Gravitational Tunneling Machine

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A new tunneling machine is described in this article. It works based on the gravity-control technology, and can reach high velocities through rocky means; possibly few *tens of meters per hour*, moreover it can move itself in *any directions below the ground*. This machine can be highly useful for urban tunneling, drainage, exploration, water supply, water diversion and accessing the mines of diamonds, coal, oil, and several others types of minerals existent in the Earth's crust.

Key words: Gravity-control technology, tunneling technology, Subterranean Space Forming, Mining Equipment.

1. Introduction

The drilling of tunnels through rocky means is a very hard work to be performed without the use of appropriate drilling machines. Several researchers in many countries had been making attempts to developing tunneling machines [1, 2, 3].

In the decade of 70 of the last century a group of scientists created the *geowinchester* technology for underground workings. At the same time the first experimental prototype of the drilling machine called *geohod* (ELANG-3) was created.

Pneumatic punchers were developed and are widely used in several countries. These machines include their underground movement control, telecommanding as well underground location and position control [4, 5, 6].

In the early 2000s, a team of Russian scientists led by Professor Vladimir Aksionov started building a new generation of *geohods* with improved geowinchester technology.

Tunnel boring isn't an easy job. The world's largest tunnel boring machine (called Bertha) consumes 18,600 kWh and moves at a speed of about 10 m per day [7].

Currently a new model of *geohod* is being developed [8]. It will have a diameter of 3.2 meters and a length of 4.5 meters (without additional modules). It will be able to reach a speed of 6 m/h. This device has no similar in the world.

Creation of a tunneling machine that can *rapidly* move itself in *any directions below the ground* is highly relevant for urban tunneling, drainage, exploration, water supply, water diversion and accessing the mines of diamonds, coal, oil, and several others types of minerals existent in the Earth's crust.

In this article we show how gravity-control technology (BR Patent Number: PI0805046-5, July 31, 2008 [9]) can be used for the development this machine, here called of *Gravitational Tunneling Machine* (GTM).

2. Theory

The quantization of gravity shows that the *gravitational mass* m_g and *inertial mass* m_i are not equivalents, but correlated by means of a factor χ, which, under certain circumstances can be negative. The correlation equation is [10]

$$m_g = \chi \; m_{i0} \tag{1}$$

where m_{i0} is the *rest* inertial mass of the particle.

The expression of χ can be put in the following forms [10]:

$$\chi = \frac{m_g}{m_{i0}} = \left\{1 - 2\left[\sqrt{1+\left(\frac{W}{\rho\, c^2}n_r\right)^2} - 1\right]\right\} \tag{2}$$

$$\chi = \frac{m_g}{m_{i0}} = \left\{1 - 2\left[\sqrt{1 + \left(\frac{D\ n_r^2}{\rho c^3}\right)^2} - 1\right]\right\} \qquad (3)$$

where W is the density of electromagnetic energy on the particle(J/kg); D is the radiation power density; ρ is the matter density of the particle (kg/m^3); n_r is the index of refraction, and c is the speed of light.

Equations (2) and (3) show that *only* for $W = 0$ or $D = 0$ *the gravitational mass is equivalent to the inertial mass* $(\chi = 1)$. Also, these equations show that the gravitational mass of a particle can be significtively reduced or made strongly *negative* when the particle is subjected to high-densities of electromagnetic energy.

Also, it was shown that, if the *weight* of a particle in a side of a lamina is $\vec{P} = m_g \vec{g}$ ($\vec{g}$ perpendicular to the lamina) then the weight of the same particle, in the other side of the lamina is $\vec{P}' = \chi m_g \vec{g}$, where $\chi = m_g / m_{i0}$ (m_g and m_{i0} are respectively, the gravitational mass and the inertial mass of the lamina). Only when $\chi = 1$, the weight is equal in both sides of the lamina. The lamina works as a Gravitational Shielding. This is the *Gravitational Shielding* effect. Since $P' = \chi P = (\chi m_g) g = m_g (\chi g)$, we can consider that $m'_g = \chi m_g$ or that $g' = \chi g$.

