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Moonplane—A Spacecraft for Regular Delivery of Astronauts onto the Moon

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Abstract

A project of spacecraft "moonplane" for regular delivery of astronauts onto the Moon is considered. At the first stage of flight by using a carrier rocket, equipped with a chemical rocket engine, the astronauts are delivered on the international space station ISS. For flights from Earth orbit into Moon orbit, the design of a moonplane "MOND", consisting of an interorbital module and a lunar module, has been developed. The interorbital module is an electric rocket, equipped with four superconductive magnetoplasma engine MARS. To power supply of the electromotors, a solar battery of gallium arsenide is used. The design of the lunar module with cabin astronauts, which is equipped with a chemical rocket engine for landing and take-off from the surface of the Moon, is developed. A method and a device for refuelling of the electrical rocket engines with nitrogen and for refuelling of the chemical rocket engines with oxygen and hydrogen, which are stored in cryogenic tanks of the moonplane in the liquid state is developed. The developed spacecraft is capable to regularly transport four astronauts off a moorage of ISS onto the surface of the Moon and back during 6 days. The total cost delivery of one astronaut is 4 million US dollars.

Keywords

Moonplane, Superconducting Magnetoplasma Electrorocket Engine MARS, Interorbital Module, Lunar Module, Solar Battery of Gallium Arsenide

1. Introduction

50 years have passed since the day (July 20, 1969) when the human being stepped onto the lunar surface. This was due to creation of the rocket "Saturn-5" and the spaceship "Apollo" and has become the most outstanding event in the life of mankind in the 20 century.

For many witnesses of this event, it seemed that soon the regular flights to the Moon and the implementation of the flight to Mars will begin. But this did not happen. After the successful flight of "Apollo-17" in December 1972, the NASA lunar program was closed. The interest in flights onto the Moon arose again already in the 21 century, when NASA has developed a new space program "Constellation" [1], which had provided for landing and going out on the Moon surface of three astronauts in year 2018.

For this purpose, carrier rockets "Ares-1", "Ares-5" and spaceship "Orion" have been developed. The carrier rocket "Ares-5", equipped with chemical rocket engines, was supposed to deliver into Moon orbit the capsule "Orion".

The landing of astronauts on the Moon was supposed to implement using the unit LSAM (Lunar Surface Access Modul) equipped with a chemical rocket engine. After visiting the Moon, the unit LSAM docked with the capsule "Orion". The capsule "Orion" using parachutes splashed down in the Pacific Ocean.

Program "Constellation" in 2014 year was replaced by a new NASA program [2]. In this new programme, instead of carrier rockets Ares, the carrier rocket SLS (Space Launch System), which is capable to put into orbit around the Earth mass of 130 tons with a starting weight 2900 tons, is developed. For landing and take-off from the surface of the Moon, the module "Morpheus" is developed. The module "Morpheus" is equipped with a chemical rocket engine, which uses methane as fuel and oxygen as oxidizer. "Morpheus" provides the amount of payload—500 kg. During the flight, the crew of the expedition, consisting of 5 astronauts is located in the command module "Orion".

Detailed description of rocket SLS is given in [3], where in particular it stated that the initial cost of SLS rocket is 500 million dollars. And this in our opinion is the biggest drawback of the new programme of NASA—the cost of the carrier rocket is too high.

It should be recalled that the cost of regular delivery of three astronauts from surface of the Earth onto the international space station ISS, (which performs the orbital flight), is 45 million dollars [4]. Today, this is done using the Russian carrier rocket "Soyuz".

Another drawback of the new lunar NASA project is non-rational usage of working substance in rocket engines when moving of the spacecraft SLS from the Earth orbit onto the Moon orbit and from the Moon orbit onto the Earth orbit.

In the recent interview with the legendary participant of the first expedition onto the Moon, Buzz Aldrin is provided the detailed diagram of orbital flight of the spacecraft "Apollo-11" [5].

The flight trajectory to the Moon consisted of three sections, on each of which the gravitational field has substantially different magnitude.

