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(Research Article)

Using Solar Energy and Fiber Optics to Provide an Uninterrupted Movement of an Electric Vehicle

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Abstract

This paper discusses 24-hour solar illumination of a photoelectrolyzer-generator located in the interior of an electric vehicle, using a light receiver that dynamically tracks the light activity of sunlight collected during the day, transmitted via optical fiber directly to the photovoltaic generator to produce oxygen and hydrogen and then charge the fuel cell of the electric vehicle engine for its uninterrupted movement.

24-hour continuous production of hydrogen and oxygen for 24-hour continuous charging of the fuel cell of an electric vehicle engine in a specially designed photoelectrolyzer-generator is achieved by using sunlight from a light receiver transmitted via optical fiber as light for the photoelectrolyzer-generator, and a light-emitting diode with a battery charged during the day by illuminating the photoelectrolyzer-generator with sunlight, which begins to illuminate the photoelectrolyzer-generator in the absence of sunlight at night until the battery is completely discharged in the morning, and continuously filling the photoelectrolyzer-generator with water.

Keywords: Light receiver; fiber optics; photoelectrolyzer-generator; photocells; light - emitting diode (LED), fuel cell of electric vehicle engine.

1. Introduction

The sunflower-shaped solar radiation receiver is a device that includes 36 Fresnel lenses that rotate uniformly around their axis inside the receiver, following the sun throughout the day (Figure 1, [1]).

Dynamic tracking of the solar light activity is carried out, using a built-in photo sensor, a microprocessor and motors, the total power consumption of which does not exceed 10 W. The light receiver is assembled for 6000 lumens. The light receiver is installed on the roof of the electric vehicle.

Sunlight collected during the day is transported into the electric vehicle cabin via optical fiber directly to the electrolyzer-generator. Optical fiber is a thin glass thread of circular cross-section [2 - 8].

Structurally, optical fiber is a coaxial structure consisting of a core and a frame coated with an acrylate composition to protect it from the external environment. The core is made from fused quartz (Figure 2).

Despite the fact that both parts of the fiber are made from quartz glass, they have different refractive indices: the core has a higher refractive index; the shell has a lower one.

The core of the fiber serves to transmit the light flux, while the shell is needed to create conditions for the phenomenon of total internal reflection.

Internal reflection is the phenomenon of reflection of an electromagnetic wave (light is also an electromagnetic wave) from the interface of two media (marked in the Figure 3).

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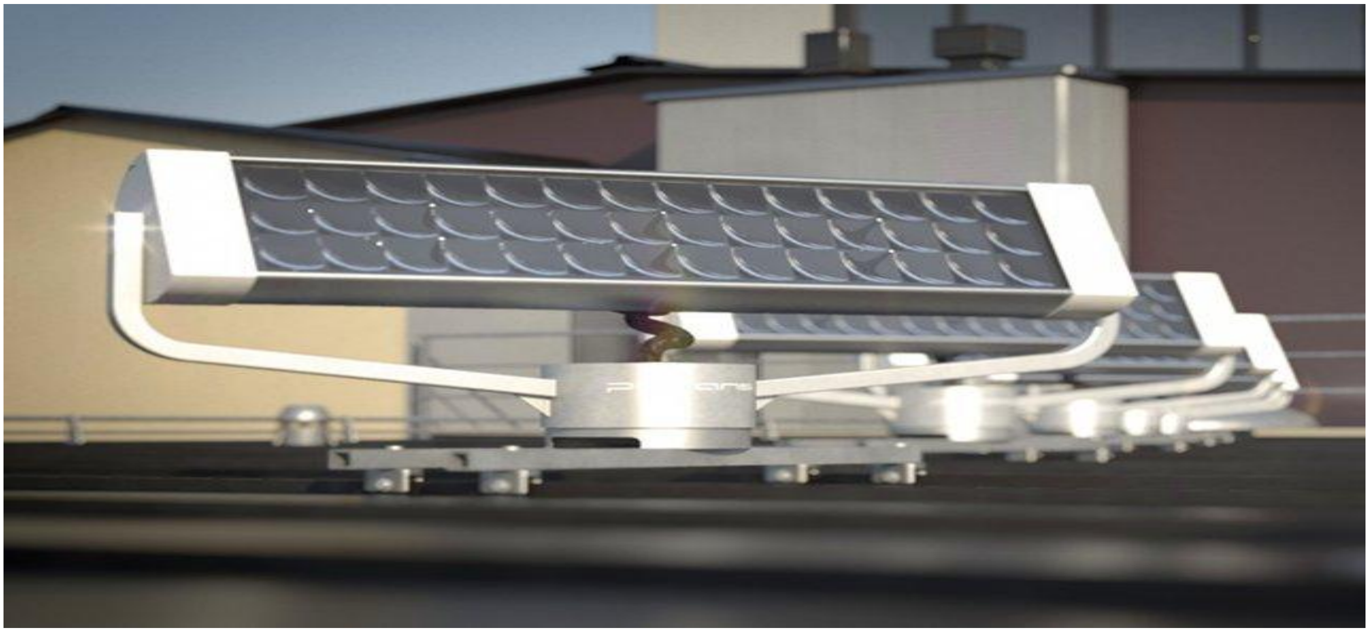