If we take two parallel gravitational shieldings, with χ_1 and χ_2 respectively, then the gravitational masses become: $m_{g1} = \chi_1 m_g$, $m_{g2} = \chi_2 m_{g1} = \chi_1 \chi_2 m_g$, and the gravity will be given by $g_1 = \chi_1 g$, $g_2 = \chi_2 g_1 = \chi_1 \chi_2 g$. In the case of multiples gravitational shieldings, with $\chi_1, \chi_2, ..., \chi_n$, we can write that, after the n^{th} gravitational shielding the gravitational mass, m_{gn}, and the gravity, g_n, will be given by

$$m_{gn} = \chi_1 \chi_2 \chi_3 \cdots \chi_n m_g\ , \quad g_n = \chi_1 \chi_2 \chi_3 \cdots \chi_n g \quad (4)$$

This means that, n superposed gravitational shieldings with different $\chi_1, \chi_2, \chi_3, \ldots, \chi_n$ are equivalent to a single gravitational shielding with $\chi = \chi_1 \chi_2 \chi_3 \cdots \chi_n$.

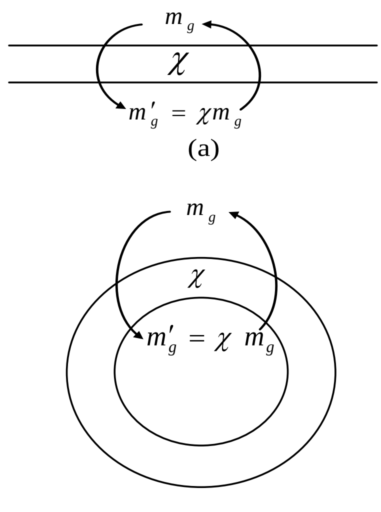

Fig. 1 – *Plane* and *Spherical* Gravitational Shieldings. When the radius of the gravitational shielding (b) is very small, any particle inside the spherical crust will have its gravitational mass given by $m'_g = \chi\ m_g$, where m_g is its gravitational mass out of the crust.

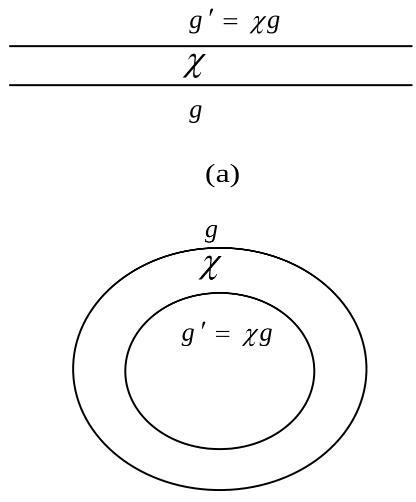

Fig. 2 – The gravity acceleration in both sides of the gravitational shielding.

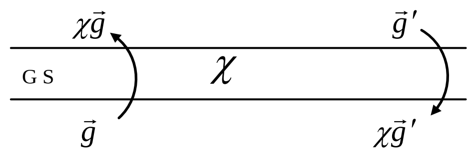

Fig. 3 – *Gravitational Shielding* (GS). If the *gravity* at a side of the GS is $\vec{g}$ ($\vec{g}$ perpendicular to the lamina) then the gravity at the other side of the GS is $\chi\vec{g}$. Thus, in the case of $\vec{g}$ and $\vec{g}'$ (see figure above) the resultant gravity at each side is $\vec{g} + \chi\vec{g}'$ and $\vec{g}' + \chi\vec{g}$, respectively.

*The extension of the shielding effec*t, i.e., the distance at which the gravitational shielding effect reach, beyond the gravitational shielding, depends basically of the magnitude of the shielding's surface. Experiments show that, when the shielding's surface is large (a disk with radius a) the action of the gravitational shielding extends up to a distance $d \cong 20a$ [11]. When the shielding's surface is *very small* the extension of the shielding effect becomes experimentally undetectable .

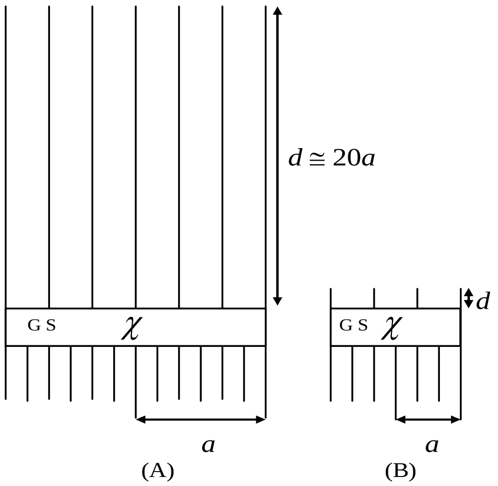

Fig. 4 - When the shielding's surface is large the action of the gravitational shielding extends up to a distance $d \cong 20a$ (A).When the shielding's surface is *very small* the extension of the shielding effect becomes experimentally undetectable (B).

