

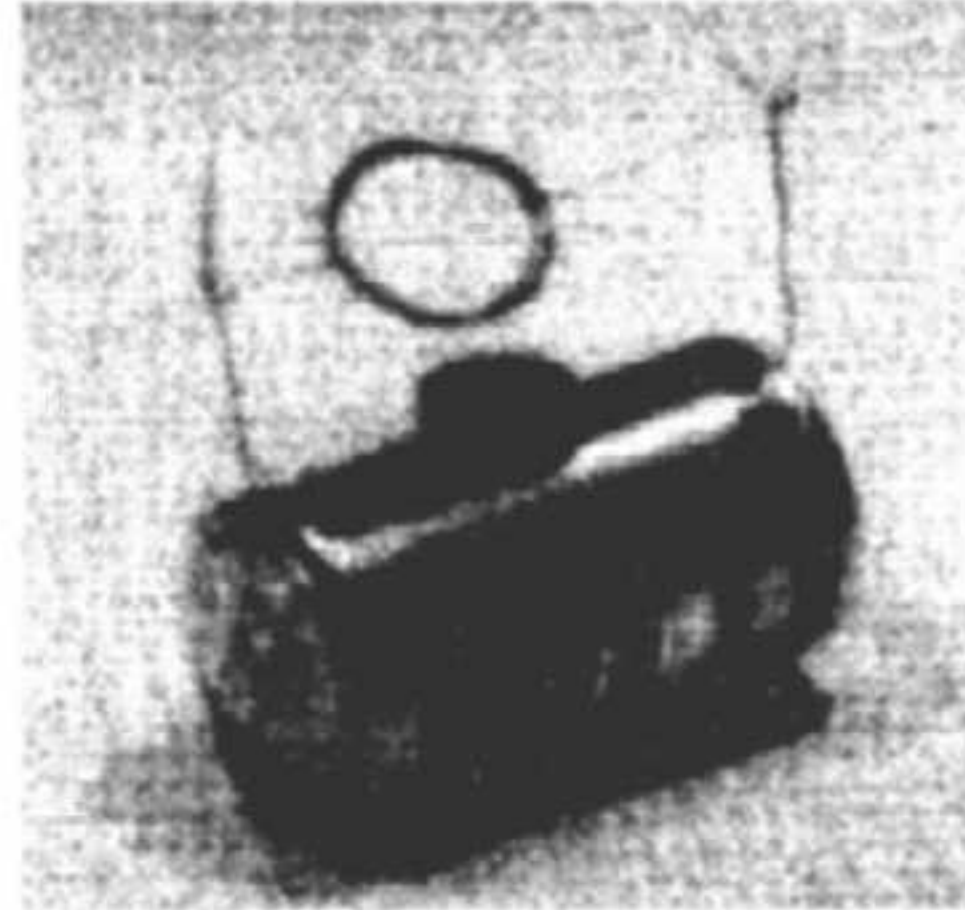
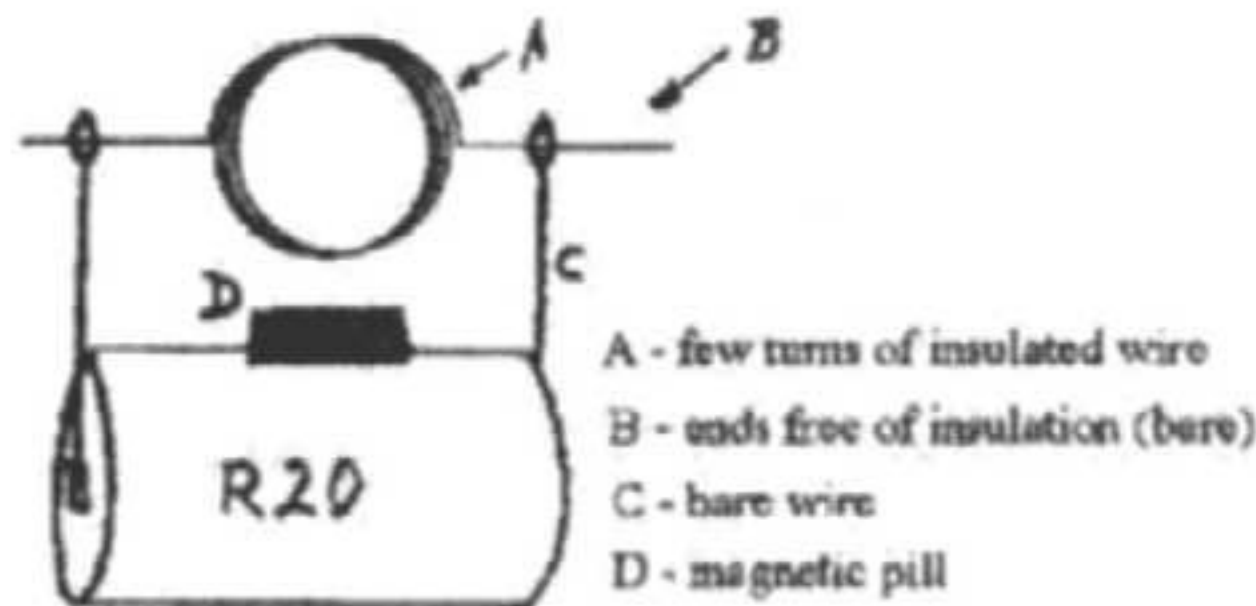
### 3. MAGIC MOTOR

