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Renewable Energy Source from Natural Thermal Expansion and Contraction of Matters

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Abstract

Worldwide energy consumption is increasing year by year decreasing limited non-renewable sources. In spite of that the electrical energy produced from renewable sources is growing gradually, its amount is not enough yet and we are far from rejecting use of gaseous, liquid and solid fuel. Furthermore, combustion of these fuels is accompanied by emission of hazardous substances. The new method of generating energy from renewable sources is presented. Expansion and contraction of matters by changing in environment temperature is lying on the basis of technique. It is known that the enormous forces and pressures occur by thermal expansion of solids and liquids respectively. The ways of application these forces and pressures to produce useful energy is suggested. The mathematical model of device created in Matlab. Very slow thermal movement of matters can be amplified by thousands and even much more times in three stages and converted into mechanical and electrical energy. The power of unit can be chosen from several watt/hours to dozens of megawatt/hours. The device made by suggested method can work round-the-clock and year-round due to day and night temperature difference. Preliminary evaluations show that the expected efficiency is almost 60%. It makes possible to provide with the electricity remote farms in rural areas. Big differences in night and day temperatures show for possibility of use such devices in space conditions. Cool water of sea and oceans can afford use of them in ships also.

Keywords: contraction; electricity; expansion; thermal.

1. Introduction

There are quite a number of methods of generating energy from renewable sources.

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Due to that electrical energy can be transferred to long distances, converted into another kind of energy and measured easily, majority of these methods are based on obtaining electricity. As it is mentioned in [1], the most of distributed means use hydroelectric, tidal, wave, solar, wind and geothermal energy and biomass. They are developing and improving rapidly and the percentage of electricity, produced using renewable sources is increasing gradually. For instance, the modern devices, which use wind energy and solar photovoltaic cells, are developed as work of art. As it is stated in [2, 3] efficiency of wind generators reaches 46-48% and photovoltaic cells can provide 40.8% respectively. But in spite of above discussed, according to [1], none of the existing means can afford to decline from fossil fuels, the resources of which are exhaustible. If to analyze the sources of electricity production in the world, presented in [4], one can find that the all methods based on renewable sources together can't replace the nonrenewable sources: the percentage of electricity produced using renewable sources, from 2002 to 2010 increased from 18.3 to 20.8 %. In other words, the slightly more than one fraction of electricity from five was produced using renewable sources in the world in 2010. The hydraulic power units are shared 78 % of electricity produced in 2012 in structure of renewable sources. Using the solar energy increased from 1.7 TWh to 104.5 TWh from 2002 to 2012 and composed 2.2 % in 2012. The major part is shared by solar panels and only 4.1 TWh generated by solar thermal units. These data stimulate the interest to create new methods of using renewable sources for producing electrical energy. A new method of generating electricity, based on natural thermal expansion and contraction of matters, is presented in this paper. The rest of work is organized as follows: section 2 describes related work; scope is presented in section 3; section 4 presents conclusion; section 5 provides acknowledgements and section 6 presents the references.

2. Related work

Use of geothermal energy is one of the reliable ways of producing electricity. Usually, the water is pumped interior in this binary method. Steam, which rotates the turbine, is obtained by hot underground rocks. The thermal energy of underground rocks needed to rise to the surface in another case. As it is mentioned in [5], the advantage of geo power unit is that such device can work nearly all of the time, when wind turbine can deliver the power 40% of the time and solar machine 15%. But geothermal sources are not found everywhere and drilling multitude deep rock holes is expensive. One of such methods and device for transformation of the geothermal energy into electrical is described in [6]: the energy is produced by sampling of the heat energy from geothermal environment directly using a working substance. The working substance, in the heat-exchanger, passes through the entire well, expands with phase transition and transfers to the turbine by heat-insulated pipe. The discharged steam of the working fluid comes back to the well, condenses giving the heat at the upper cool part of the well, where the static pressure raises with the depth. The condensed fluid continues downward motion by small diameter pipe, where the temperature and pressure increases gradually. Evaporation of the condensed fluid, at the expanded bottom part of the heat-exchanger will be accompanied by further heat removal from the geothermal environment. This gaseous working substance, heated, transferred to the turbine input and the cycle is closed. The method, working as a thermal siphon, affords to create an efficient, ecological and durable power plant, and economically use out-of-operation oil and gas wells. But it needed to build them near of the suspended wells or to drill the new ones. As it is stated in [7], the research of the geothermal sources is associated with the financial risk and the most of companies can't take chances unless government support. The invention [8] is related to methods and devices for transforming the heat energy of exhaust gases of cars and

