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Wave Engine with Internal Energy Consumption of Electromagnetic Cones

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Strictly as per the compliance and regulations of:

Wave Engine with Internal Energy Consumption of Electromagnetic Cones

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I. Introduction

At the basis of reactive thrust the law of momentum conservation lies. If from the closed system in some direction mass is ejected, then there is always a recoil momentum, which is reactive thrust.

It is known that the electromagnetic waves with the drop on any surface exert to it pressure. If there is an antenna, which emits electromagnetic waves, then the emission of such waves always accompanies the recoil momentum, opposite to the direction of the emission EM waves.

It is known that there are radio-technical systems, which ensure the emission EM waves in some preferred direction. Radars, which ensure the narrow radiation pattern EM of energy in the assigned direction, are an example of such systems. With this emission exiter experiences pressure in the direction reverse to the direction of the emission of energy.

The jet engines, in which the engine thrust is created due to the expiration of electromagnetic radiation, is conventionally designated as conditionally the photon engines [1, 2]. The most feasible discharge velocity, equal to the speed of light in the vacuum, is the key advantage of such engines. For the rocket apparatus this is the only widely known method to reach the any considerable proportion of light of velocity with the reasonable values of the mass ratio Z, of that characterizing the mass-ratio of the filled and empty rocket. Necessary to note, however, that also in this case the discussion deals with number Z on the order of several hundreds, with the technically realized values of order 10 for the multistage rockets. The low efficiency of the chain of the conversion of energy from the primary source to the flow of the expiration of electromagnetic radiation is a central failure in the photon engine. The application of reaction of annihilation for direct obtaining of the expiration of electromagnetic radiation considerably does not descend the sharpness of problem, since it is necessary to consider losses to the storage of antimatter (to say nothing of its production) and difficulty of the focusing of the obtained emission. Furthermore, as more real, were examined the use as the source of electromagnetic radiation of thermonuclear plasma (including for the generation of laser emission) and the use of emission of more long-wave range. In the first case the problems of generation and borrowing in the steady state of plasma with the necessary parameters remain thus far unresolved. In the second case the task of the focusing of radiant flux considerably simplifies, but the efficiency of propeller complex sharply are decreased.

II. Engine System Emdrive

A question of the creation of engine EmDrive, in which is absent the ejection of the outside work substance in the form of electromagnetic radiation, long ago it is discussed sufficiently. In Wikipedia even there is an article with this name https://ru.wikipedia.org/wiki/EmDrive.

Let us give the brief theses of this article.

EmDrive - engine installation, consisting of the magnetron and resonator , assumed fitness for work of which will not be coordinated with the contemporary scientific ideas.

Installation EmDrive was for the first time proposed British by the engineer by Roger John Shawyer in 1999. The magnetron utilized in it generates microwave, energy of their fluctuations is accumulated in the resonator high quality, and, on the statements of the author, the standing wave the electromagnetic vibrations in the locked resonator of special form it is the source the thrust. Out of the resonator is not

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emitted not only the substance, but also electromagnetic radiation, EmDrive it is not in other words, photon engine. But even if the micro waves created by magnetron completely were emitted in one direction, the obtained thrust would be considerably less than the declared thrust EmDrive.