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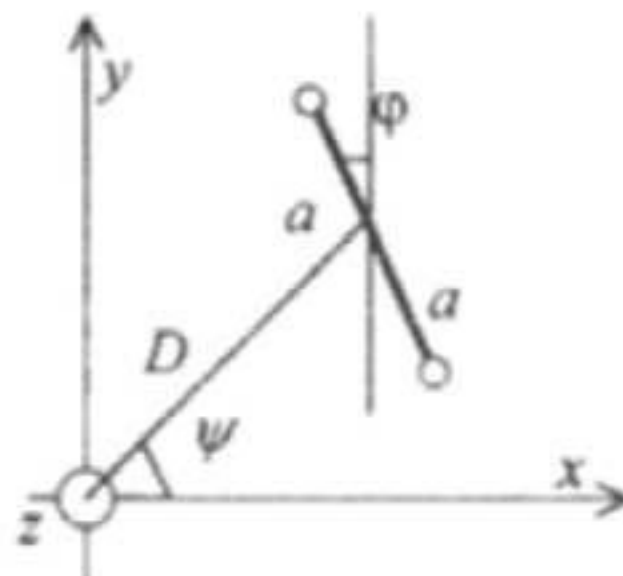
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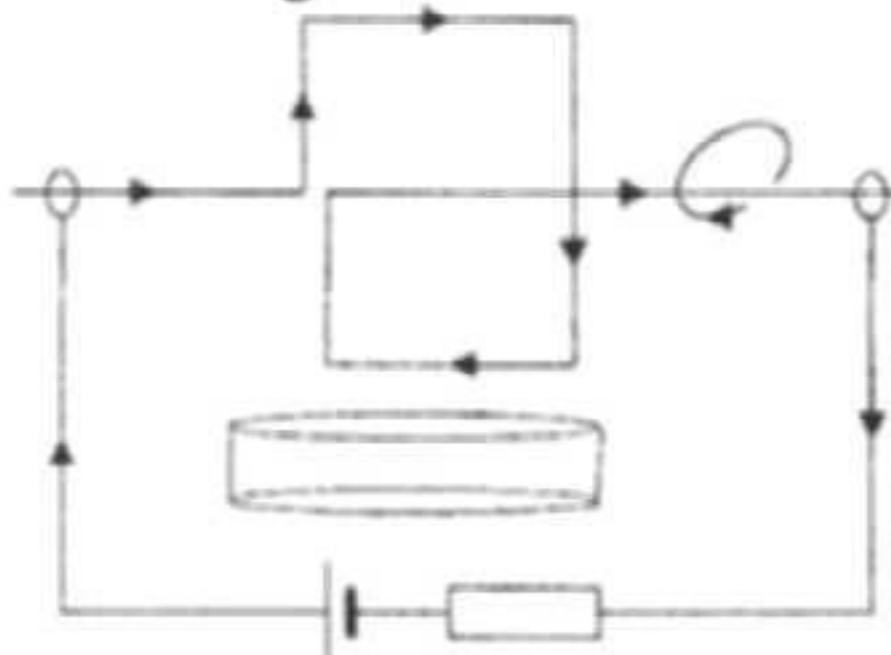


We have motor shown on the picture. In our model we consider rectangular frame as coil and take dipol magnetic field. Because inductivity of coil is small  $L \sim 10^{-6}$  and E.M.F. caused by alternating of magnetic flux through frame is negligible  $\sim 10^{-5}$  V. We consider battery E.M.F.  $\xi$  and constant current  $I = \xi / R$ . The proposed approach is in good agreement with experiments. We get following data:



$$\begin{aligned}\xi &= 9 \text{ V} \\ R_0 &\approx 20 \Omega \\ 2a &= 2 \text{ cm} \\ d &= 0.2 \text{ mm} \\ A &= 0.001 \text{ T} \cdot \text{m}^3 \\ k &= 0.5 \\ g &= 9.8 \text{ m/s}^2 \\ D &= 6 \text{ cm}\end{aligned}$$

where  $R_0$  is resistance of battery,  $d$  - diameter of wire,  $k$  - index of friction between wires,  $g$  is free falling acceleration.