Now consider figure 5, which shows a set of n spherical gravitational shieldings, with $\chi_1, \chi_2, ..., \chi_n$, respectively. When these gravitational shielding are *deactivated*, the gravity generated is $g = -Gm_{gs}/r^2 \cong -Gm_{i0s}/r^2$, where m_{i0s} is the total inertial mass of the n spherical gravitational shieldings. When the system is *actived*, the gravitational mass becomes $m_{gs} = (\chi_1\chi_2...\chi_n)m_{i0s}$, and the gravity is given by

$$g' = (\chi_1\chi_2...\chi_n)g = -(\chi_1\chi_2...\chi_n)Gm_{i0s}/r^2 \qquad (5)$$

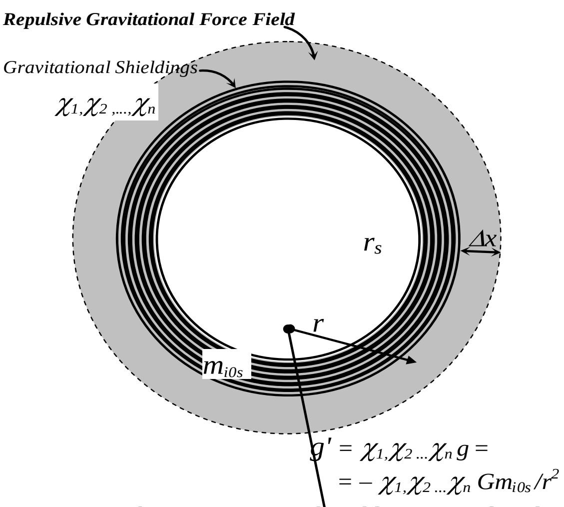

Fig. 5 – *Repulsive Gravitational Field Force* produced by the Spherical Gravitational Shieldings (1,2,…,*n*), (n odd).

If we make $(\chi_1\chi_2...\chi_n)$ *negative* (n odd) the gravity g' becomes *repulsive*, producing a pressure p upon the matter around the sphere. This pressure can be expressed by means of the following equation

$$p = \frac{F}{S} = \frac{m_{i0(matter)}g'}{S} = \frac{\rho_{i(matter)}S\Delta x g'}{S} =$$

$$= \rho_{i(matter)}\Delta x g' \qquad (6)$$

Substitution of Eq. (5) into Eq. (6), gives

$$p = -(\chi_1\chi_2...\chi_n)\rho_{i(matter)}\Delta x\left(Gm_{i0s}/r^2\right) \qquad (7)$$

If the matter around the sphere is only the atmospheric air ($p_a = 1.013\times10^5 N.m^{-2}$), then, in order to expel all the atmospheric air from the inside the belt with Δx - thickness (See Fig. 5), we must have $p > p_a$. This requires that

$$(\chi_1\chi_2...\chi_n) > \frac{p_a r^2}{\rho_{i(matter)}\Delta x G m_{i0s}} \qquad (8)$$

Satisfied this condition, *all* the matter is expelled from this region, except the *Continuous Universal Fluid* (CUF), which density is $\rho_{CUF} \cong 10^{-27} kg.m^{-3}$ [12].

The density of the Universal Quantum Fluid is clearly *not uniform* along the Universe. At *supercompressed* state, it gives *origin* to the *known matter* (quarks, electrons, protons, neutrons, etc). Thus, the *gravitational mass* arises with the supercompression state. At the normal state (free space, far from matter), the local *inertial mass* of Universal Quantum Fluid does not generate gravitational mass, i.e., $\chi = 0$. However, if some bodies are placed in the neighborhoods, then this value will become greater than zero, due to *proximity effect*, and the gravitational mass will have a non-null value. This is the case of the region with Δx - thickness, i.e., in spite of *all* the matter be expelled from the region, remaining in place just the Universal Quantum Fluid, the proximity of neighboring matter makes non-null the gravitational mass of this region, but extremely close to zero, in such way that, the value of $\chi = m_g/m_{i0}$ is also extremely close to zero (m_{i0} is the inertial mass of the Universal Quantum Fluid in the mentioned region).