On the first section of the trajectory: the surface of the Earth—Earth's orbit, where the gravity of the Earth acts, the usage of chemical rocket engines is unequivocally. On the second section of the trajectory: Earth's orbit—Moon' orbit, the flight of the carrier rocket occurs in weightlessness. It is known that the application of chemical rocket engines for orbital flights is irrationally. The specific impulse chemical rocket engine is 400 sec, while electric rocket engine has specific impulse of 8000 sec. Therefore, one should expect an increase of the carrier rocket mass due to the large expense of a working substance on the second section of the trajectory. On the third section of the trajectory when the spacecraft (takeoff-landing capsule) is under the influence of lunar gravity, chemical rocket engine should be used.

Calculations performed in this project have showed that in order to get rid of these drawbacks and to solve the problem of regular delivery of astronauts on the lunar surface with minimal expenses it is advisable to divide the process into two stages.

In the first stage, the astronauts using carrier rocket equipped with a chemical rocket engine are delivered on the international space station ISS.

For implementation of the second phase it is necessary to develop special spacecraft—moonplane, with which help to carry out flights from the Earth orbit into orbit of the Moon.

On the moonplane, it is necessary to install: electric rocket engines and landing capsule for carrying out a flight from the ISS moorage (on Earth orbit) into Moon orbit, landing on the lunar surface, take-off from the surface of the Moon and the return flight with arrival to a moorage of the ISS. This eliminates the need for manufacturing of expensive carrier rocket.

The development of the moonplane is the purpose of this work.

2. The Concept of Delivering of Astronauts to the Moon Using a Moonplane

To deliver astronauts to the Moon, in the project a moonplane "MOND" has been developed. General view of the moonplane "MOND" is shown in **Figure 1**.

The moonplane "MOND" is an electric rocket, consisting of an interorbital module 1 and a lunar module 4. The interorbital module 1 is equipped with electric rocket engines 5 and 6. Source of electric energy for the work of the rocket engines 5 and 6 is the solar battery 2.

Working substance for electrorocket engines (liquid nitrogen) is stored in a cryogenic tank, which is located along the longitudinal axis of the rocket. In the

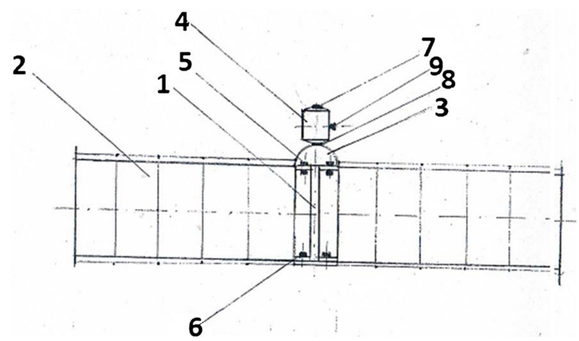

Figure 1. General view of the moonplane "MOND".

interorbital module there is a cabin 3, in which astronauts are located. Lunar module 4 is connected with the interorbital module 1 using the docking unit 8. For connection to moorage of the station ISS the lunar module has docking unit 7.

Using electric rocket engines 5 and 6 the moonplane "MOND" carries out flight from Earth orbit onto the orbit of the Moon.

Being on Moon orbit, the lunar module 4 is separated from the orbital module 1. Using chemical rocket engine 9 the lunar module 4 carries out landing on the lunar surface. After implementation of the program stay on the Moon, the lunar module 4 takes off from the lunar surface and goes into orbit around the Moon. Being on Moon orbit, the lunar module 4 docks the interorbital module 1. Using electric rocket engines 5 and 6 the moonplane "MOND" flies from the Moon orbit onto the Earth orbit.

After entering onto Earth orbit the moonplane is connecting to a moorage of ISS.

The moonplane "MOND" is delivered to Earth orbit using reusable carrier rocket Falcon-X. A detailed description of the moonplane design is given below.

Let's trace sequentially the process of passengers delivering to the Moon. It is obvious that the first passengers of the moonplane will be astronauts which are working at the station ISS. The moonplane shall be controlled by a pilot-specialist in the field of space technology. He will be the first who will test the moonplane on the orbit of the Earth, being in the cabin 3 of the interorbital module 1. The second pilot takes the working place inside the lunar module 4. Being inside moonplane the pilots carry out testing of control system and safety system of the moonplane.