smoke jets of boiler plants into mechanical. The pressure of the working fluid, which drives the generator, obtained due to thermal expansion of an S-shape plate with shape memory. The plate expands when heated and returns to initial position when cooled. Heated gases and atmospheric air are supplied for heating and cooling respectively. The shortcoming of the device is that, it can be used near boiler plant and delivery of electrical energy to the customer requires extra charges. Moreover, the power of such units is limited. The automotive variant leads to increase in total mass and volume, which restricts its use in cars particularly. Plurality of elements and blocks will result in higher price of the device and in decreased reliability.

3. Scope

The temperature of the earth and air starts to rise gradually and all matters expand every day from the early morning. Some of them expand faster and others slowly with increasing of temperature. This process is continued until the sun comes to the zenith. Then the inverse process begins: the temperature of the earth and air falls gradually, matters start to contract. Process continues after sunset also, while the temperature is decreasing. The matters expand and contract periodically due to day and night temperature difference even on those days, when the sun is not visible entirely. It is known that the giant mechanical forces are generated by expanding and shrinking of solid materials can destroy railways and bridges. The fluids in closed vessels generate huge excess pressures and vacuum by temperature variations. This phenomenon can be used for generating electrical energy. The ways of realization of stated problem was applied for patent [9]. The goal of present research is to open possibilities of this application and develop the alternative method of electricity production by thermal expansion and contraction of the solid and liquid matters. The problem will be solved by amplifying in three steps the speed of very slow motion, resulting in thermal expansion and contraction of matters. The device is considered in two variants, where the working fluid (3.1. Variant a) and the long metal rod (3.3. Variant b) are used as a source of driving force.

3.1. Variant a

Figure 1 illustrates general principle scheme of the power unit.

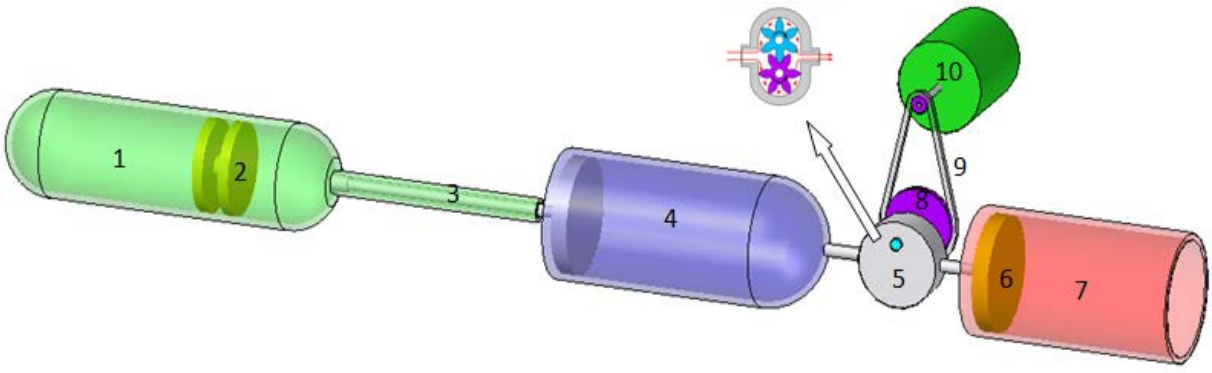

Figure 1: General principle scheme of the power unit. 1 – hydraulic preamplifier; 2, 3 and 6 – are pistons; 4 – main hydraulic amplifier; 5 – transducer; 7 – hydraulic cylinder; 8 and 9 – are band drive; 10 – generator.