Since in the region with Δx - thickness, the value of χ is extremely close to zero, we can conclude that *the gravitational mass of the sphere*, which is given by $m_{gs}=\chi(\chi_1\chi_2..\chi_n)m_{i0s}$, *becomes very close to zero*.

Now consider Fig. 6, where we show a *Gravitational Tunneling Machine*, which works based on the principles above described. Encrusted inside the tungsten tip of the tunneling machine there is a set of n plane gravitational shieldings, with $\chi_{1,}\chi_{2,}...,\chi_n$, respectively. Just before the gravitational shielding χ_1 there is a *cube of tungsten*, which produces a gravity acceleration g_i on its surface (See Fig.6). When the set of gravitational shielding is actived the gravity g_i is increased to $(\chi_1....\chi_n)g_i$. Thus, if n is *odd*, the rock in front of the tunneling machine will be *attracted* to it with a gravitational force given by $F_e=M_{ge}(\chi_1....\chi_n)g_i$, where M_{ge} is the gravitational mass of the rock. Similarly, the tunneling machine will be attracted to the rock with a gravitational force $F_i=M_{gi}(\chi_1....\chi_n)g_e$, where g_e is the gravity produced by M_{ge} on the surface of the rock (See Fig.6). Thus, by increasing the values of $(\chi_1....\chi_n)$ the pressure upon the rock can surpass its compressive strength, and the tunneling machine progresses. The compressive strength of the tungsten is about $100GPa$ while the maximum compressive strength of the rocks is about $1GPa$. Consequently, the strong compression does not affect the tungsten tip of the tunneling machine. In order to support this enormous compression, it is necessary to use, between the tungsten plates of the gravity control cells, Silicon Carbide (SiC) (or similar), whose compressive strength is about $10GPa$ (See Fig.6).

Note that before the tungsten cube there is a cell with *air*. When the set of gravitational shielding is actived the gravity acceleration upon the air molecules becomes equal to $(\chi_1....\chi_n)g_e$, then if condition (8) is satisfied, *all* the matter will be expelled from this cell, except the *Continuous Universal Fluid* (CUF), which density is $\rho_{CUF}\cong 10^{-27}kg.m^{-3}$. As we have already seen, the consequence is that the gravitational mass of the air in this region becomes extremely close to zero, and consequently, the value of χ in this region (χ_0) is also *extremely close to zero*. This works as a strong attenuator of gravity, reducing the enormous gravity $(\chi_1....\chi_n)g_e$ down to $\chi_0(\chi_1....\chi_n)g_e$. Thus, the value of the gravity acceleration $(\chi_1....\chi_n)g_e$ before the air cell is practically *nullified* (See Fig. 6).

Note that the axis of the tunneling machine can be easily displaced. This makes possible the machine move itself in *any directions below the ground*.

Obviously, this machine can include systems to control its underground movement, as well underground location and position, etc. Also additional modules can be included for others specific uses.

In order to drill the rock, the pressure, $p=F/S$, exerted by the tunneling machine on the rock must be proportional to compressive strength of the rock, σ_r, i.e.,

$$p=k\sigma_r \tag{9}$$

where k is the factor of proportionality. For $k\le 1$ the force F does not carry out work. The work just occurs for $k>1$. In this case we can write that

$$dW=(k-1)Fdr \qquad for \qquad k>1 \tag{10}$$

Then the potential energy $U(r)$ is given by

$$U(r)=\int_\infty^r dW=\int_\infty^r (k-1)Fdr=$$

$$=\int_\infty^r (k-1)(\chi_1\chi_2...\chi_n)G\frac{M_{gi}M_{ge}}{r^2}dr=$$

$$=(k-1)(\chi_1\chi_2...\chi_n)GM_{gi}M_{ge}\left[-\frac{1}{r}\right]_\infty^r=$$