The loading of the first passengers begins, which through the docking unit 7 are passing from ISS in the module 4 and through it inside the cabins 3 and are taking their places.

The flight of the moonplane from the Earth orbit into the orbit of the Moon begins. Using the docking unit 7 the moonplane detaches from the moorage of ISS. The first pilot, who controls movement of the moonplane switches on the engines 6 of backward movement and the moonplane departs from the ISS. The moonplane begins movement along the calculated trajectory. The trajectory is calculated using astrodynamical program based on the task solution of the body motion in the gravitational field of the solar system in the zone of the Earth's orbit and its satellite Moon [6].

The flight to the Moon consists of several stages. In the first stage of flight, the pilot switches on cruise electric rocket engines of forward movement 5. The moonplane continues to move along the Earth orbit, but his movement speed is increasing. Via 22 hours after the start of the engines, the relative velocity of the moonplane increases by the amount of 3 km/s. Absolute speed of the moonplane becomes equal to second space speed. The moonplane is leaving Earth orbit and sets course to the Moon, moving along the calculated trajectory that has the shape of an ellipse.

In the second stage of flight, moving along the calculated trajectory using the rocket engines of forward movement 5, the moonplane during 36 hours increases the relative speed of movement to the Moon up to 3 km/s and flies by the path of length 210,000 km.

Then the engines 5 are switched off and the moonplane during 12 hours in the mode of inertial flight flies by the next section (130,000 km long) on the way to the Moon.

To pass the last section of the path, the moonplane using the engine 6 of backward movement, makes a manoeuvre with 180˚ turn. After the turn, pilot switches on the engines 5 of forward movement and the moonplane enters in brake mode of flight.

Movement speed of the moonplane decreases during 24 hours from 3 km/s up to 2.2 km/s. And doing so, the moonplane flies by 220,000 km and reaches the Moon orbit.

Moving along the orbit around the Moon, the moonplane becomes Moon satellite. It moves at altitude of 70 km from the Moon's surface at the speed of 1.9 km/s, while making one revolution around the Moon in 96 minutes.

The phase of landing of astronauts on the surface of the Moon begins.

Four astronauts clothe the soft spacesuits, leave the cabin 3 of interorbital module and via the docking, unit 8 are passing inside cabin of landing module 4.

There they are met by the second pilot, which takes his place at the control panel of the landing module. The astronauts are taking places in the cabin of the landing module.

The first pilot, being at the control panel in the cabin of the interorbital module 3, gives command on landing.

Using the docking unit 8, the undocking of moonplane modules takes place. The first pilot switches on the electric rocket engines 6 of backward movement and the interorbital module 1 departs from the landing module 4.

Now both modules are continuing to move orbiting the Moon at a distance of 1 km from each other. The second pilot switches on the chemical rocket engine 9 of the landing module. The speed of the landing module (in braking mode) decreases to 1.6 km/s.

Under the influence of gravity the landing module is approaching the surface of the moon. At altitude of 18 km the speed of the module becomes equal to 0.7 km/s.

The second pilot switches on the telescopic device for release of landing undercarriage.

Landing on the Moon surface is carried out in automatic mode with the help of computer program. It should be reminded that such a program has been developed by NASA as far back as 50 years ago for landing of the first astronauts on the Moon.

The landing of the module onto the surface of the moon can be performed in those places where the lunar bases are located. A detailed description of a lunar base is given in [7].

The Moon base [7] has the specially equipped sites for landing and take-off lunar modules.

If such a base still not exists, it is desirable to carry out "lunar landing" in some known place, for instance, in the "Sea of tranquillity", where 50 years ago there was lunar landing of lunar module "Apollo".

After the soft landing of the lunar module of the moonplane "MOND", the astronauts go out to the Moon's surface, where they are already awaited by new passengers—astronauts who have finished their work on the Moon and are ready for flight from the surface of the Moon to the international space station ISS. The arrived astronauts are loaded in a lunar rover and are driving to the lunar base. After loading of new passengers inside the landing module, the second pilot switches on chemical rocket engine 9 (**Figure 1**).