The hydraulic preamplifier (1), the left side of piston (2), is filled by working fluid with high coefficient of thermal expansion. The right side of piston (2) and the main amplifier can be filled with low thermal coefficient liquid. The two side piston (3) has smaller area from the preamplifier side and larger one from the main amplifier side. All pistons should move freely in both directions. This allows keeping the pressure in vessels constant during expansion and contraction of the working fluid. When the temperature of environment starts to raise from early morning, the working fluid in preamplifier (1) starts to expand. The piston (2) moves to the right due to the excessive volume at its left side and extrudes the working fluid on its right side and moves the piston (3) – the first amplifying stage. Insignificant expansion of the working fluid in preamplifier (1) and the small displacement of piston (2) will lead to appreciable movement of piston (3) because of high ratio of diameters. The latter, in turn, will extrude the large amount of the working fluid from the main amplifier (4) to the hydraulic cylinder (7) through a transducer (5) by small a diameter conduit. The leading shaft of the transducer, which is like the positive displacement flow meter or pump, starts to rotate, let say, clockwise. This way the movement of working fluid under hydraulic pressure is transformed into rotational motion – the second amplifying stage. The rotational motion of the shaft amplified by band drive (8, 9) – the third amplifying stage, and transferred to the generator (10), which will produce the electricity. This process will continue until the temperature of working fluid in preamplifier (1) ceases to rise. The temperature of working fluid starts to fall after some time achieving the maximum. This will lead to originate the vacuum in hydraulic preamplifier (1) by volume contraction of the working fluid. Again, insignificant contraction will result in appreciable motion of piston (3) in backward direction. The working fluid is sucked back into the main hydraulic amplifier (4) from the hydraulic cylinder (7), rotating the shaft of transducer (5) counterclockwise. The rotational motion is amplified and transferred to the generator. Thereby, the electrical energy will be generated as during expansion and during contraction of working fluid as well. The materials of the hydraulic amplifiers and cylinder should be chosen as similar and with the high heat-conductivity.

3.2. Some preliminary calculations

Let we try make some calculations for a prototype of power unit for a small farm in rural area. Assume that the temperature of working fluid fluctuates during year from -20 ^{o}C to +60 ^{o}C. The methanol is chosen as working fluid and its coefficient of thermal expansion is $\beta = 1200 \cdot 10^{-6}$ K^{-1} according to [10]. Volume expansion defined as [11]:

$$\Delta V = V_i \beta \Delta T, \qquad (1)$$

where V_i is the initial volume of working fluid, ΔT is the change in temperature under consideration time. Initial volume of working fluid is 0.3 m^3 at temperature 0 ^{o}C. Pressure of working fluid in preamplifier is $2 \cdot 10^7$ *Pa*. Geometrical parameters of the device and calculated values of pressure and force are presented in Table 1. The maximal expansion volume, *0.0288* m^3, and corresponding moving distance of piston (3), *1.432 m* are defined for temperature diapason (from -20 to +60 ^{o}C) at given geometry and chosen working liquid. Mathematical model of the device was developed in Matlab and performance of the model is analyzed. The real history of temperature changes for 10 hours in Tashkent city (capital of Uzbekistan) from 16 pm November 4, 2015 to 01 am November 5, 2015 is considered. The expression for temperature changes during considered time was

obtained by polynomial fitting for simulation. Figure 2 shows how the temperature, volume of working fluid and distance passed by Piston 3 changes within considered 10 hours.

Table 1: Geometrical parameters of device and calculated values of pressure and force.