$$\vec{B} = A \frac{(\vec{\mu} \cdot \vec{r}) \cdot \vec{r} - r^2 \cdot \vec{\mu}}{r^5}$$

$$\vec{r}(x, y, z)$$

$$\vec{\mu}(0, 1, 0)$$

$$\vec{F}_1 = I \cdot \vec{a}_1 \times \vec{B}_1 \quad \vec{a}_1(0, 0, 2a)$$

$$\vec{F}_2 = I \cdot \vec{a}_2 \times \vec{B}_2 \quad \vec{a}_2(0, 0, -2a)$$

where  $\mu$  is dipole moment

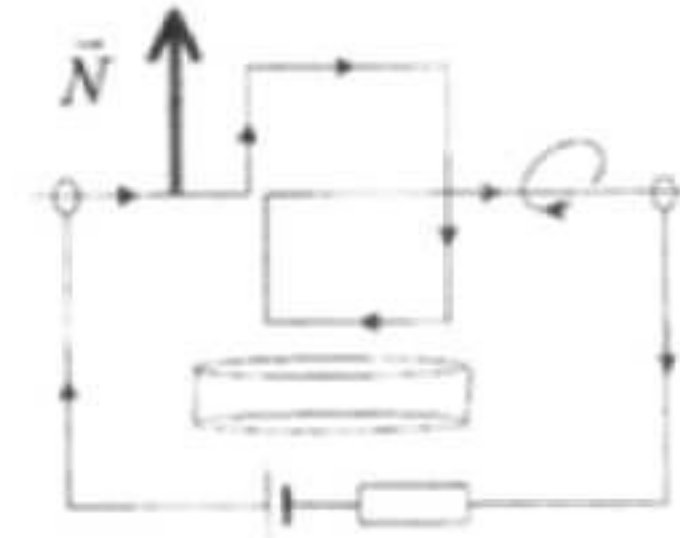
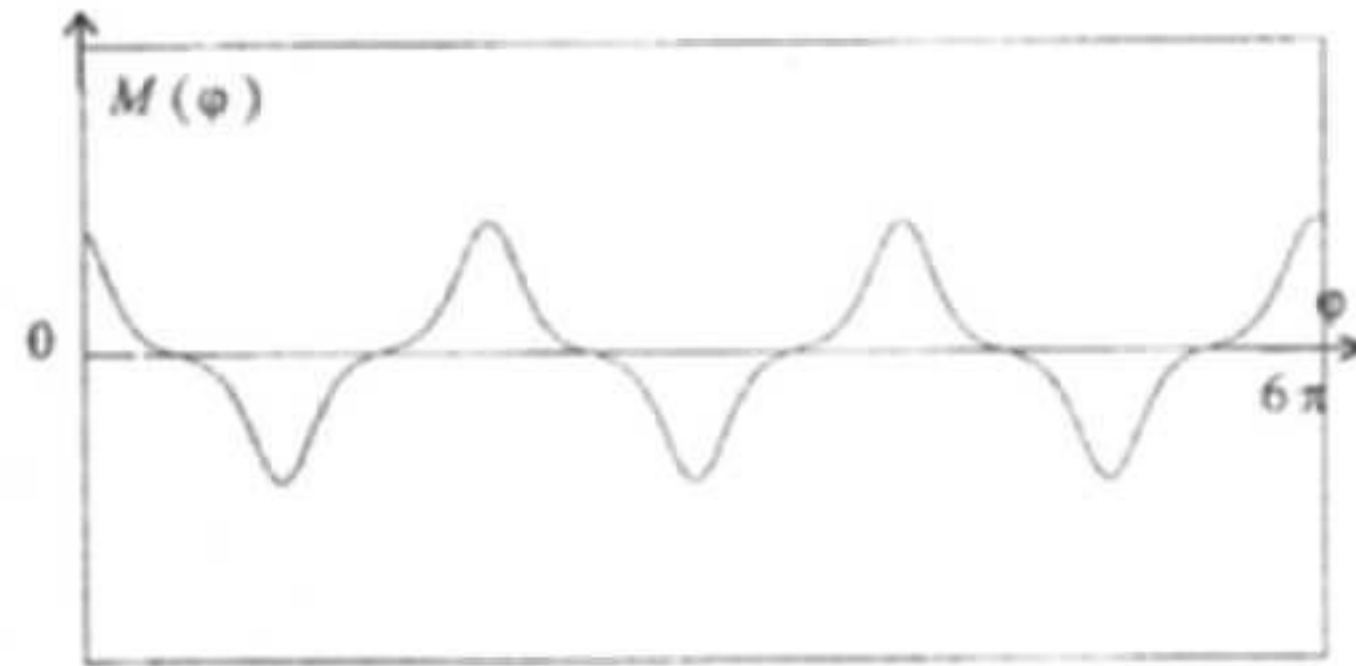
From magnetic field on frame with current act forces  $F_1$  and  $F_2$  they make moments  $M_1$  and  $M_2$  with respect to c.m. of frame and it begins to rotate.