The landing module (**Figure 1**) comes off from the Moon's surface and moves along the calculated trajectory to the orbit around the Moon. Trough 75 sec the landing module is already moving around the Moon at speed of 2 km/s and becomes a Moon satellite.

The first pilot, being in the cabin 3 of the interorbital module, using electric rocket engines 5 and 6 performs manoeuvring of the interorbital module 1 in orbit around the Moon. The interorbital module 1 is approaching to the landing module 4 and is docking with it. After docking of the modules, the astronauts and the second pilot are passing into cabin 3 of the interorbital module. The final stage begins: flight from the Moon orbit onto the Earth orbit. The first pilot switches on electric rocket engines of the forward movement 5, and the moonplane increases the speed. Moving along orbit around the Moon the moonplane through 2.5 hours reaches speeds of 2.3 km/s. During 24 hours in the process of flight the moonplane is accelerated to a speed of 30 km/s and then electric rocket engines 5 are switched off. During 12 hours the moonplane is in inertia flight. The first pilot switches on the electric rocket engines of backward movement 6, with which help, the braking mode is carried out. While being in braking mode the moonplane reduces the relative velocity to zero within 36 hours. The moonplane goes into orbit of the Earth, which is at a distance of 380 km from the Earth's surface. The first pilot switches on electric rocket engines 5 of forward movement and the moonplane is approaching to the international space station ISS.

After approaching to ISS, the moonplane is docking to it using the docking unit 7. Astronauts, which have arrived from the Moon, are passing into the station while the pilots remain in the moonplane.

Let us now trace, how the refilling of the moonplane with working substance for implementation of the next flight onto the Moon is carried out.

The diagram of the moonplane refuelling with working substance is shown in **Figure 2**, where the refueller 8 is a tank-container with three components: nitrogen, oxygen and hydrogen, which are in the liquid state.

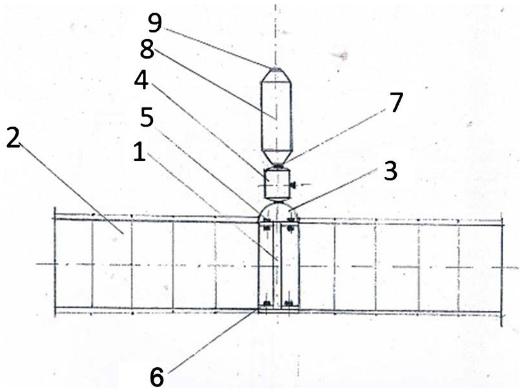

Figure 2. Schema of the moonplane refuelling with working substance using space refueller.

The refueller design description is given below.

Using the docking unit 9, the refueller is connected with a ISS moorage, where he was delivered from the surface of the Earth by means of the carrier rocket Falcon-9.

The refuelling operation is performed by the first and second pilot of the moonplane.

The first pilot being in the cabin 3 of the moonplane performs mooring of the moonplane to the refueller. Using the docking unit 7 the moonplane is connecting with the refueller 8.

The second pilot, being in the landing module 4, proceeds to moonplane refuelling.

Through the docking unit 7 he penetrates in the end chamber of the refueller 8. On the control panel of the end chamber, he connects the flexible cryogenic hoses, which pass from the tanks with working substances in interorbital module 1 and in the landing module 4 Long hose with liquid nitrogen passes through the cabin 3 and module 4.

Short cryogenic hoses with liquid oxygen and liquid hydrogen pass through the docking unit 7 of the landing module 4. After filling of tanks in interorbital and landing module with working substance, the second pilot detaches the hoses and remains at his workplace in the cabin of landing module 4.

After undocking from the refueller 8, the first pilot switches on the electric rocket engine 6 of backward movement and the moonplane departs from the refueller.

The first pilot sends the moonplane to a free moorage of the ISS. After moorage, the refilled moonplane is ready to sending of new batch of astronauts to the Moon. Sending astronauts on the lunar surface and their return to the ISS takes 6 days.

Design calculations have showed that the volume of working substance in the refueller 8 (**Figure 2**) provides the possibility to implement four flights of the moonplane on the surface of the Moon.

It is clear that the cost of delivery of astronauts to the Moon is the key question.

The study, conducted in this work, has showed that today, real possibilities to deliver astronauts to the surface of the Moon have two space firms.