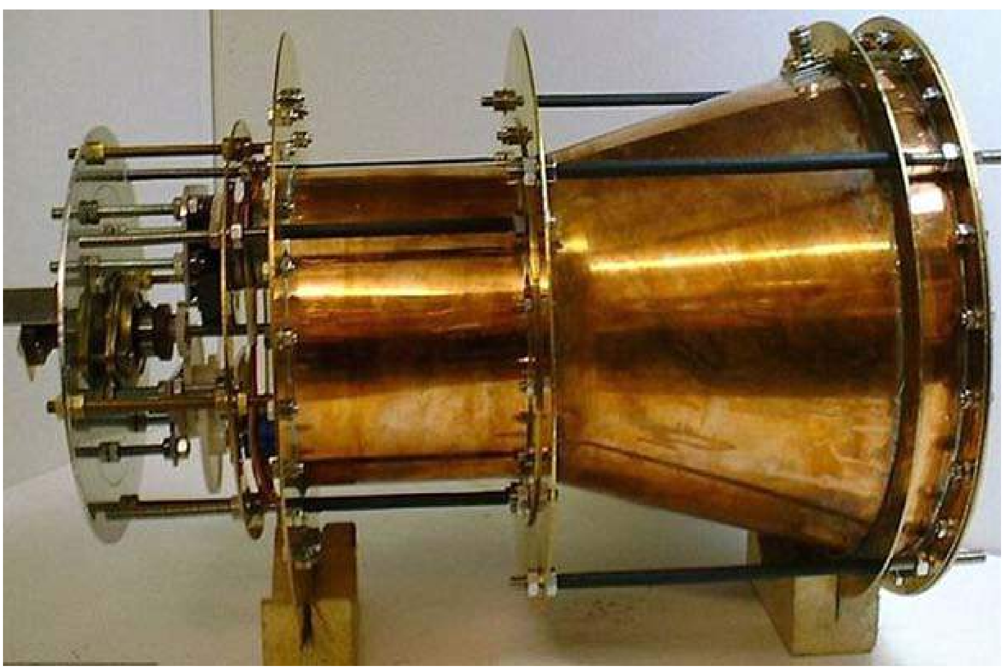
Absence of that expended the working component , apparently, it disrupts in this engine the law of momentum conservation, and any conventional explanation of this contradiction by the authors of developments is not proposed. Shawyer itself published work with the explanation, but physics they note that the theory of radiation pressure is more complex than the simplified apparatus, used by Shawyer, but its explanations as a whole are contradictory.

Experimental data do not give single-valued confirmation or refutation of the fitness for work of a similar installation, which is connected, including with the small magnitude of the assumed effect, compared with errors of measurement.

Physics are explained the obtained by experimenters not numerous positive results by the errors in the experiments. The only published in the scientific journal independent study, which showed positive result, this is the experiment of the groupEagleworks2016; in it many sources of possible errors were removed; however, scientific group of the Dresden technical university assumes that the thrust obtained Eagleworks by group appeared as a result of the influence of earth's magnetic field to the elements of installation, but not because of the very EmDrive.

In December 2016, referring to press conference of one of the daughterly companies Chinese academy of the space technologies (CAST), the publication International Business Times it reported that the government of Chinese Peoples' Republic from 2010 finances studies of engine, and prototypes EmDrive were sent for space for the checking on board the space laboratory « Eyangun-2 ». Doctor Chen Yue from CAST, according to publication International Business Times, confirmed the fact of the production of the prototype of engine for the testing in the low near earth orbit.

In September 2017 appeared new communications about the successful creation of the working prototype of engine EmDrive in China. Even photograph of engine is given.



Theoretical physics predicts that EmDrive it is inefficient and any positive results of experiments can be only the artifacts of measurements, since the fitness for work EmDrive would contradict the law of momentum conservation. Different theoretical explanations EmDrive which contradict the ideas, established in physics were proposed for the assumed fact of fitness for work.

In the proposed article the attempt to find the theoretical substantiation of the work of the engines is made EmDrive.

III. Physics Of Ponderomotive the Action Of Electromagnetic Fields On

The important task of electrodynamics is the presence of laws governing the appearance of electrical fields on, and, therefore, also the forces of those acting on the charge, at the particular point spaces, since. only electric fields, generated other one or method or

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another, exert power influences on the charge. Such fields can be obtained, changing the arrangement of other charges around this point of space or accelerating these charges. If around the point in question is some static configuration of charges, then the tension of electric field will be at the particular point determined by the relationship $\mathbf{E} = -\text{grad}\,\varphi$, where φ the scalar potential at the assigned point, determined by the assigned configuration of charges. To another configuration of charges correspond other values of scalar potential, and, therefore, also other values of the tension of electric field at the assigned point. But, making this, it is necessary to move charges in the space, and this displacement in the required order is combined with their acceleration and subsequent retarding. Acceleration or retarding of charges also can lead to the appearance in the surrounding space of induction electrical fields on. Can arise another stationary situation, when after their acceleration charges move in the environment of the considered point with the constant velocity along circular or other locked trajectories. In this case due to the presence of the three-dimensional velocity gradients in the flows of the moving charges configurative electric fields can appear.