Figure 1. A system that transmits sunlight through optical fiber

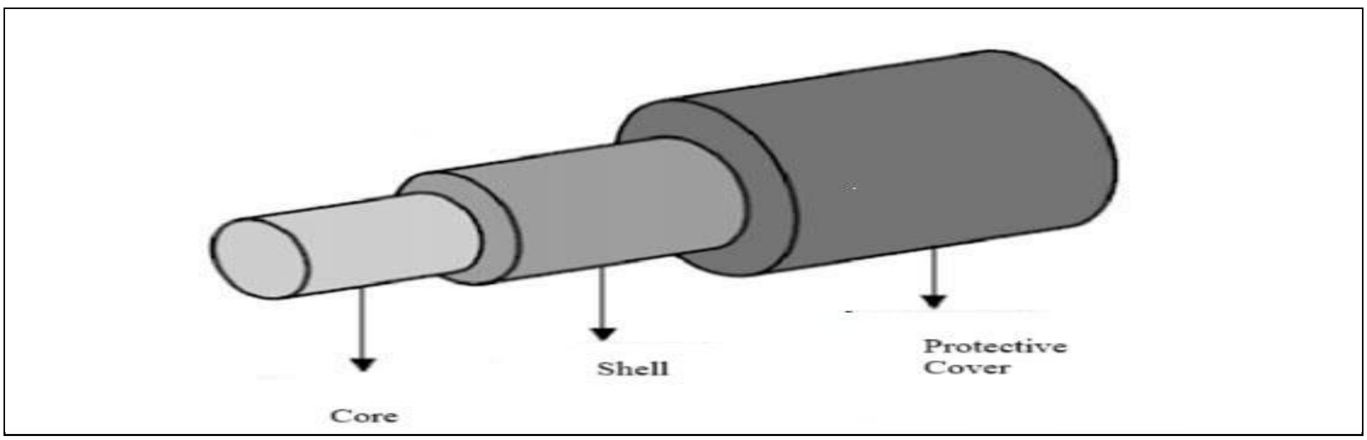

Figure 2. Optical fiber

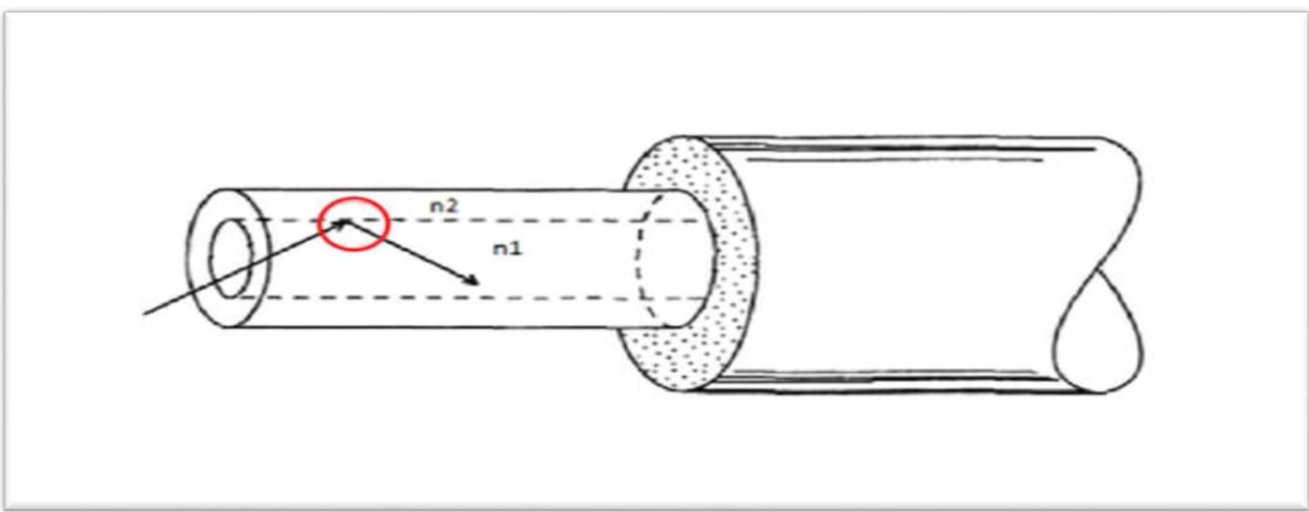

Figure 3. The phenomenon of total internal reflection in fiber

Due to total internal reflection, the light flux inside an optical fiber is capable of traveling significant distances from hundreds of meters to hundreds of kilometers.

Optical fibers are divided into two groups: multimode and single-mode (Figure 4).

Structurally, they differ only in the core diameter: in multimode fibers, it is larger than the wavelength of the transmitted light signals, due to which several optical modes (rays) are transmitted along the fiber; in single-mode fibers, the core is smaller than the wavelength of the light signal, and this allows only one mode to be transmitted.