$$\vec{M}_1 = \vec{a}'_1 \times \vec{F}_1 \quad \vec{a}'_1(-a \sin \varphi, a \cos \varphi, 0)$$

$$\vec{M}_2 = \vec{a}'_2 \times \vec{F}_2 \quad \vec{a}'_2(a \sin \varphi, a \cos \varphi, 0)$$

$$\vec{M} = \vec{M}_1 + \vec{M}_2$$

From graph one can see that work of moment per one period is zero, it means that we have not source of energy but we have a friction, loosing of energy and rotating must fade.



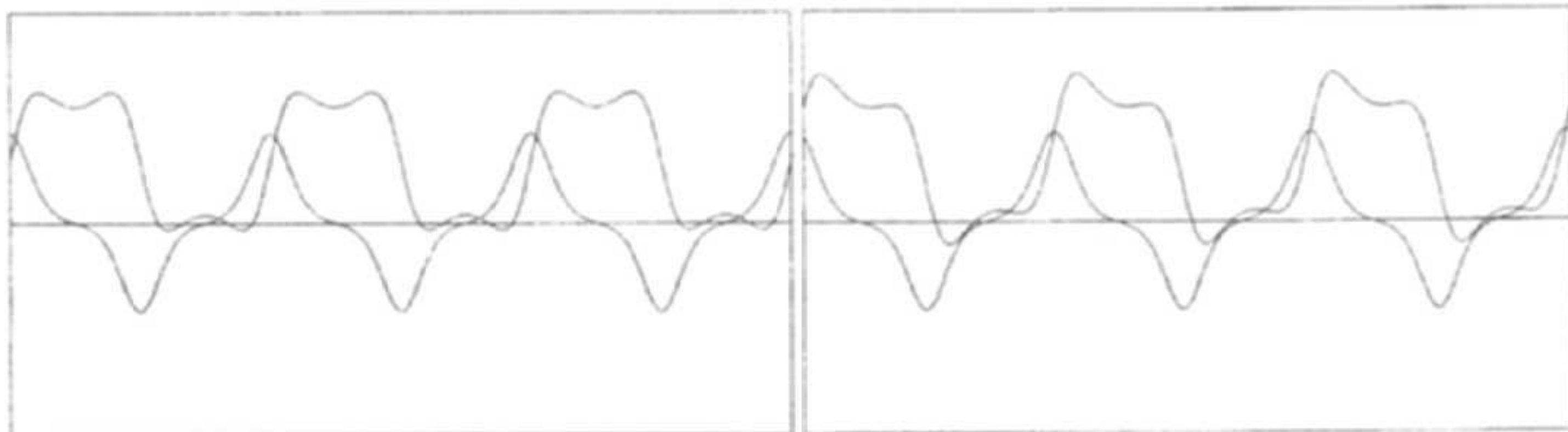
$$N_y = mg + F_{1y} + F_{2y}$$

where  $N_y$  is a reaction force between wires

When  $0 \geq N_y$ , the coil jumps. Graph (1) shows us a picture when the magnet is shifted with respect to the symmetric axe of frame, graph (2) shows a picture when the magnetic pill is exactly under frame axe.

From graph (1) is clear that during disconnection is cut negative part of moment so we have positive work

From graph (2) is clear that with disconnection is cut equal negative and positive parts of moment so work is zero



graph.1  $\psi \neq \pi/2$

graph.2  $\psi = \pi/2$

$$M_f = \begin{cases} kNd/2 & \dot{\varphi} \leq 0 \\ 0 & \dot{\varphi} = 0 \text{ or } N \leq 0 \\ -kNd/2 & \dot{\varphi} \geq 0 \end{cases}$$

$$M_{af} = -\alpha \dot{\varphi}$$

$$J\ddot{\varphi} = \vec{M}_1 + \vec{M}_2 + \vec{M}_f + \vec{M}_{af}$$

we also have friction between wires and air friction.  $M_f$  is moment of friction between wires and  $M_{af}$  – moment of air friction. Above are expressed main equation of rotation. Below we show solution of this equation for angular velocity, angle and current.