Parameter	Preamplifier	Two side Piston 3		Main Amplifier	Transducer input	Hydro-cylinder
		Left	Right			
Inner diameter, m	0.25	0.16	0.25	0.25	0.01	0.25
Cross section area, m^2	0.1963	0.02011	0.1963	0.1963	7.854e-5	0.1963
Pressure, Pa	2e+7	2e+7	2.048e+6	2.048e+6	2.048e+6	
Force, N	3926990.82	402123.86	402123.86	402123.86	160.85	

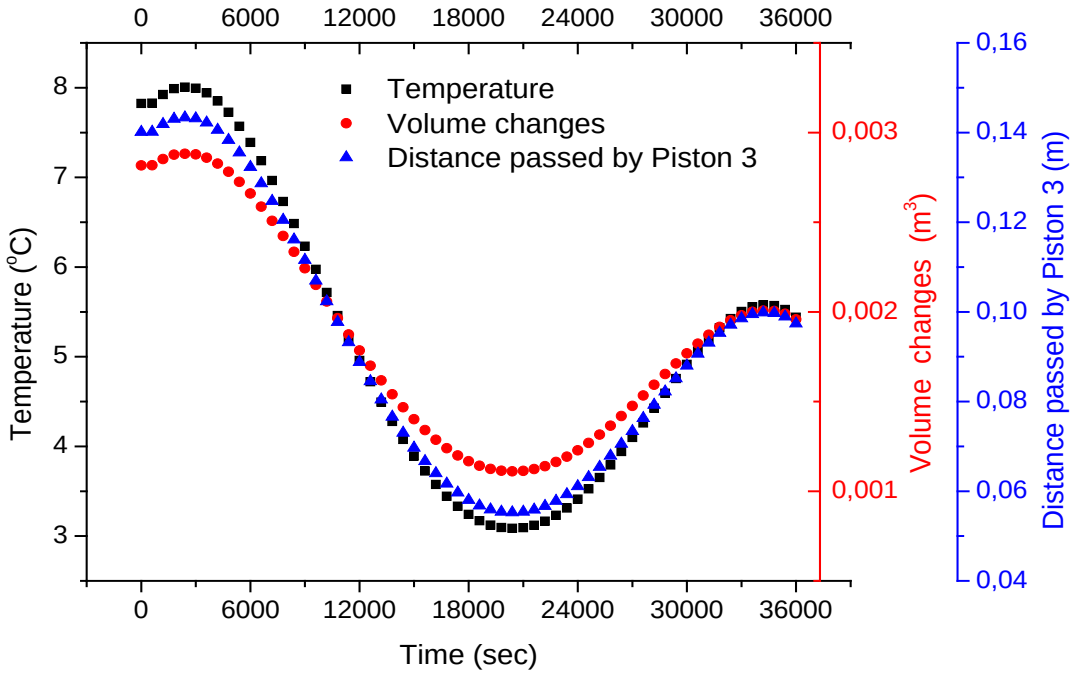

Figure 2: Changing of temperature, volume of working fluid and distance passed by Piston 3 with time.

As it is seen from Figure 2 any change of environment temperature, raise or fall, will be accompanied by increasing or decreasing of working fluid volume ΔV and moving the Piston 3. Latter moves to the right if temperature increases and to the left - if temperature falls. At given constant pressure, P, will be done some work:

$$W = P \cdot \Delta V. \qquad (2)$$

According to the Figure, from starting time until 2400 seconds the temperature will raise, then falls gradually until 20400 seconds, next, raises until 34800 seconds and finally, falls again until 36000 seconds. Total temperature change consist 8.1 ^{o}C. One can define that ΔV=2.916 *liters* and W=58320 *J*. The total distance

d=14.5 *sm*, passed by Piston 3, can be determined from Figure or using ΔV and date from the Table 1. Also one can check that $W=F\cdot d$ =58320 *J*. Figure 3 illustrates velocity of piston 2, liquid velocity at transducer input and power during considered time.