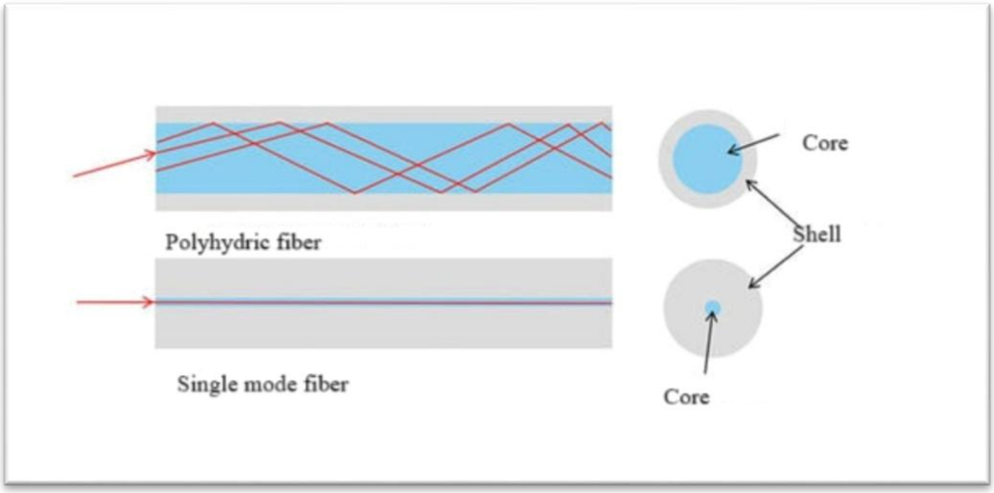

Figure 4. Multimode and single-mode of optical fibers

The scope of natural light over optical fiber is wider than that of solar panels, limited by low-rise, trajectory, and the availability of internal free space for a pipe that is bulkier than thin and inconspicuous optical fiber cables.

In addition, optical fiber solar lighting can be turned on or off using a simple switch that allows rotating the lenses away from sunlight. Sunlight via optical fiber creates better illumination of electrolyser-generator.

The author previously developed round-the-clock and continuous production of hydrogen and oxygen in a specially designed photoelectrolyzer-generator, achieved by using a lamp as a backlight for the photoelectrolyzer-generator, and an LED with a battery charged during the operation of the lamp, as a useful electrical load for the photoelectrolyzer-generator, which begins to illuminate the photoelectrolyzer-generator when the lamp is turned off until the battery is completely discharged, and continuously filling the photoelectrolyzer-generator with water [6].

The round-the-clock production of oxygen and hydrogen in a specially designed photoelectrolyzer-generator allowed the author to carry out the round-the-clock and continuous charging of the fuel cell of an electric vehicle for its uninterrupted movement.

This paper considers the round-the-clock solar illumination of a photoelectrolyzer-generator, placed in the interior of an electric vehicle, using a light receiver that dynamically tracks the light activity of sunlight collected during the day, transmitted via optical fiber directly to the photoelectric generator for the production of oxygen and hydrogen and subsequent charging of the fuel cell of the electric vehicle engine for its uninterrupted movement.

The round-the-clock, continuous production of hydrogen and oxygen for the round-the-clock, continuous charging of a fuel cell of an electric vehicle engine in a specially designed photoelectrolyzer-generator is achieved by using sunlight from a light receiver, transmitted via optical fiber as light for the photoelectrolyzer-generator, and a light-emitting diode with a battery charged during the day by illuminating the photoelectrolyzer-generator with sunlight, which begins to illuminate the photoelectrolyzer-generator in the absence of sunlight at night until the battery is completely discharged in the morning, and continuously filling the photoelectrolyzer-generator with water.

2. Materials and Methods

A vehicle electric engine is an engine whose operating principle is based on the conversion of electrical energy into mechanical rotational energy. The general appearance of the electric engine is shown in the Figure 5.

The main components of vehicle electric engine involved in energy conversion are the stator and rotor. The operating principle of any vehicle electric engine is based on the processes of mutual attraction and repulsion of the poles of the magnets on the rotor and stator. The movement is carried out under the action of the magnetic field itself and inertia.