First, using single-mission system SLS (Space Launch System), being developed by NASA. The takeoff–landing capsule, in which 5 astronauts are located, can be delivered, to the Moon. Starting cost of the project—500 million dollars [3]. The cost of one astronaut delivering will amount 100 million dollars.

Secondly, a private firm "Space X" (United States) has developed a project of the flight to the Moon, based on space system "Falcon Heavy".

The system "Falcon Heavy" is based on usage of the reusable rocket "Falcon 9" and delivering to the Moon capsule "Dracon V2", in which seven astronauts are located. Starting cost of the project—85 million dollars [3]. The cost of one astronaut delivering through the system "Falcon Heavy" will amount 12 million dollars.

In this project the cost of astronauts delivery to the Moon would consist of two parts. The first part is the cost of astronauts delivery on the ISS, and the second part is the cost of flight from ISS on the surface of the Moon and back to the ISS. Astronauts delivery on the ISS is planned to carry out using the reusable carrier rocket "Falcon 9" with the capsule "Dracon V2", in which 7 astronauts are located.

The cost of launching of carrier rocket "Falcon 9" is 21 million dollars [8]. The cost of delivery of one astronaut on the ISS will be 3 million dollars. Conducted calculations show that the cost of transporting one astronaut from the ISS to the Moon and back is 1 million dollars. The full cost of delivery of one astronaut on the Moon, using the moonplane will be 4 million dollars.

Thus application of new space device—moonplane will allow to decrease in 3 times delivery cost of astronauts to the Moon. It should be expected that the application of moonplane will accelerate the Moon exploration by man.

It should be also noted, that the moonplane "MOND" in addition to solving its main task—regular flights to the Moon—can be used to perform other important tasks required for scientific researches made on the ISS. The moonplane will make it possible to make a flyby of ISS and to move off from the station at a considerable distance with three astronauts on board. A possibility of spaceflight in the space, where the magnetosphere of the Earth is located, for the purpose of its detailed study emerges.

By using the moonplane, you can access to the geostationary orbit and observe the current state of communications satellites.

In connection with the advent of space tourism the moonplane can be used to serve the first space tourists who have chosen to stay in a space suite hotel in Earth orbit [9]. The first space suite hotel "Aurora" [9], which will be launched by NASA at a height of 320 km from the surface of the Earth, starts operating in the year 2022. Hotel "Aurora" has several docking units, to which the moonplane "MOND" may moor. It is anticipated that in Aurora hotel will stay 4 tourists and 2 stewards.

While using the moonplane "MOND", tourists-the astronauts will be able to visit the ISS, and even surface of the Moon. Very useful can be usage of the moonplane as a space power station. It should not be forgotten, that at the moonplane the photovoltaic generator of 440 kW capacity is installed.

Structure of the moonplane "Mond"

General view of the moonplane is shown in Figure 1, where: 1—interorbital module; 4—landing module; 2—solar battery; 3—cabin of the interorbital module; 5—electrorocket engines of forward movement; 6—electrorocket engines of backward movement; 7—front docking unit of landing module; 8—back docking unit of landing module; 9—chemical rocket engine of landing module.

Design of the moonplane casing is shown in Figure 3.

The interorbital module has a cylindrical casing made of aluminium alloy, to which the end disks 2 and 10 are attached. In end disk 2 two electrorocket engines 3 of forward movement are installed, and in end disk 10 two electrorocket engines 9 of backward movement are installed. Installation of the electrorocket engines in the cross-section of the disks is shown in Figure 4(a), Figure 4(b).

At Figure 4, one can see that the engines 3 of forward movement are located at an angle of 90˚ to the engines 9 of backward movement. Using electrorocket engines 2 and 9 the pitch and the yaw of the moonplane is correspondingly carried out.

At the moonplane the electrical rocket engines type MARS, the design of which was developed by author in 2006-2013 are installed.

Engines MARS belong to the class of superconducting magnetoplasma electromotors. The detailed description of the motor design is given in [10] and [11] and its basic parameters are shown in Table 1.

As working substance for reactive traction creation of the electrorocket engines MARS, nitrogen is used that is kept in a liquid state in cryogenic tank 4 (Figure 3).