In the electrodynamics the fundamental law of induction is Faraday law [3-5]. In the contemporary electrodynamics it is written in the form

$$\oint \mathbf{E}d\vec{l} = -\frac{\partial \Phi_B}{\partial t} = -\mu \int \frac{\partial \mathbf{H}}{\partial t} d\mathbf{s} = -\int \frac{\partial \mathbf{B}}{\partial t} d\mathbf{s}, \quad (3.1)$$

where $\mathbf{B} = \mu \mathbf{H}$ - magnetic induction vector, $\Phi_B = \mu \int \mathbf{H} d\mathbf{s}$ - flow of magnetic induction, and $\mu = \tilde{\mu}\mu_0$ - magnetic permeability of medium. It follows from this law that the circulation integral of the vector of electric field is equal to a change in the flow of magnetic induction through the area, which this outline covers. It is immediately necessary to emphasize the circumstance that the law in question presents the processes of mutual induction, since. for obtaining the circulation integral of the vector $\mathbf{E}$ we take the strange magnetic field, formed by strange source. From relationship (3.1) obtain the Maxwell first equation

$$\text{rot}\,\mathbf{E} = -\partial \mathbf{B}/\partial t. \quad (3.2)$$

Let us immediately point out to the terminological error. Faraday law should be called not the law of electromagnetic, as is customary in the existing literature, but by the law of magnetoelectric induction, since change in the magnetic fields on it leads to the appearance of electrical fields on, but not vice versa.

Let us introduce the vector potential of the magnetic field $\mathbf{A}_H$, which satisfies the equality

$$\mu \oint \mathbf{A}_H d\mathbf{l} = \Phi_B,$$

where the outline of the integration coincides with the outline of integration in relationship (3.1), and the vector of is determined in all sections of this outline, then

$$\mathbf{E} = -\mu\, \partial \mathbf{A}_H / \partial t \quad (3.3)$$

introduced thus vector $\mathbf{A}_H$ determines the local connection between it and by electric field, and also between the gradients this vector and the magnetic field. It is connected with the magnetic field:

$$\text{rot}\,\mathbf{A}_H = \mathbf{H} \quad (3.4)$$

Thus, if is determined vector $\mathbf{A}_H$, its local time derivative at any point of space, and also its gradients, then it is possible to determine immediately both vector $\mathbf{E}$, and vector $\mathbf{H}$.

The vector potential of magnetic field can be directly obtained also from the Ampere law, which was known long before Maxwell's equations. The Ampere law, expressed in the vector form, determines magnetic field at the point x, y, z:

$$\mathbf{H} = \frac{1}{4\pi} \int \frac{I d\mathbf{l} \times \mathbf{r}}{r^3},$$

where I - current in the element $d\mathbf{l}$, $\mathbf{r}$ - vector, directed from $d\mathbf{l}$ to the point x, y, z.

It is possible to show that

$$\frac{[\mathbf{r}d\mathbf{l}]}{r^3} = \text{grad}\left(\frac{1}{r}\right) \times d\mathbf{l};$$

$$\text{grad}\left(\frac{1}{r}\right) \times d\mathbf{l} = \text{rot}\left(\frac{d\mathbf{l}}{r}\right) - \frac{1}{r}\text{rot}\,d\mathbf{l}.$$

But the rotor $d\mathbf{l}$ is equal to zero and therefore is final

$$\mathbf{H} = rot \int I \left(\frac{d\mathbf{l}}{4\pi r}\right) = rot\mathbf{A}_H,$$

where

$$\mathbf{A}_H = \int I \left(\frac{d\mathbf{l}}{4\pi r}\right).$$

In this case vector potential is determined no longer through the magnetic flux, but through the current, which flows through the specific section of conductor. The remarkable property of this expression is that that the vector potential depends from the distance to the observation point as. Specifically, this property makes it possible to obtain emission laws.