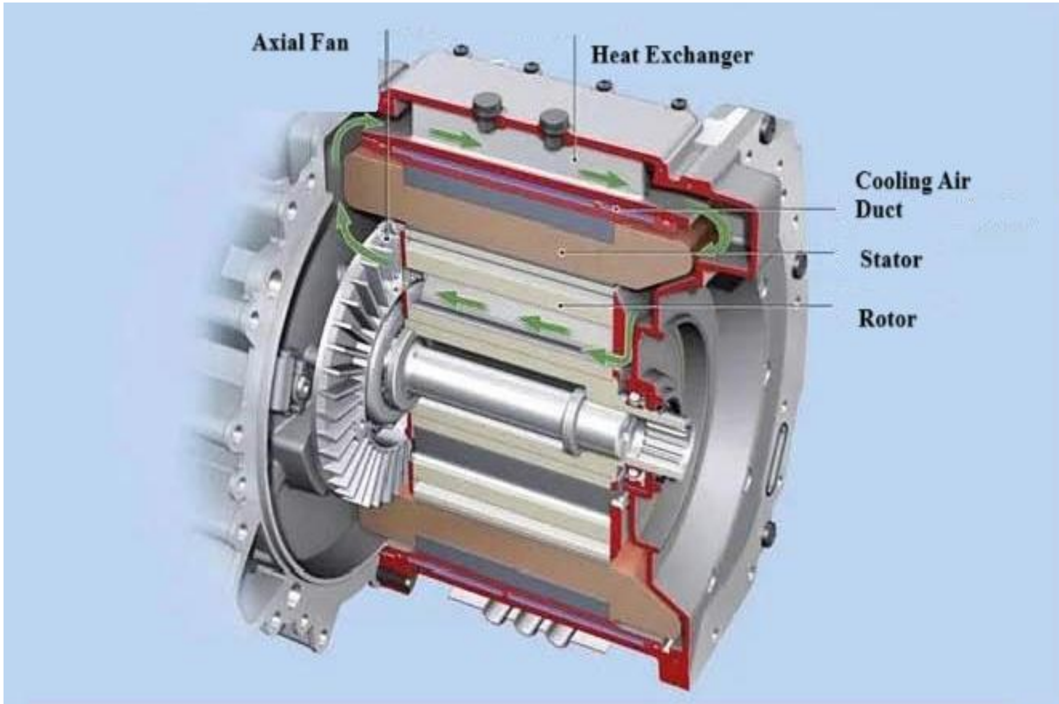

Figure 5. The general appearance of the electric engine

The rotor is the rotating component of the vehicle electric engine, consisting of a core, winding and shaft. The stator (inductor) is stationary. It is responsible for creating a stationary magnetic field. The stator consists of a frame, a core and a winding: The core is a metal rod, on the periphery of which the winding is located. The magnetic circuit of the electric engine is closed directly through the core. The core is made from round steel plates, similar to a layer cake.

Insulated sheets of steel with silicon additives are used in the production of cores, which ensures an increase of the efficiency of the vehicle electric engine, the lowest specific losses in the metal per unit mass, a decrease in the magnitude of demagnetizing eddy currents.

Foucault, which occur due to the remagnetization of the core. There are longitudinal grooves on the surface of the core. The winding is laid through them. The shaft is a metal rod that directly transmits torque also made from electrical steel and serves as a basis for mounting the core. At the ends of the shaft there is a thread, recesses for gears, rolling bearings, pulleys.

The stator frame is the stator housing. As a rule, the housing is aluminum or cast iron. The frame serves as a base for fastening the main and additional poles. The stator core is a cylinder made from profiled steel sheets. It is fixed with screws inside the frame.

It is equipped with slots for the winding, which creates a magnetic flux and, when crossing the rotor conductors, induces an electromotive force in them.

The developed early by author the round-the-clock and continuous production of hydrogen and oxygen in the photoelectrolyzer-generator allowed to carry out round-the-clock and continuous charging of the fuel cell of the vehicle electric engine for uninterrupted vehicle movement, ensured, by using as a light for the photoelectrolyzer-generator, sunlight from a light receiver, transmitted via optical fiber, and as a useful electrical load of the photoelectrolyzer-generator, a light-emitting diode with a battery charged in the process of illuminating the photoelectrolyzer-generator with sunlight during the day, which begins to illuminate the photoelectrolyzer-generator in the absence of sunlight at night until the battery is completely discharged in the morning, and continuously filling the photoelectrolyzer-generator with water from tank.

In our case, the hydrogen and oxygen, produced by the photoelectrolyzer – generator, charge the fuel cells of the vehicle electric engine, which provides the mechanical force, needed to uninterrupted vehicle movement.

Thus, the process of using solar energy and fiber optics to provide round-the-clock for uninterrupted vehicle movement is divided into two stages:

Round-the-clock and continuous production of hydrogen and oxygen in a photoelectrolyzer-generator and round-the-clock and continuous charging of the fuel cell of the vehicle electric engine for uninterrupted vehicle movement.

3. Theoretical and Experimental Research

The use of the theoretically described by author [9] mechanism of the round-the-clock water photoelectrolysis process under the influence of sun light energy on combined anode from silicon semiconductor with attached metallic mesh of photoelectrolyzer-generator, permitted to develop a new photoelectrolyzer-generator, powered by the sunlight energy, for the round-the-clock production pure hydrogen and oxygen, which charges the fuel cell of engine of electric generator for the round-the-clock its operation.

Hydrogen and oxygen in the developed generator are produced by electrolysis of ordinary water, continuously supplied to the photoelectrolyzer-generator, at a cost below the market price, due to a specially designed electrolysis base, including a fire hose membrane, placed between the electrodes and a mechanism for adjusting the gap between the electrodes, located at the bottom of the photoelectrolyzer-generator.

Round-the-clock production of oxygen and hydrogen in the photoelectrolyzer-generator and therefore round-the-clock continuous charging of the fuel cell of an engine of electric generator for its non-stop operation is ensured by using as a light for the photoelectrolyzer-generator, sunlight from a light receiver transmitted via optical fiber, and as a useful electrical load of the photoelectrolyzer-generator, a light-emitting diode with a battery charged in the process of illuminating the photoelectrolyzer-generator with sunlight during the day, which begins to illuminate the photoelectrolyzer-generator in the absence of sunlight at night until the battery is completely discharged in the morning, and continuously filling the photoelectrolyzer-generator with water.

3.1 A photoelectrochemical cell: A photoelectrochemical cell is a silicon semiconductor with an attached mesh anode and a cathode, connected by an electrical circuit for the flow of direct electric current, generated by the action of light on the silicon semiconductor with an attached mesh anode, immersed in an aqueous electrolyte solution [10, 11].