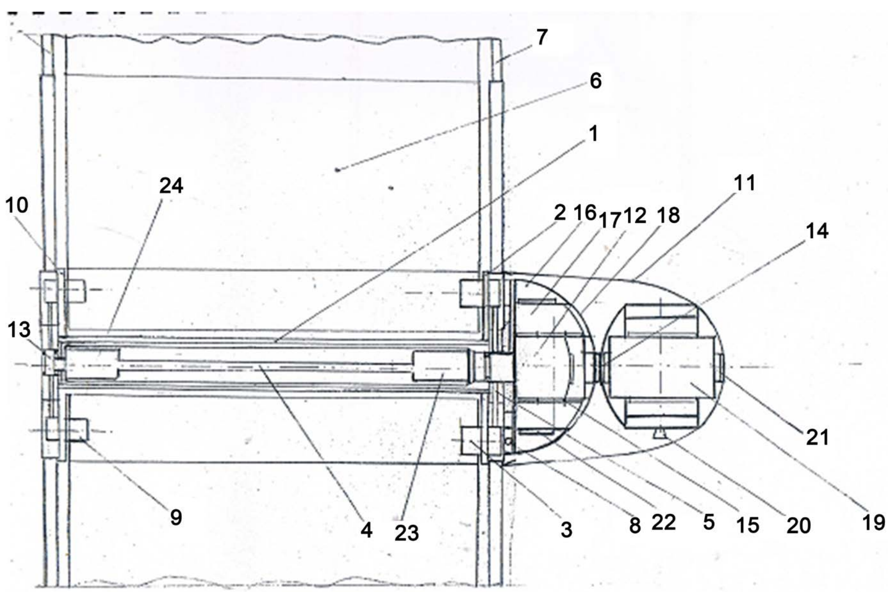

Figure 3. Design of the moonplane casing

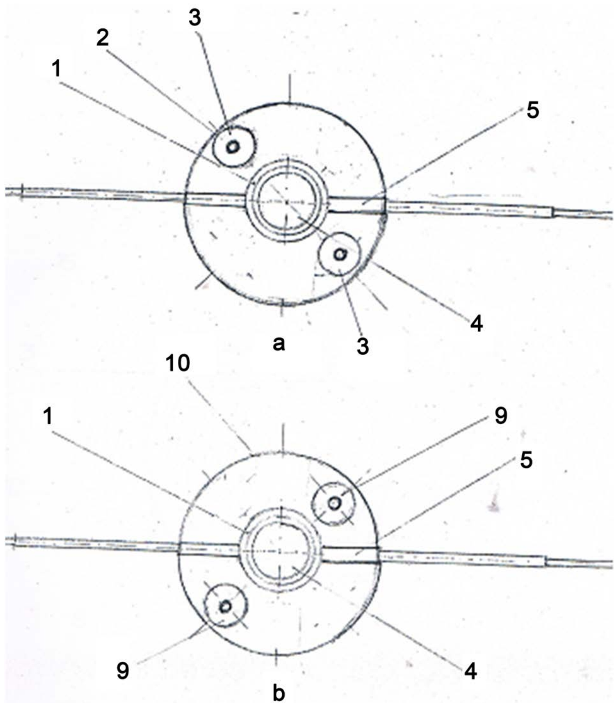

Figure 4. Location of electrorocket engines of forward and backward movement.

Table 1. Main characteristics of electrorocket engine MARS.

Tractive force	27 N
Power	270 kW
Current	270 A
Voltage	1000 V
Efficiency	94%
Specific impulse	6000 s
Working substance consumption	0.3 G/s
Discharge velocity of working substance	10 km/s
Magnetic induction	1.5 T
Anode diameter	170 mm
Cathode diameter	40 mm
Anode length	60 mm
Cathode length	50 мм
Diameter of external cylinder	600 mm
Length of external cylinder	400 mm

The cryogenic tank 4 is located on the longitudinal axis of the interorbital module. It consists of the semi tank 23, from which nitrogen is supplied in engines 3 of the forward movement and of the semi tank 24, from which using the distributor 13 the, nitrogen is supplied in the engines 9 of the backward movement. The cryogenic tank 4 is made of carbon and has a screen-vacuum insulation. Solar battery that provides work of the electrorocket engines has folding design. It is collected from panels 6 (Figure 3), manufactured from carbon-filled plastic.