Since $I = gv$, where g the quantity of charges, which falls per unit of the length of conductor, we obtain:

$$\mathbf{A}_H = \int \frac{gv\ d\mathbf{l}}{4\pi r}.$$

For the single charge e this relationship takes the form:

$$\mathbf{A}_H = \frac{e\mathbf{v}}{4\pi r},$$

and since is fulfilled relationship (3.3), that

$$\mathbf{E} = -\mu \int \frac{g \frac{\partial v}{\partial t} d\mathbf{l}}{4\pi r} = -\mu \int \frac{ga\ d\mathbf{l}}{4\pi r},$$

where a - acceleration of charge.

This relationship appears as follows for the single charge:

$$\mathbf{E} = -\frac{\mu e\mathbf{a}}{4\pi r}.$$

This is the law of induction, which connects the appearance of electrical fields on directly with the acceleration of charge.

If it is necessary to find the induced electric fields during the motion in the field of the three-dimensional- changing vector potential, should be used the total derivative:

$$\mathbf{E}' = -\mu\, d\mathbf{A}_H / dt. \tag{3.5}$$

The prime near the vector $\mathbf{E}$ means that we determine this field in the moving coordinate system. This means that the vector potential can have not only local, but also convection derivative, i.e., it can change both due to the change in the time and due to the motion in the three-dimensional changing field of this potential. In this case relationship (3.5) can be rewritten as follows:

$$\mathbf{E}' = -\mu \frac{\partial \mathbf{A}_H}{\partial t} - \mu(\mathbf{v}\nabla)\mathbf{A}_H,$$

where $\mathbf{v}$ - speed of the prime system.

Convective part of the force, which acts on the charge in the moving system,

$$\mathbf{F}'_{v,1} = -\mu e(\mathbf{v}\nabla)\mathbf{A}_H.$$

This force depends only on the gradients of vector potential and charge rate.

The charge, which moves in the field of the vector potential of with the speed of, possesses potential energy [4]

$$W = -e\mu(\mathbf{v}\mathbf{A}_H).$$

Therefore must exist one additional force, which acts on the charge in the moving coordinate system, namely:

$$\mathbf{F}'_{v,2} = -\operatorname{grad} W = e\mu \operatorname{grad}(\mathbf{v}\mathbf{A}_H).$$

Thus, the value $(\mathbf{v}\mathbf{A}_H)$ plays the same role, as the scalar potential φ, whose gradient also gives force.

The most simply ponderomotive action of electromagnetic fields on it is possible to show based on the example of superconductors.

The macroscopic electrodynamic properties of superconductors are described by the phenomenological equations of London:

$$\frac{d\mathbf{j}}{dt} = \frac{1}{\mu_0 \lambda_L^2}\mathbf{E}, \tag{3.6}$$

$$\Delta\mathbf{H} = \frac{1}{\lambda_L^2}\mathbf{H} = 0. \tag{3.7}$$

Here $\mathbf{E}$, $\mathbf{H}$, $\mathbf{j}$ - electrical, magnetic fields and current density, $\lambda_L = \sqrt{\frac{m_0}{\mu_0 n e_0}}$ - depth of penetration of magnetic field into the superconductor.

Equations give the connection between the currents and the fields in the superconductors.

Taking (3.4) into account, we obtain from (3.6) and (3.7) that

$$\mathbf{j} = ne\mathbf{v} = \frac{1}{\lambda_L^2}\mathbf{A} = \frac{1}{\lambda}\mathbf{H}_0, \tag{3.8}$$

where $\mathbf{v}$ - the electron velocity, and $\mathbf{H}_0$ - the tension of magnetic field on the surface of superconductor.