In the N-type layer of silicon, added by phosphorus, has the joint outer orbit, overcrowded with electrons that leads to the tendency of the N-type silicon layer with added phosphorus to give up electrons to bring the common orbit to a normal state, therefore, a combined anode from silicon semiconductor and metallic mesh, immersed in an aqueous electrolyte solution, excited by four photons of light, "loses four electrons, leaving four positively charged "holes" that attract four electrons from four hydroxyl anions ($4OH^-$) of the adjacent dissociated into the hydrogen cation (H^+) and hydroxyl anion (OH^-) of water:

$$H_2O \leftrightarrow H^+ + OH^-, \quad (1)$$

Resulting in the formation of two water molecules and an oxygen molecule, which in an aqueous electrolyte solution takes the form of oxygen electrolysis bubble, floating from the cathode to the free surface of the aqueous electrolyte solution:

$$4OH^- - 4e^- = 2H_2O + O_2\uparrow \quad (2)$$

Two positively charged hydrogen cations $2H^+$ of a neighboring dissociated aqueous solution, having reached the negatively charged cathode, the negative charge of the cathode is due to the freed four electrons, flowing from a combined anode from silicon semiconductor with attached metallic mesh through the load to the cathode, returning two electrons to it, neutralizing into two separate hydrogen atoms, being in a free state, connecting to each other, forming a gaseous hydrogen molecule, which in an aqueous electrolyte solution takes the form of hydrogen electrolysis bubble, floating from the cathode to the free surface of the aqueous electrolyte solution.

$$2H^+ + 2e^- \rightarrow H_2\uparrow \quad (3)$$

Four electrons "knocked out" from a combined anode from silicon semiconductor and metallic mesh, passing through the N-type layer of a combined anode from silicon semiconductor with attached metallic mesh, along the electrical circuit to the cathode and two electrons returned to the cathode from two hydrogen cations, make it a negative pole, and the anode, which loses electrons, becomes a positive pole generate a constant electric current, directed from a combined anode from silicon semiconductor and metallic mesh to the cathode (Figure 6).

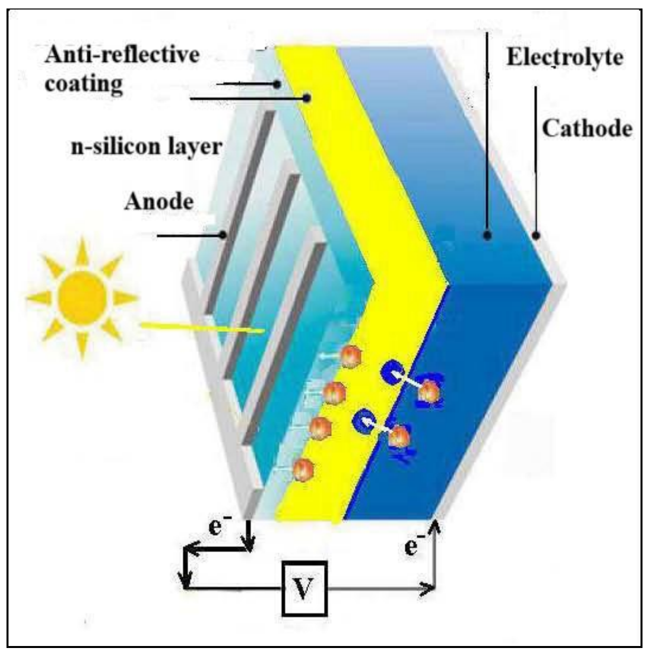

Figure 6. The combined anode

3.2 Developed photoelectrolyzer – generator: As established earlier [6], the size and intensity of formation of negatively charged electrolysis bubbles of hydrogen and positively charged oxygen bubbles can be controlled by increasing the electric potential of the electrodes, making the intensively formed bubbles as small as required by the technological process.

The conclusion stated above, became the basis for the development of a new photoelectrolyzer - generator. The important feature of the developed a photoelectrolyzer - generator that produces pure hydrogen and oxygen at a below market price is a specially designed electrolysis base, including a fire hose material membrane, located between a combined anode from silicon semiconductor with attached metallic mesh, and made from burnt graphite cathode, and a mechanism for adjusting the gap between electrodes at the bottom of the photoelectrolyzer - generator.

A thin fire hose membrane, placed between a combined anode from silicon semiconductor with attached metallic mesh and cathode in an electrolysis base prevents the penetration of electrolysis oxygen bubbles, resulting from the attraction of the four hydroxyl anions of surrounding the dissociated water, donating four electrons to the four positively charged "holes", formed by the impact of four photons of light on a combined anode from silicon semiconductor with attached metallic mesh, resulting in the formation of two water molecules and an oxygen molecule, released in the form of an oxygen gas bubble that floats from the surface of the silicon semiconductor with an attached mesh anode to the top of a photoelectrolyzer - generator and is released as a foam of gas oxygen from the anode zone of the photoelectrolyzer-generator through the oxygen outlet tube.

As a result of electrolysis, electrolysis hydrogen bubbles are intensively formed in the cathode zone of the photoelectrolyzer-generator and are removed in the form of foam of hydrogen gas from the cathode zone of the photoelectrolyzer through the hydrogen tube.