From the outside in the panel a layer of photovoltaic conversion, that is made from gallium arsenide, is embedded. The solar battery panels 6 are unfolded using concentric rods 7. Movement of the concentric rods 7 is carried out by means of pneumatic impact when applying gaseous nitrogen under pressure.

Installed capacity of the solar battery—440 kW.

The cabin for astronauts in the interorbital module 12 has the shape of a hemisphere with external sheath 18 (Figure 3). It is provided accommodation of four astronauts and two pilots, governing flight of the moonplane from the control panel.

On the external side of the cabin the cryogenic tank 16 is located, which has cylindrical shape and is filled with liquid nitrogen.

The layer of liquid nitrogen serves as protection of astronauts from hard cosmic radiation. To protect the astronauts from a stream of charged particles on the inner surface of the tank 16 the solenoid 22 made of superconductor magnesium-boron is installed. The superconducting solenoid 22 creates around cabin a constant magnetic field, which deflects charged particles of the solar wind.

From the outside of the cabin 12 there is a cylindrical space 17, in which the devices of a system of orientation, coordination, communication and control of the moonplane are located.

The system of orientation performs the tracking of the moonplane movement regarding the Sun position. Using the on-board computer, the rotation angle of the moonplane with respect to the axis is continuously determined, which provides maximum of solar power. This signal controls electrorocket engine 8, which performs rotation of the moonplane.

The control system of the moonplane enables its piloting in both manual control and autopilot mode.

In the nasal part of the cabin 12 there is a gateway 15, which allows astronauts to go out into space via the docking unit 14.

Structure of the lunar module

Longitudinal section of the lunar module shown in Figure 5, while the cross-section on Figure 6.

The main feature of the lunar module design is that chemical rocket engine is located not on the longitudinal axis, but on the transverse axis. This allows performing refuelling of the moonplane with working substance in Earth orbit through the inner space of the lunar module using the flexible cryogenic pipelines which are located along the longitudinal axis, as shown in Figure 2.

In lunar module the hydrogen-oxygen rocket engine is installed, which traction force is equal to 7 KN.

As the fuel in this chemical rocket engine the hydrogen is used, which is stored in liquid state in cryogenic tank 6.

As oxidizer for this chemical rocket engine, oxygen is used, which is kept in

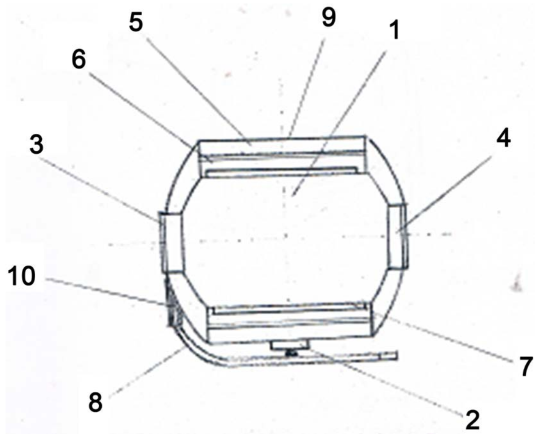

Figure 5. Lunar module (longitudinal section).

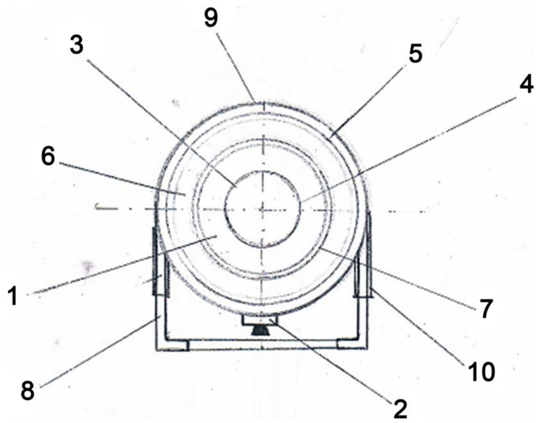

Figure 6. Lunar module (cross section).

outside in annular cryogenic tank 5.