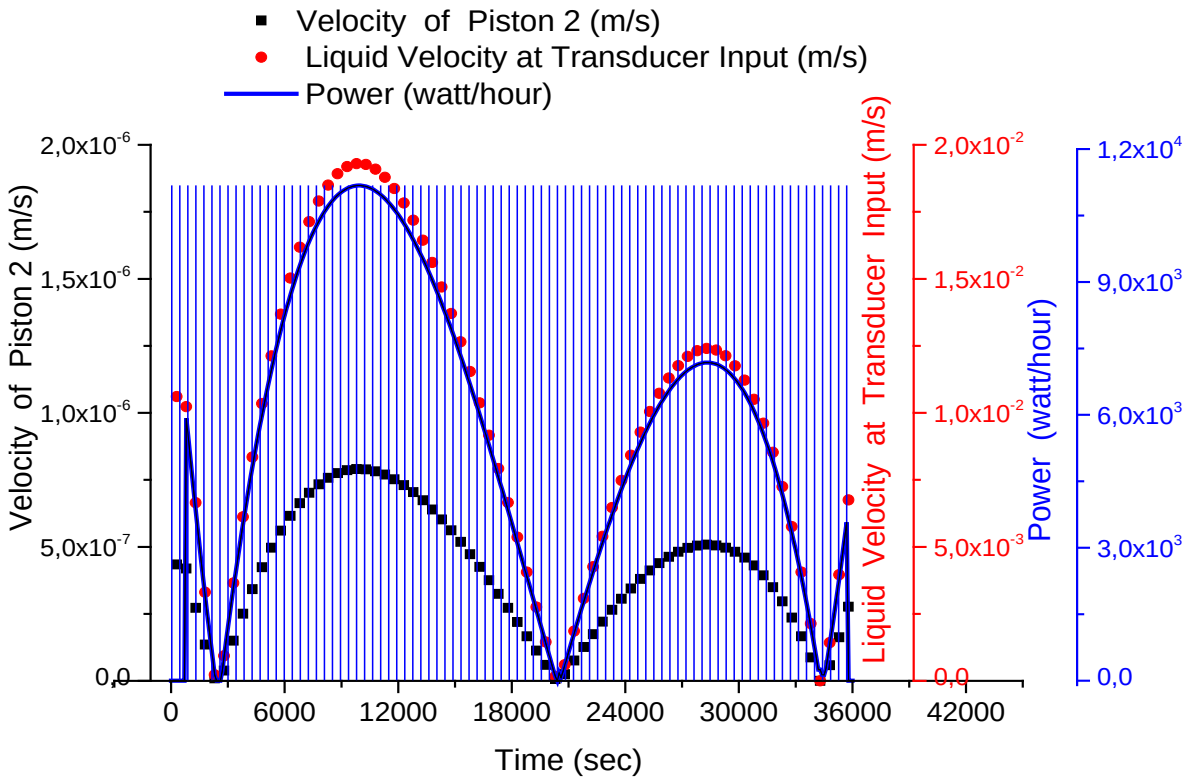

Figure 3: Velocity of piston 2, liquid velocity at transducer input and power during considered time.

The work can be written as integral of power over time:

$$W=\int P_O \, dt, \qquad (3)$$

where P_O is the power. This work is equal to work (2) and illustrated as hatched area under power curve in Figure 3. If compare from Figure the velocity of Piston 2 with the velocity of liquid at transducer input, one can determine that the latter is amplified 24414 times. According to principle of conservation of energy, the force obtained in preamplifier, is reduced for the same amount at transducer input (see Table 1). The pressure at the input of transducer was reduced almost for decade. It depends on cross section area of hydraulic amplifiers and should be chosen such a way that the end pressure of working fluid at the hydraulic cylinder should be equal to the atmospheric pressure taking into account the pressure drop in transducer. Thereby in ideal case thermal expansion work 58320 *J* is equal to support in average 5832 *watt/hour* energy within 10 hours. But in reality we must consider energy losses. The preliminary medium efficiency of device can be derived taking into account efficiencies of similar devices presented: electric generator 95% [12], external gear (transducer) 85% [13], hydro-mechanic piston 95% [14] and belt drive 90% [15] (see Figure 4).