Location of the electrolysis base, i.e. electrodes with a thin membrane and a mechanism for adjusting the gap between them, in the lower part of the photoelectrolyzer-generator, leads, in contrast to photoelectrochemical cells, existing today, where the electrodes are located vertically, to the intensive release of hydrogen and oxygen bubbles without the use of expensive electrolytes.

The arrangement of the electrodes in the vertical direction, as happens in photoelectrochemical cells with an aqueous electrolyte solution in contrast to the electrolysis base, located at the bottom of the photoelectrolyzer - generator, where, as in all electroflotation devices, the electrodes are located in the horizontal direction, occupying the entire bottom of the electroflotation apparatus, sharply reduces the cross-sectional area and increases the length of the conductive layer between the electrodes.

The efficiency of a photoelectrochemical cell or photoelectrolyzer-generator is determined by the intensity of gas evolution in them.

According to Faraday’s law, the mass of gas (M), released on the electrode during time (t), is equal to:

$$M = jigSt \qquad (4)$$

Where j - the electrochemical equivalent of gas (for hydrogen j = 1.0 10–7 кg/ (A· s); for oxygen j = 8.29 10–8 кg/ (A· s)); i - the current density, A/m^2; g = 90%, 95% - current output (the ratio of actual gas mass transfer to the theoretical calculated in percentage terms); S - the cross-sectional square of the conductive layer between the electrodes, m^2.

A sharp decrease of the cross-sectional area and a sharp increase of the length of the conductive layer between the electrodes in accordance with (4) leads to a sharp decrease of the gas evolution of hydrogen and oxygen in the photoelectrochemical cell or photoelectrolyzer-generator and, as a consequence, to a sharp decrease of the efficiency of the photoelectrochemical cell or photoelectrolyzer-generator.

For compensation of the reduction of gas evolution of hydrogen and oxygen in an aqueous electrolyte solution, an expensive electrolyte (for example, ùNaOH) is used, the concentration of which in the solution is 40%, which leads to a sharp increase of the energy consumption of the photoelectrochemical cell, reaching 4.5 kWh/m^3 for hydrogen and oxygen production.

A significant advantage of the developed photoelectrolyzer-generator over existing electroflotation devices is the absence of electrodes in the electrolysis base, which use dense meshes with small cells, causing high currents of the order of 100 amperes at low voltages (20-30V).

The explanation of this significant advantage is as follows.
If we consider i – the process current density as I/S, where I is the direct current of the process, then equation (4) will take the following form:

$$M = jIgt \qquad (5)$$

From equation (5) it is clear that the mass of gas, released on the electrode during time t, is directly proportional to the magnitude of the direct current and does not depend on the area of the electrode.

However, in accordance with Ohm's law, the value of the direct current of the process is directly proportional to the electrode voltage (U) and inversely proportional to the resistance of the inter electrode medium (R):

$$I = U/R \qquad (6)$$

The resistance of inter electrode medium (R), in turn, depends on the inter electrode gap (L) and the cross-sectional square of the conductive layer between the electrodes (S) as follows:

$$R = \rho \frac{L}{S} \tag{7}$$

Where ρ – resistivity of the inter electrode medium.
Substituting (2.7) to (2.6) will obtain:

$$I = (US/\rho L) \tag{8}$$

Thus, from (8) it can be seen that the reduction of the cross-sectional square of conductive layer between the electrodes of photoelectrochemical cell or photoelectrolyzer-generator (S), in our case a change of the form of electrode (silicon semiconductor with attached mesh anode), can be compensated by rising of the voltage (U) on the electrodes for maintaining the previous effectiveness of the work of photoelectrochemical cell or photoelectrolyzer-generator (the previous gas content of system - M).

Increasing of the voltage on the electrodes not only does not reduce the efficiency of the energy consumption of the photoelectrochemical cell, reaching 4.5 kWh/m^3 (for sunlight using photoelectrolyzer-generator the efficiency of the energy consumption reaches 0) for hydrogen and oxygen production. A significant advantage of the developed photoelectrolyzer-generator over existing electroflotation devices is the absence of electrodes in the electrolysis base, which use dense meshes with small cells, causing high currents of the order of 100 amperes at low voltages (20-30V).

The arrangement of the electrodes in the vertical direction not only sharply reduces the cross-sectional area and the length of the conductive layer between the electrodes, which leads to a sharp decrease of gas evolution and the intensity of the formation of electrolysis bubbles of hydrogen and oxygen, but also prevents the formation and rapid removal of electrolysis bubbles of hydrogen and oxygen through hydrogen and oxygen tubes accordingly.

Electrolysis hydrogen bubbles or oxygen bubbles, formed on the entire horizontal surface of the electrode or anode, breaking away from the electrode surface, rush upward and are removed in the form of bubbles of hydrogen gas or of bubbles of oxygen from the photoelectrolyzer-generator through the hydrogen or oxygen tubes due to the Archimedes force, acting in a strictly vertical direction in relation to the cathode or to anode.

In vertically located electrodes, the resulting bubbles of hydrogen and oxygen float up near the cathode and anode, forming a narrow flow due to the Archimedes force, acting tangentially to the cathode or anode, preventing the separation of hydrogen bubbles from the cathode or oxygen bubbles from the anode.