If we take x the component of magnetic field and y the component of current density, then, taking into account (3.6), (3.8) we will obtain:

$$F'_{v,2,z} = \frac{2\mu_0}{n\lambda_L} H_{0,x}^2 e^{-\frac{2z}{\lambda}}. \tag{3.9}$$

Relationship (3.9) determines the force, which acts on the single electron in the region of the depth of penetration of magnetic field. When magnetic field variable $H_x = H_{o,x}\sin\omega t$ i.e. currents on the surface of superconductor are induced with the aid of the external variable electrical fields on the incident electromagnetic wave, relationship (3.9) will be rewritten:

$$F'_{v,2,z} = \frac{2\mu_0}{n\lambda_L} H_{0,x}^2 \sin^2\omega t \ e^{-\frac{2z}{\lambda}}.$$

Taking into account this relationship, the element of force, which acts on the single surface with thickness dz in the direction of axis z, is determined by the relationship

$$dF'_{v,2,z} = \frac{2\mu_0}{n\lambda_L} H_{0,x}^2 \sin^2\omega t \ e^{-\frac{2z}{\lambda}} dz \qquad (3.10)$$

By integrating relationship (3.10) on the coordinate z and by averaging over the time, we will obtain the composite force, which acts on the single square of the surface of the superconductor:

$$F_\Sigma = \frac{1}{2}\mu_0 H_{0,x}^2 . \qquad (3.11)$$

Thus, the force, which acts on the single area of superconductor, with the drop on it EM wave is equal to the specific energy of the magnetic field of this wave. The electrical and magnetic fields EM wave in the free space are connected with the relationship

$$\frac{E}{H} = \sqrt{\frac{\mu_0}{\varepsilon_0}} = Z \qquad (3.12)$$

where Z - wave drag of free space. From (3.11) and (3.12) follows

$$F_\Sigma = \mu_0 H_0^2 = \varepsilon_0 E_0^2 .$$

Thus, the pressure, which renders EM wave with its drop on the superconductor, it is equal to the value of its specific energy. This situation is characteristic for the case of the total reflection EM wave from the surface, on which it falls, since the superconductor in the version EM examined wave does not absorb.

Phenomenological approach to the solution of the problem of the ponderomotive action of electromagnetic fields on examined in the monograph [6].

Let us examine the plane linearly polarized electromagnetic wave, which is extended to the side of the negative values z.

$$E_x = E\cos(\omega t - kz);\quad E_y = 0;$$

$$E_z = 0;\quad H_z = 0;\quad H_x = 0;\quad ,$$

$$H_y = E\sqrt{\frac{\varepsilon_0}{\mu_0}}\cos(\omega t - kz).$$

where $k = \frac{2\pi}{\lambda} = \frac{\omega}{c}$ - wave number, $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$ - the speed of light in the vacuum.

We will use the system of the Maxwellian tensions [3]. If wave is incident on surface, then we obtain for the components of stress tensor:

$$T_{xx} = \frac{1}{2}\varepsilon_0 E_x^2 - \frac{1}{2}\mu_0 H_y^2 = 0$$

$$T_{yy} = -\frac{1}{2}\varepsilon_0 E_x^2 + \frac{1}{2}\mu_0 H_y^2 = 0$$

$$T_{zz} = -\frac{1}{2}\varepsilon_0 E_x^2 - \frac{1}{2}\mu_0 H_y^2 = -\varepsilon_0 E_x^2\cos^2(\omega t - kz)$$

Normal component of tensor of tensions, equal to the force gradient, which acts on the single surface, comprises

$$F_0 = T_{zz} = -\varepsilon_0 E_x^2 \cos^2(\omega t - kz).$$

This force is directed to the side of plane, on which is incident the wave.