Cryogenic tanks 5 and 6 are made of carbon and have screen-vacuum insulation.

Lunar module has an outer cylindrical shell 9, made of aluminium alloy.

In internal cylindrical space of the lunar module the cabin 1 is located, in which there are chairs for astronauts and the devices of control and communications.

The cabin is separated from the tank 6 by a vacuum insulation sheath 7.

At end faces of the lunar module the docking units 3 and 4 are located.

The docking unit 3 connects the interorbital and lunar modules. The docking unit 4 is intended for connection of the moonplane with the international space station ISS.

Telescopic device 10, installed on landing stanchion 8, allows while using a pneumatic actuator to pull out the stanchion at 2 m.

The lunar module parameters are shown in Table 2.

The moonplane parameters are shown in Table 3.

Moonplane refueller

Moonplane refueller design is shown in Figure 7.

Constructively the refueller is performed as a system of concentric cryogenic

Table 2. Lunar module parameters.

Lunar module dimensions:	
Outer diameter	3.8 m
Heigh	5.2 m
Length	4.3 m
Cabin diameter	2.0 m
Lunar module weight	3.6 t

Table 3. Moonplane parameters.

Outer diameter	6.0 m
Length	16.0 m
Cabin diameter	3.8 m
Solar battery width	12 m
Solar battery wing length	30 m
Moonplane weight	10 t

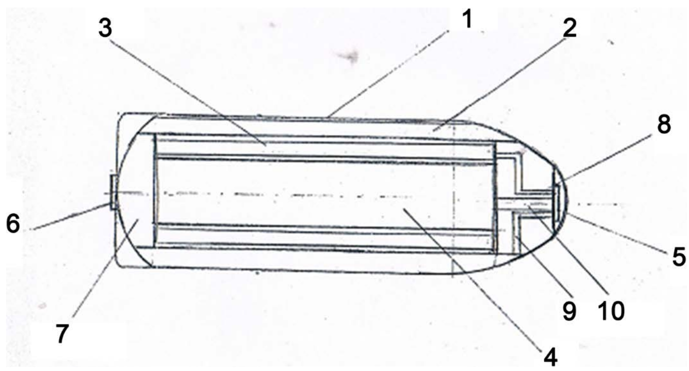

Figure 7. Moonplane refueller with working substance.

tanks with working substances for electrorocket and chemical rocket engine of the moonplane. The refueller has an outer cylindrical sheath 1, made of aluminium alloy. Inside of the sheath 1 the cryogenic tank 2 with liquid oxygen is located. In an internal cavity of the tank 2, cryogenic tank 3 with liquid nitrogen is installed.

Cylindrical tank 4, located along the axis of the refueller, is filled with liquid hydrogen. All tanks are made of carbon and have screen-vacuum insulation

In nasal part of the refueller there is the docking unit 5 through which it connects with the lunar module, as shown in Figure 2. In the rear of the refueller there is docking unit 6 through which it connects with the international space station ISS.

In cylindrical compartment 7 of the tail part of the refueller, the devices of control and communication systems are located. In the nasal part the cryogenic pipelines (nitrogen—8, oxygen—9 and hydrogen—10) are located, with which help the refuelling of lunar and interorbital modules is performed. The refueller

(**Figure 7**) has the outer diameter—4 m, the length—12 m and weight—9.5 tons.

3. Conclusions

For the first time, the task of creation of "Moonplane"—a spacecraft for regular delivery of astronauts onto the Moon using electric rocket is solved.

The method of a two-stage delivery of astronauts on the surface of the Moon using the ISS as a space base is developed.

The complex scientific investigation and development of the moonplane—space apparatus for flights of astronauts from Earth orbit into the orbit of the Moon and back, using electric rocket has been performed.

The design of electric rocket, consisting of an interorbital and a lunar module is developed. For flights from Earth orbit into the orbit of the Moon electric rocket engines are used, which enable by several times to reduce the consumption of working substances as compared with chemical rocket engines.

The developed design of the moonplane will allow for regular delivery of 4-x astronauts to the Moon during 6 days. The cost of astronaut delivery is reduced by 3 times.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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