Round-the-clock, continuous production of hydrogen and oxygen for uninterrupted vehicle movement is carried out in the developed photoelectrolyzer-generator, using the same technology described above, i.e. by using in this case sunlight from a light receiver, transmitted via optical fiber as the photoelectrolyzer-generator's lighting, and as the useful electrical load of the photoelectrolyzer-generator, a light-emitting diode (3) with a battery, charged in the process of illuminating the photoelectrolyzer-generator with sunlight during the day, which begins to illuminate the photoelectrolyzer-generator in the absence of sunlight at night until the battery is completely discharged in the morning, and continuously filling the photoelectrolyzer-generator with water (Figure 7).

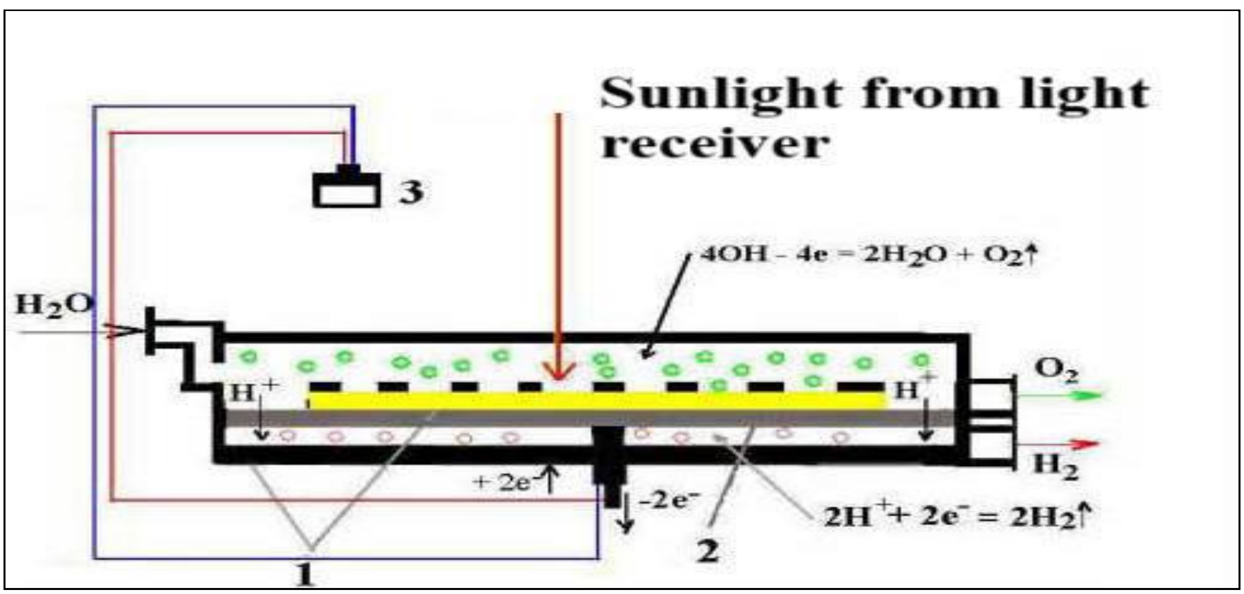

Figure 7. Round-the-clock, continuous production of hydrogen and oxygen for the underground life support system

3.3 Useful electrical load: Useful electrical load of the photoelectrolyzer-generator, a light-emitting diode with a battery, charged in the process of illuminating the photoelectrolyzer-generator with sunlight during the day

In our case, as a useful electrical load of the photoelectrolyzer-generator is used a light-emitting diode with a battery charged in the process of illuminating the photoelectrolyzer-generator with sunlight during the day, which begins to illuminate the photoelectrolyzer-generator in the absence of sunlight at night until the battery is completely discharged in the morning.
In this case the principle schema of LED control board will look as shown on Figure 8.

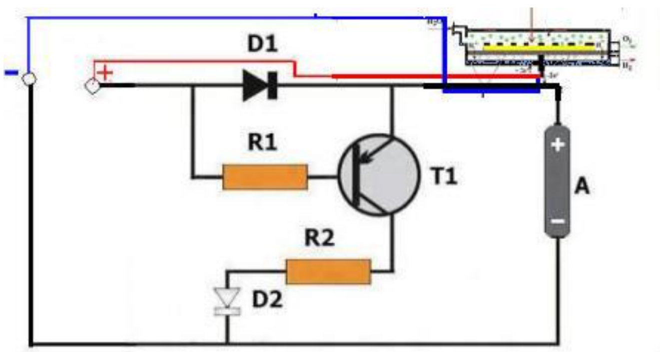

Figure 8. The principle schema of the LED light control board

The current, generated by photoelectrolyzer-generator, through diode D1 charges the battery (A). The positive potential, applied to the base through resistor R1 “holds” transistor T1 in the off state and LED D2 does not light up. With a significant decrease of illumination of the photoelectrolyzer-generator anode, the transistor opens (due to a decrease in the positive potential, applied to the base) and connects LED D2 to the battery.

The LED starts to light up, illuminating the photoelectrolyzer-generator anode. Diode D1 prevents the battery from discharging during the light illumination.