If the incident wave is not completely absorbed by plane, then with the calculation of tension should be considered the wave reflected.

$$E_{x(in)} + E_{x(ref)} = (E_{(in)} + E_{(ref)})\cos\omega t$$

$$H_{y(in)} + H_{y(ref)} = \sqrt{\frac{\varepsilon_0}{\mu_0}}(E_{(in)} + E_{(ref)})\cos\omega t$$

In this case the average values of the components of stress tensor will be written down:

$$\overline{T}_{xx} = \frac{1}{2}\varepsilon_0(E_{(nad)} + E_{(ref)})^2 - \frac{1}{2}\varepsilon_0(E_{(in)} - E_{(ref)})^2 = \varepsilon_0 E_{(in)} E_{(ref)}$$

$$\overline{T}_{yy} = -\frac{1}{2}\varepsilon_0(E_{(nad)} + E_{(ref)})^2 + \frac{1}{2}\varepsilon_0(E_{(in)} - E_{(ref)})^2 = \varepsilon_0 E_{(in)} E_{(ref)}$$

$$\overline{T}_{zz} = -\frac{1}{2}\varepsilon_0(E_{(nad)} + E_{(ref)})^2 - \frac{1}{2}\varepsilon_0(E_{(in)} - E_{(ref)})^2 = \frac{1}{2}\varepsilon_0(E^2_{(in)} + E^2_{(ref)})$$

Consequently, the unit power, which acts on the surface, will be equal

$$F_0 = -\frac{1}{2}\varepsilon_0 (E^2{}_{(in)} + E^2{}_{(ref)})$$

Thus, pressure on the surface depends on the relationship between the falling and reflected wave. Let us introduce this coefficient as

$$K = \frac{E^2{}_{(in)}}{E^2{}_{(ref)}}.$$

Then expression for the force gradient is written down

$$F_0 = \frac{1}{2}\varepsilon_0 E^2{}_{(in)}(1-K).$$

From the given relationships it is evident that the force, which acts on the completely reflecting surface, is two times more than force acting on the completely absorbing surface. But these forces are not great. If the power drops to 3 W on the surface, then the pressure exerted on the completely absorbing surface is 10^{-8} N, and the pressure exerted on the completely reflecting surface will be equal to $2x10^{-8}$ N. And even with a power increase 30 kW, the pressure is only 10^{-4} N and $2x10^{-4}$ N, respectively.

IV. Engine With The Domestic Spending Of The Wave Energy

Let us take square metallic plate by thickness d and length of edge L and will connect the voltage source to it U. If we the specific resistance of the metal of plate early ρ, i.e., impedance are determined by relationship $R = \rho\frac{L}{S} = \rho\frac{L}{dL} = \rho\frac{1}{d}$ and will not depend on the length of the edge of square. In this case it is accepted to speak about the resistance, which is fallen to the single square of surface. The tension of electric field on the surface of plate and inside it will be equal $E = \frac{U}{L}$, and the current, which flows through the plate, it will comprise $I = \frac{Ud}{\rho}$. Current density in the plate in this case will be equal $j = \frac{I}{S} = \frac{E}{\rho}$.

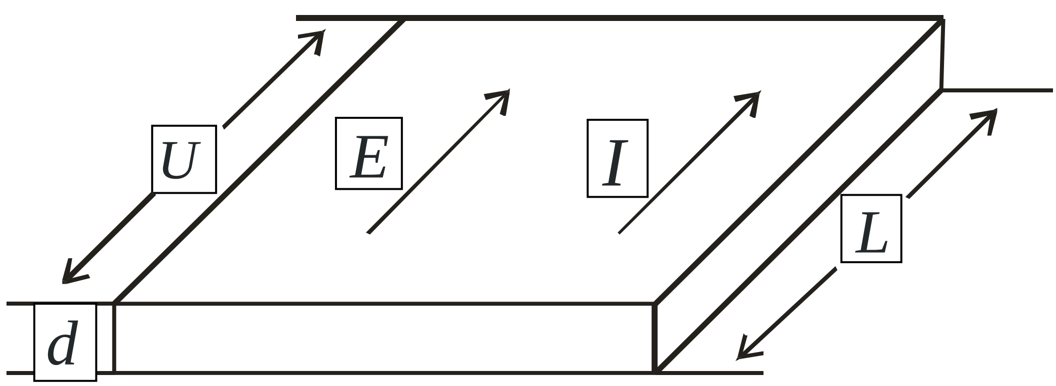

Fig. 1: Fields and currents in the square metallic plate

If there is an electromagnetic wave, which falls to the metallic surface, then the case, when in connection with the presence of skin effect wave penetrates only to the specific depth, occurs. If there isa half-space, when the thickness of plate to approach infinity, then complex depth of penetration is introduced