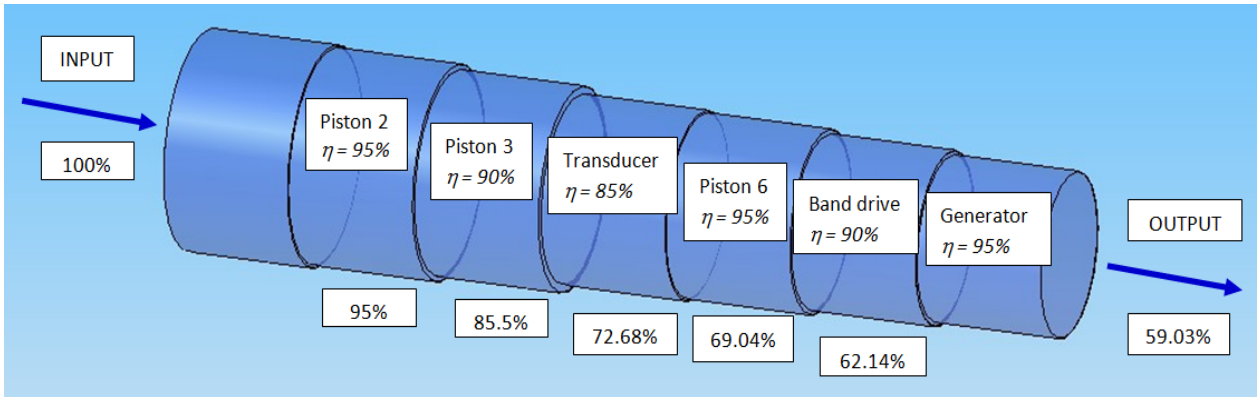

Figure 4: The average efficiency of device expected.

The 59.03% of 5832 *watt/hour* consists 3442 *watt/hour*. This energy produces for small changes in temperature (oscillations occurred between 8°C and 3°C) and it is enough for a small farm. It should be noted that in reality temperature oscillations will be greater because of direct sun rays falling to the surface of preamplifier, which is made from heat conductive material. The more changes in temperature, the more is work done. There are four parameters which can help us to increase the power: the pressure, initial volume of working fluid, thermal expansion coefficient of working fluid and the span of temperature oscillations during a given period of time. Figure 5 represents the results of power calculations for 4 discrete values of pressure and for 5 values of the initial volume of working fluid. Assumed that the temperature increased linearly for 10 °C during 10 hours and the thermal expansion coefficient of working fluid is $\beta = 1200 \cdot 10^{-6}$ K^{-1}.

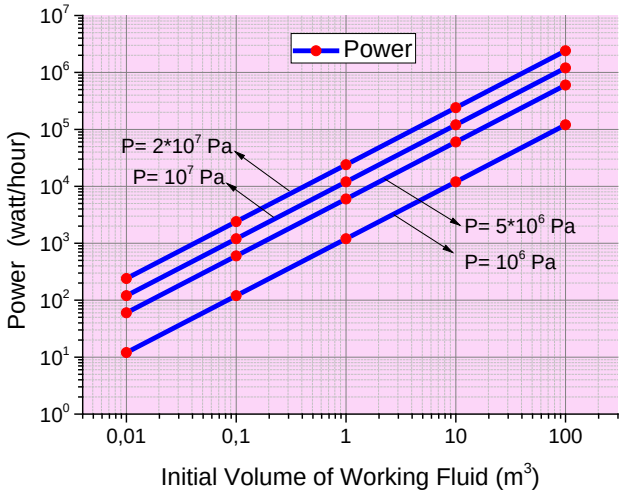

Figure 5: Power for 4 different values of pressure (10^6, $5 \cdot 10^6$, 10^7 and $2 \cdot 10^7$ *Pa*), and for 5 values of initial volume of working fluid (0.01, 0.1, 1.0, 10 and 100 m^3). The thermal expansion coefficient of working fluid is $\beta = 1200 \cdot 10^{-6}$ K^{-1}. Assumed that the temperature increased linearly for 10 °C during 10 hours.