$$=-(k-1)(\chi_1\chi_2...\chi_n)GM_{gi}M_{ge} \tag{11}$$

On the other hand, the kinetic energy of the tunneling machine is

$$E_k=F.r=M_{gi}(\chi_1\chi_2...\chi_n)g_e r=$$

$$=M_{gi}(\chi_1\chi_2...\chi_n)\left(\frac{v^2}{2}\right) \tag{12}$$

By comparing equations (11) and (12), we obtain

$$v=\sqrt{2(k-1)\frac{GM_{ge}}{r}} \tag{13}$$

For $p=10GPa$ (maximum pressure supported by the tungsten) and $\sigma_r=0.2GPa$ (compressive strength of *granite*), we get $k=p/\sigma_r=50$. Considering just a granite block in front of the tunneling machine, whose center of mass is at a distance $r \cong 10m$ of the center of mass of the tunneling tip, then we can assume $M_{ge} \approx 100\ tons$. Thus, for $k = 50$ Eq. (13), gives

$$v \approx 10\,m/h \qquad (14)$$

This is therefore the order of magnitude of the *velocity of the tunneling through the granite*. Note that this velocity is greater than the velocity of the new model of *geohod* mentioned at the introduction of this work. Through soft soil $\sigma_r \cong 50kPa$ *the velocity of the tunneling increases to* $\approx 1km/h$.

The pressure exerted upon the rock heats the tip of the tunneling machine. In order to calculate the temperature due to this pressure we start considering that the thermal energy E_T produced by the frictional force, F_μ, is given by

$$E_T = F_\mu d = \mu mad = \mu m\left(\frac{v^2}{2}\right) = \mu E_k \qquad (15)$$

where μ coefficient of friction.

By dividing both members of this equation by the volume, V, we get $W_T = \mu W_k = \mu\left(\frac{1}{2}\rho_t v^2\right)$, where ρ_t is the density of the tip of the tunneling machine (tungsten), and v is its velocity. Since $D_T = W_T(c/4)$ and $D_T = \sigma_B T^4$ ($\sigma_B = 5.67\times10^{-8} W/m^2K^4$ is the *Stefan-Boltzmann's constant*.), we obtain

$$T = \sqrt[4]{\frac{\mu c \rho_t v^2}{8\sigma_B}} \qquad (16)$$

For $v \approx 10m/h \approx 3\times10^{-3} m/s$, $\rho_t = 19{,}250 kg/m^3$, we obtain

$$T \cong 3{,}271.7\mu^{\frac{1}{4}} \qquad (17)$$

The value of μ for any two materials depends on system variables like temperature, velocity, pressure, as well as on *geometric properties of the interface between the materials*. In the particular case of the tunneling machine shown in Fig.6, due to *the elliptic surface*, the value of μ should be *very less than* that associated with *kinetic friction** and *very greater than* the values for the coefficient of *rolling* resistance, which typical values are about 0.001 [13]. Assuming that, for the tunneling machine, the value of μ is of the order of 0.01, then Eq. (17) shows that the temperature at the tip of the tunneling machine is of the order of 1,000K (~800°C). This temperature is sufficient to melt the rock , and then the molten rock is pushed from the tip is immediately turned into a glass-like material, which coats the inner diameter of the tunnel, creating an initial tunnel liner.

Since k is expressed by

$$k = \frac{p}{\sigma_r} = \frac{(\chi_1\chi_2\cdots\chi_n)M_{gi}g_e}{S\sigma_r} =$$

$$= (\chi_1\chi_2\cdots\chi_n)\frac{GM_{ge}M_{gi}}{S\sigma_r r^2} \qquad (15)$$

we can conclude that, for $k = 50$, $M_{gi} = M_{ge} \approx 100\ tons$, $S = (3.2)^2 = 10.2m^2$, $r \cong 10m$ and $\sigma_r = 0.2GPa$, we must have

$$(\chi_1\chi_2\cdots\chi_n) = \frac{S\sigma_r r^2 k}{GM_{ge}M_{gi}} \approx 10^{12} \qquad (16)$$

Thus, if $\chi_1 = \chi_2 = \ldots = \chi_n$ and $n = 8$, we get

$$\chi_1 = \chi_2 = \ldots = \chi_8 = \chi = \sqrt[8]{10^{12}} \approx -31.6 \qquad (17)$$

This is, therefore, the necessary value of χ, at each gravity control cell, in order to produce $(\chi_1\chi_2\cdots\chi_n) \approx 10^{12}$.