$$\delta_\kappa = \frac{1}{H_T(0)\int_0^\infty H_T(z)dz} = \delta_1 + i\delta_2,$$

where $H_T(0)$ - the tangential component of the magnetic field of wave on the surface, and coordinate z is directed into the depths of the metal.

Reactive and active components of surface impedance in this case are written

$$X = \omega\mu_0\delta_1, \quad R = \omega\mu_0\delta_2.$$

Value R represents the active component that falling to the single square of surface of surface resistance.

If the wave drag of free space $Z = \sqrt{\frac{\mu_0}{\varepsilon_0}}$ is considerably more than R, that this wave practically completely is reflected from this surface.

But if is posed the problem of the total absorption of the incident wave by the assigned surface, then should be organized this surface whose $Z = R$, A $X = 0$.

Let us examine the shortened out waveguide, on which is propagated EM wave (Fig. 2.)

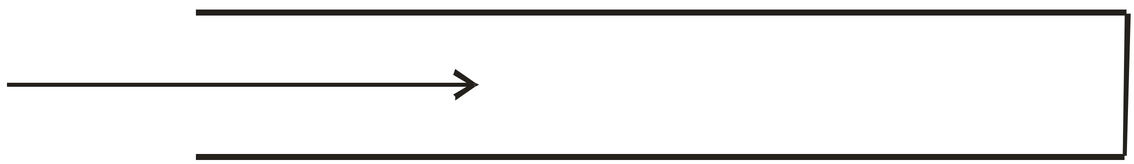

Fig. 2: Shortened out waveguide

If metallic plate with the high conductivity (for example copper) is the end wall of waveguide, then wave practically completely will be reflected from this wall. But if the absorbing plate with the properties assigned above is used as the end wall, then wave will be completely absorbed by this wall. Specifically, these cases are examined in the previous division, when was calculated the specific pressure of the wave, which falls on the surface with different properties.

Let us examine the case, when in the end of the waveguide is located not continuous end wall, but the cavity resonator, connected with the waveguide with opening in this wall (Fig. 3.).

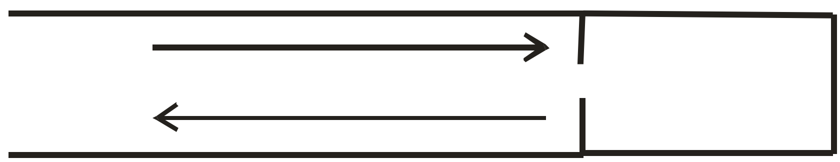

Fig. 3: Waveguide, loaded with the resonator

The processes, proceeding in this system are known [7]. At the initial moment of the time, when in the resonator still were not established the fluctuations, the wave incident to the partition, whose frequency wound to the resonance frequency of resonator, practically completely is reflected from the partition. With an increase the amplitude of fluctuations in the resonator through the opening in the partition begins to be emitted the reverse wave, which begins to compensate the incident wave. And in the steady-state regime the wave, which emerges from the resonator through the opening in the partition, completely compensates the incident wave, and resonator proves to be that coordinated with the waveguide.

In this case entire power, betrayed on the waveguide, is absorbed in the resonator, and the amplitude of the fluctuations EM wave in the resonator occurs Q once more than in the waveguide, where Q the quality of resonator. This they will indicate that the pressure on the walls of resonator, exerted EM wave, will be Q^2 once more than in the waveguide, since the pressure of wave on the walls of resonator is proportional to the square of electric field. This circumstance gives the possibility to create engine with the domestic spending of wave energy (Fig. 4).