As it is seen from Figure power units in wide range will be available. Calculated values from 12 *watt/hour* to 2.4 *megawatt/hour* can be transferred as from 7.08 *watt/hour* to 1.41*megawatt/hour* in light of evaluated efficiency, 59.03%. Taking into account that obtaining pressure much more than $2 \cdot 10^7$ *Pa* is not a problem and the initial volume of working fluid may be increased if use modern techniques and technologies, we can state that it is possible creating much higher power stations.

3.3. Variant b

The prototype, described above, has two shortcomings, which can restrict its use in public places: 1.The higher operation pressure is needed for higher power. In the other hand high pressure conditions require expensive safety arrangements. 2. The higher thermal expansion coefficient of working fluid is required for higher power. But, mostly, fluids with the high thermal expansion coefficient are flammable at high temperatures. These shortcomings can be overcome through using displacement of solid material ends due to thermal expansion and contraction. For example, to displace the piston (2) in Figure 1 it can be applied the long metal rod with a lever system, which serves as amplifier of movement. The levers have articulated joints with rod bearings and themselves and will operate as during elongation of the rod and shortening as well. In the case of steel with the coefficient of linear expansion $\alpha = 12 \cdot 10^{-6}$ K^{-1} according to [10], the initial length of L_i=10 *meters*, it elongates for ΔL=0.0096 *meters* when temperature raises for ΔT =80 ^oC linearly in concordance with [11] relative to initial condition:

$$\Delta L = L_i \alpha \Delta T \, . \qquad (4)$$

The two-stage lever system amplifies the linear motion of the second end of steel rod let say, 100 times and provides the movement almost 0.96 meters and moves the piston (2). Note that the first end of the rod is rigid. Further, the process will follow according to above described sequence until the rising of temperature of the rod ceases. The generator will stop when the temperature reaches the maximum and the inverse process starts after some time. Temperature of metal rod and the working fluid starts to fall gradually, the rod starts to shrink, and the working fluid starts to contract moving the piston (2) backwards. The process continues even after sundown until the temperature reaches the minimum.

4. Conclusion

The new method of generating energy from renewable sources, based on natural thermal expansion and contraction of matters is presented. It allows generating electricity even at insignificant changes in environment temperature. Effectiveness can be increased in favorable conditions. The power of the device is dictated by the initial volume of working fluid and the value of the pressure, which can be supported by the case of preliminary hydraulic amplifier. The larger is the volume of working fluid - the more is thermal expansion and the higher is the power. Another way to increase power is to choose the working matters with the bigger coefficients of thermal expansion. The multiple cycles of expansion and contraction in a day can be implemented by simple opening and closing the direct sunrays to the surface of hydraulic amplifiers and the metal rod in sunny days. Then the difference in temperature at the shadow and at the broiling sun will be enough to produce the

electricity. In addition, the continuous cyclic process can be provided by cooling the preliminary hydraulic amplifier and the metal rod by sinking them to the cool water periodically. The method distinguishes the simplicity of construction and small amount of moving parts. It is ecological and resource saving: the fossil is not used and there is no waste. The power plant, which works automatically by day and night temperature difference, affords to produce the electricity round-the-clock and year round, can be created using the last achievements of science and technology. It makes possible to provide with the electricity the remote farms in rural areas. Low temperatures of sea and ocean waters can afford use it in ships. The space variants of such device can be developed in close future if to take into account big difference in day and night temperatures, in the moon for instance, which promotes the effectiveness of the plant constructed by this method.