It is important to note that the energy necessary to move this tunneling machine is just the energy used to produce the gravitational shieldings. This is a very small amount of energy, and can be supplied by a common battery only. Thus, this is the world's most economical tunneling machine, and has no analogues in the world, and represents a completely new type of tunneling machine.

* Most dry materials in combination have friction coefficient values between 0.3 and 0.6. Values outside this range are rarer.

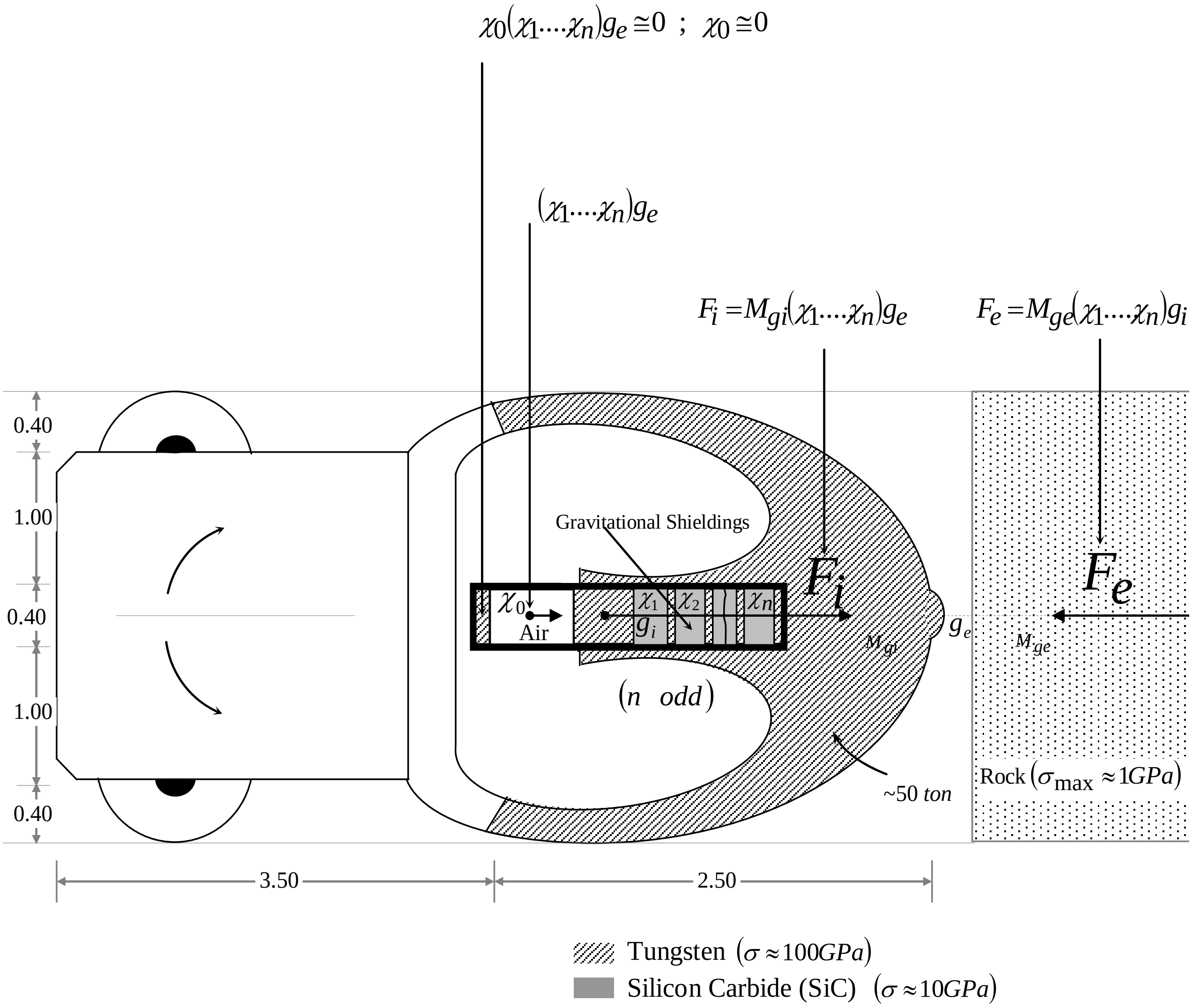

Fig. 6 - *Gravitational Tunneling Machine*

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