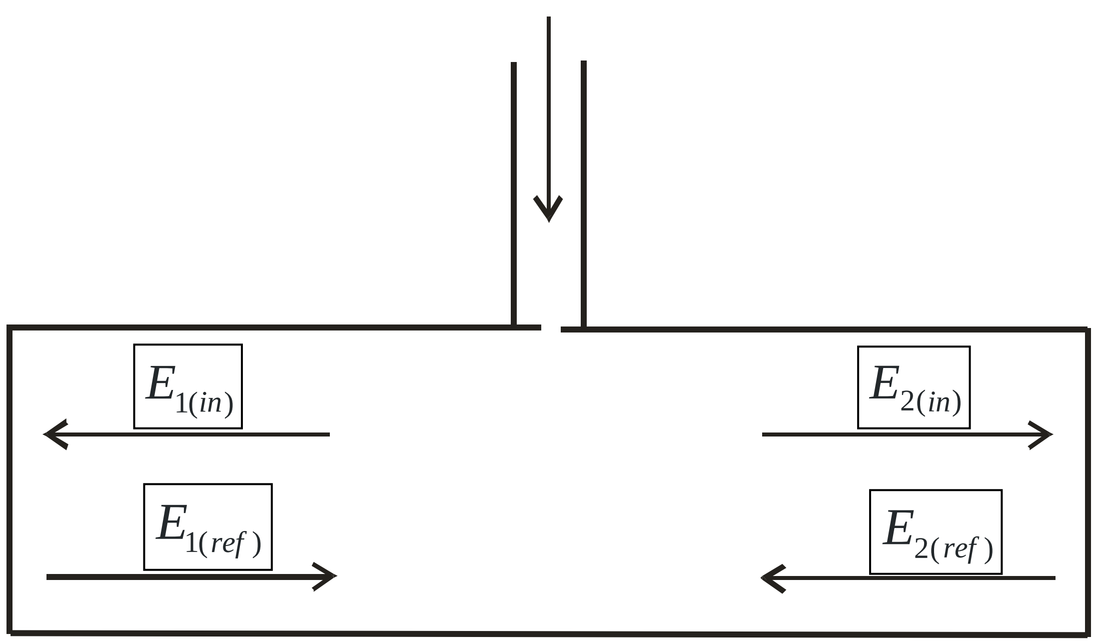

Fig. 4: Schematic of engine with the domestic spending of the wave energy

Engine consists of the cavity resonator, energy into which is introduced with the aid of the waveguide. Pointers in the diagram depicted the electric fields, falling and reflected from the opposite end walls of resonator. The surface resistance of end walls should be selected so that the reflection coefficients from these walls strongly would differ. Then the force, which acts on the wall, reflection coefficient in which is considerably above, it will be considerably more than in opposite wall, in the direction of this wall will be directed the thrusts of engine.

Let us examine the concrete example: If by the waveguide delivered power 3 W, then the pressure, exerted to its metallic end wall (Fig. 2), early $2x10^{-8}$ N. In the resonator this pressure increases Q^2. In the case of using the normal metals, such as copper and silver, for the cavity resonators are accessible the values of the quality of order 10^4 [7], therefore with the power of generator 3 W the accessible values of thrusts they will compose order 2 N, and with the power of generator 3 kW this value will compose $2x10^3$ N. In order to decrease the influence on the quality of the resonator of end wall with the increased surface resistance, should be increased the length of resonator.

V. Conclusion

At the basis of reactive thrust the law of momentum conservation lies. If from the closed system in some direction is ejected work substance, for example mass, then there is always a recoil momentum, which is reactive thrust. In the photon engines work substance are electromagnetic (EM) waves. Before the appearance of works the description of engines of the type EmDrive were not known the jet engines, in which there is no ejection of work substance. The electromagnetic waves, which outside engine do not leave, are work substance in the engines of such type, but is formed standing wave in the resonator. The works, carried out by the Chinese scientists, who installed this engine on the satellite, they proved its fitness for work. However, the theoretical substantiation of the work of such engines up to now is absent. In the proposed article the attempt to find the physical substantiation of their work is made.

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