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References

[1]. Alternative Energy. Alternative Energy Solutions for the 21st Century. "Renewable Energy." Internet: http://www.altenergy.org/renewables/renewables.html, [Jan.16, 2015].

[2]. Scienmet Group. Научно-производственная группа компаний. « Альтернативная энергия: ветроэнергетика.» Internet: http://www.scienmet.ru/occupation/vetroenergetika, [Jul. 19, 2015]

[3]. Alternative Energy. Alternative Energy Solutions for the 21st Century. "Solar Energy." Internet: http://www.altenergy.org/renewables/solar.html, [Jan. 16, 2015].

[4]. Worldwide electricity production from renewable energy sources. Stats and figures series. Fifteenth inventory – Edition 2013. Chapter 1. "Energy production in the world: general forecasts." Internet: http://www.energies-renouvelables.org/observ-er/html/inventaire/Eng/methode.asp, chrome-extension://oemmndcbldboiebfnladdacbdfmadadm/http://www.energies-renouvelables.org/observ-er/html/inventaire/pdf/15e-inventaire-Chap01-Eng.pdf, [May 31, 2014]

[5]. A.Tomkins. "Geothermal: deeply interesting." Internet: http://www.holden-partners.co.uk/news/article/39/Geothermal:-Deeply-interesting, Jun. 22, 2015 [Jul. 19, 2015].

[6]. S.E.Uglovsky, R.Sh.Tahautdinov. "Device and method for converting geothermal well energy into electrical energy." RU. Patent WO2013060340 A1, May 2, 2013.

[7]. Ch.Helston. EnergyBC. "Low-temperature Geothermal Energy." Internet: http://www.energybc.ca/profiles/lowtempgeo.html, [Jun. 17, 2015].

[8]. V.I.Kovalenko. «Device for converting heat energy into mechanical energy.» RU. Patent RU2360144 C2. Feb. 20, 2007.

[9]. A.G.Parsokhonov. "Method of generating electricity using thermal expansion and contraction of matters." UZ. Application for patent: IAP 20150090. Mar. 11, 2015. Decision for considering: Aug. 18, 2015.

[10]. A Star Math and Physics. "Comparing Coefficients of Thermal Expansion for Gases, Solids and

Liquids." Internet: http://astarmathsandphysics.com/a-level-physics-notes/182-thermal-physics-and-gases/3032-comparing-coefficients-of-thermal-expansion-for-gases-solids-and-liquids.html, [Nov. 18, 2014].

[11]. UPBTOC. "Chapter 17 Thermal Expansion and the Gas Laws." Internet: chrome-extension://oemmndcbldboiebfnladdacbdfmadadm/http://www.farmingdale.edu/faculty/peter-nolan/pdf/UPCh17.pdf, [Nov. 18, 2014].

[12]. S.Ferrel. "Efficiency of energy conversion." Internet: chrome-extension://oemmndcbldboiebfnladdacbdfmadadm/http://www.ems.psu.edu/~radovic/Chapter4.pdf, [May 13, 2016].

[13]. B.Casey. A Noria Publication "Hydraulic Pumps and Motors Considering Efficiency." Internet: file:///D:/Patent/Research/2016/Article/Literature/14/Hydraulic%20Pumps%20and%20Motors%20%20Considering%20Efficiency.htm, [May 13, 2016].

[14]. H.Hatami. Rexroth Bosch Group. "Hydraulic Formulary." Internet: chrome-extension://oemmndcbldboiebfnladdacbdfmadadm/https://www.boschrexroth.com/business_units/bri/de/downloads/hyd_formelsammlung_en.pdf, Jan. 10, 2013 [May 13, 2016].

[15]. Mechanical Transmission Efficiency. "Typical Power Transmission Efficiencies." Internet: chrome-extension://oemmndcbldboiebfnladdacbdfmadadm/http://www.womackmachine.com/pdf/rb365/47th/section10/sec10pg504pumpmotortransmissionefficiencies.pdf, [Jun. 22, 2016].