When the light illumination is turned on, the positive voltage coming from the "+" output of the the photoelectrolyzer-generator anode to the base "closes" transistor T1 and LED D2 stops glowing, and the battery starts charging.

3.4 Continuous charging of the fuel cell of the vehicle electric engine: Continuous charging of the fuel cell of the vehicle electric engine for the round-the clock uninterrupted vehicle movement is carried out as follows.

The obtained gases separately enter hydrogen into the porous hydrogen electrode (anode), oxygen into the porous oxygen electrode (cathode) of the fuel cell (Figure 9).

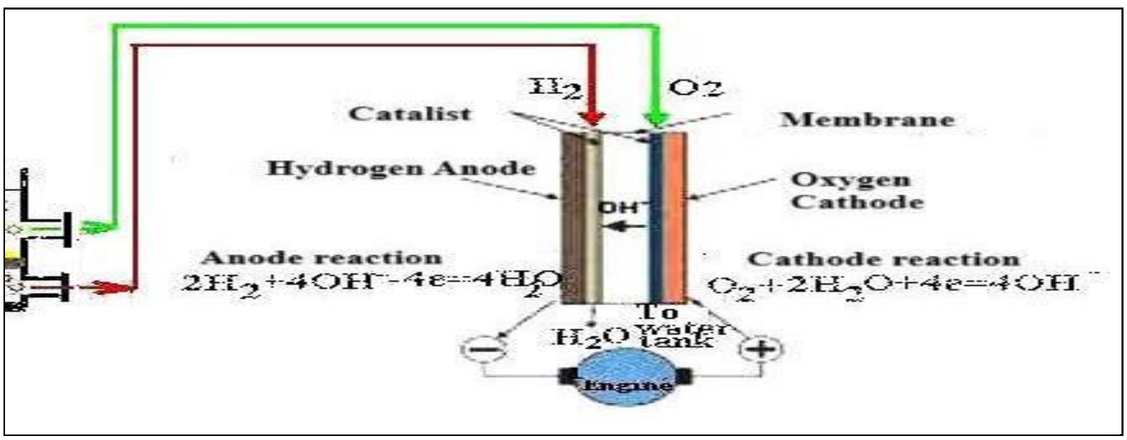

Figure 9. The obtained gases separately enter hydrogen into the porous hydrogen electrode (anode), oxygen into the porous oxygen electrode (cathode) of the fuel cell

The anode and cathode are separated by a membrane. Each of the electrodes is covered with a catalyst layer. As a result, four hydrogen molecules in the hydrogen electrode lose four electrons, creating a negative potential at one of the engine contacts, and reacting with four OH^- anions received from the oxygen electrode due to the reaction of an oxygen molecule with two water molecules, releasing four positively charged particles, creating a positive potential on the other contact of the vehicle electric engine, form four water molecules (water vapor):

$$O_2 + 2H_2O + 4e \rightarrow 4OH- \rightarrow 2H_2 + 4OH^- - 4e \rightarrow 4H_2O \qquad (9)$$

As a result, the vehicle electric engine is started and the generated water vapor is recycled back to the ordinary water tank, closing the cycle.

4. Results and Discussions

The main result of the theoretical and experimental study of the possibility of round-the-clock charging of the fuel cell of the electric vehicle engine for its uninterrupted movement was the round-the-clock and continuous production of pure hydrogen and oxygen in the developed photoelectrolyzer-generator.

Thus, in the developed photoelectrolyzer-generator, which uses sunlight from a light receiver transmitted via optical fiber as a backlight, and a light-emitting diode with a battery charged in the process of backlighting the photoelectrolyzer-generator with sunlight during the day, backlighting the photoelectrolyzer-generator in the absence of sunlight at night until the battery is completely discharged in the morning, round-the-clock and continuous production of pure oxygen and hydrogen is carried out, thanks to the photoelectrolysis of ordinary water continuously supplied from the tank.

The resulting oxygen and hydrogen round-the-clock and continuously charge the fuel cell of the electric vehicle engine for its uninterrupted movement. This process is accompanied by the return of water vapor released during charging of the fuel cell of the electric vehicle engine to a tank with ordinary water, which supplies the photoelectrolyzer-generator with water. Figure 10 shows an electric vehicle with a natural lighting system using sunlight passing through optical fiber installed on its roof.

Figure10. An electric vehicle with a natural lighting system that uses sunlight, passing through optical fiber, installed on its roof

5. Conclusions

Thus, the developed round-the-clock, continuous production of hydrogen and oxygen in a specially designed photoelectrolyzer-generator, achieved by using sunlight from a light receiver transmitted via optical fiber into the passenger compartment of an electric vehicle as lighting for the photoelectrolyzer-generator, and a light-emitting diode with a battery, charged during the day by illuminating the photoelectrolyzer-generator with sunlight, which begins to illuminate the photoelectrolyzer-generator in the absence of sunlight at night until the battery is completely discharged in the morning, and continuously filling the photoelectrolyzer-generator with water, made it possible to continuously charge the fuel cell of the electric vehicle engine around the clock for uninterrupted movement of the electric vehicle both day and night.

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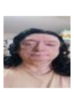
Biographical notes



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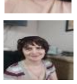

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