured that the value of the speed of the magnets ( $V$ ) is larger than a certain minimum value. The following basic relationships between the parameters listed above were found:  $Q = Lb$ ,  $P_m = F_{vert} V_{vert}$ ,

$$M_{mvert} = mV_{vert}, P_{mz} = 0.5VHBb, V_{vert} = \sqrt[3]{\frac{HBVQ}{2m}}$$

$$F_{vert} = b \sqrt[3]{\frac{(HBV)^2 r_g}{4G}}, V = \frac{1}{Hb} \sqrt[3]{\frac{4GF_{vert}^2}{r_p b^3}}$$

Also, the parameters  $I_m$  and  $\Psi_m$  are defined by formulae (55) and (61), respectively.

The obtained relations together with known external forces allow us to calculate the dynamics of flight. The vertical in this case is the direction of the axis of rotation of the disk. Therefore, all of the above applies to fly in any direction.

**CONCLUSION**

The paper has proposed the device for converting an electromagnetic pulse into a mechanical pulse. An experiment was also described for demonstration of the existence of traction in the proposed device. It was found that the specific thrust of this device can be 1,000 times larger than the specific thrust of a jet engine. Several examples of calculations of various parameters were demonstrated.

**Appendix 1. Flight to the Moon**

The proposed device is comparable to a helicopter engine in terms of “thrust/power”. Therefore, we consider a device equivalent to the Mi-26 helicopter (<https://ru.wikipedia.org/wiki/%D0%9C%D0%B8-26>) but characterized by the absence of external screws and external shape. Table 2 shows the technical characteristics of such an apparatus and the helicopter.

To illustrate the application apparatus in space, we consider the flight of such an apparatus to the Moon. The flight path is shown in Figure 6, and flight parameters are shown in Table 3. While, Figure 5 shows the Earth with the atmosphere, apparatus and the two positions of the Moon at the time of the launch of the apparatus (Moon-1) and at the time of landing (Moon-2).

Table 2. The technical characteristics of the apparatus and the Mi-26 helicopter.

Parameter	Characteristic	
	Helicopter	Apparatus
Diameter of Carrier screw	32 m	-
Volume	40×34×8=11,000 m <sup>3</sup>	10,000 m <sup>3</sup>
Empty mass	28,200 kg	30,000 kg
Normal take-off weight	49,500 kg	50,000 kg
Engine power	22,800 h.p.	20,000 h.p.
Fuel consumption	3,100 km/h	3,100 km/h
Helicopter cruising speed	265 km/h	250 km/h
Cruising Speed in Space	-	unlimited
Flight range at maximum refueling in helicopter mode	800 km	800 km
Flight range in space	-	see example
Fuel weight	10,000 kg	40,000 kg
Load capacity in the cargo compartment	20,000 kg	-
Crew and soldiers and their weight	90 and 20,000 kg	-
Total payload	40,000 kg	40,000 kg
Total weight	78,000 kg	90,000 kg

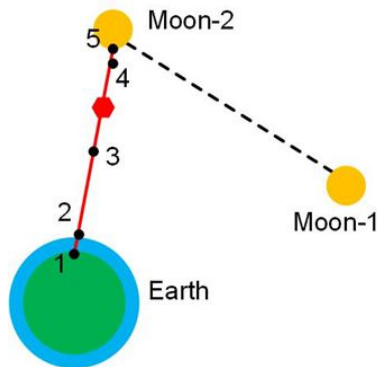


Fig. 6. The flight path apparatus to the Moon.

Table 3. The parameters of individual sections of the trajectory.

section	length km	speed km/h	acceleration	time hour
1-2	500	250	0	2
2-3	190,000	250... $V_{23}$	1 G	1.73
3-4	190,000	$V_{23}$ ...250	1 G	1.73
4-5	250	250	0	1
total				6.46

In section 1-2 in figure 6, the apparatus flies in the Earth's atmosphere at a speed of 250 km/h or

$$V_{12} = \frac{250000}{3600} = 70 \text{ [m/s]}$$

In section 2-3 in figure 6, the apparatus flies with acceleration  $G$  and at the end of this section it picks up the speed  $V_{23}$ . The length of this section is equal to half the distance from the Earth to the Moon, i.e.  $S_{23} = 190,000$  km. Therefore, the flight time in this section can be found as

$$T_{23} = \sqrt{2S_{23}/G} = 6,227 \text{ [s]} = 1.73 \text{ [h]}$$

Then

$$V_{23} = 70 + GT_{23} = 61,000 \text{ [m/s]} = 220,000 \text{ [km/h]}$$

In section 3-4 in figure 6, the apparatus flies with a slowdown and at the end of this section reduces the speed to 250 km/h. At section 4-5, the apparatus flies at a speed of 250 km/h and descends to the Moon. The flight parameters in the opposite direction are determined in the same way.

Thus, the total flight time with the engine turned on is 6.5 hours. In this case, the device spends on a flight in both directions as much as  $Q = 3100 \times 6.46 \times 2 = 40,000$  kg of fuel. Obviously, the capabilities of the apparatus allow one to fly to the Moon and back. The comparison between the parameters of this flight and the parameters of the Apollo project are listed in Table 4 (Shuneiko, 1973).

Table 4. The comparison of Apollo and apparatus flight parameters.

Parameter	Apparatus	Apollo	The ratio 3/2
1	2	3	4
duration	6.5 hours	195 hours	30
fuel	40 tons	2100 tons	52
acceleration	1 G	5 G	5
starting weight	90 tons	2728 tons	30
returned weight	90 tons	120 tons	1.3

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