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BY A. P. C.

L. GUSSALLI
ASTRONAUTIC VEHICLE
Filed Oct. 3, 1939

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297,773
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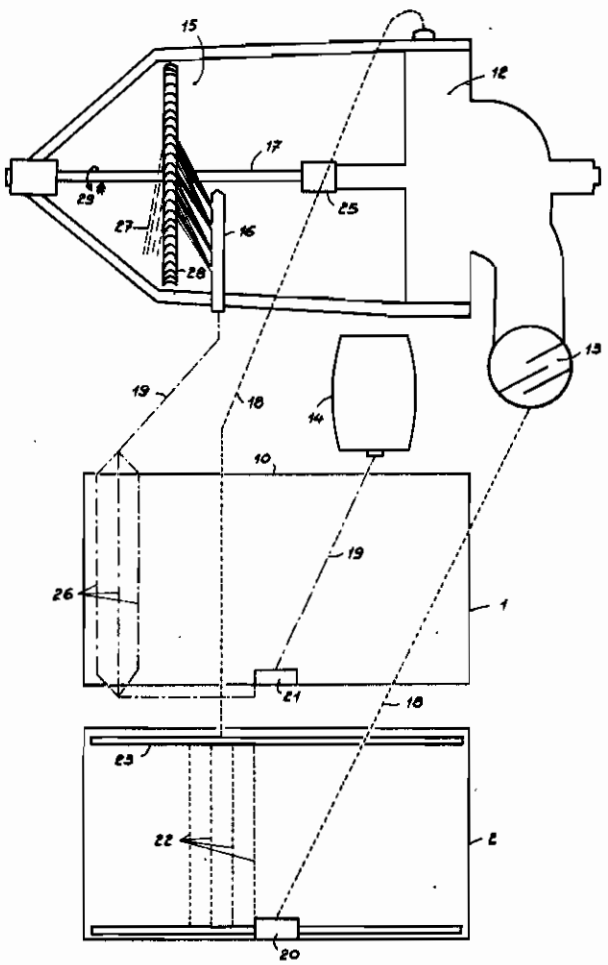

Fig. 1

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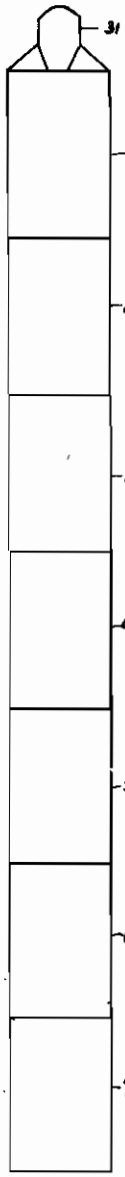

Fig 2

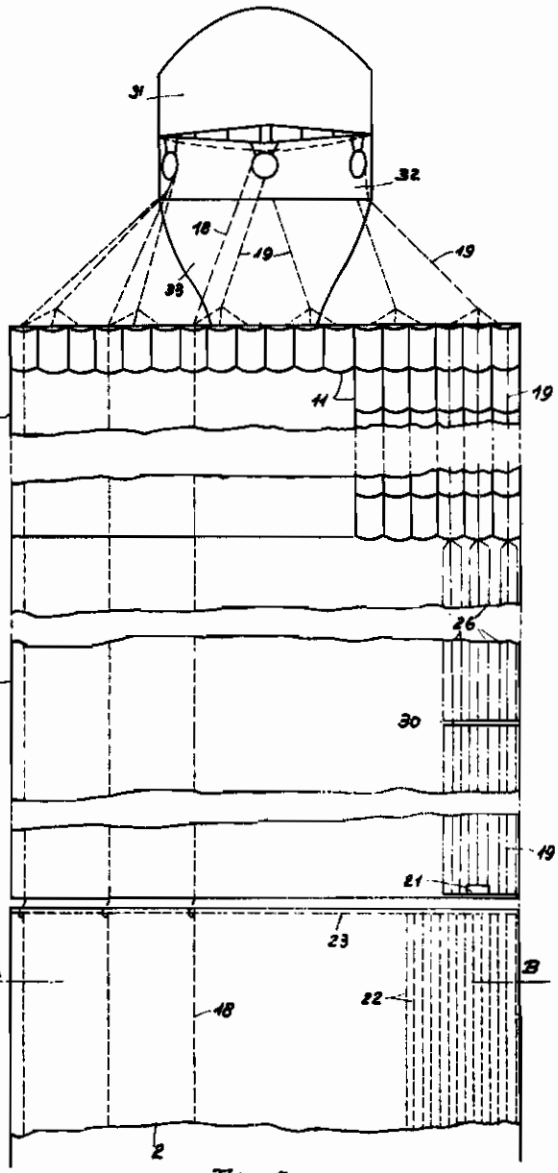

Fig. 3

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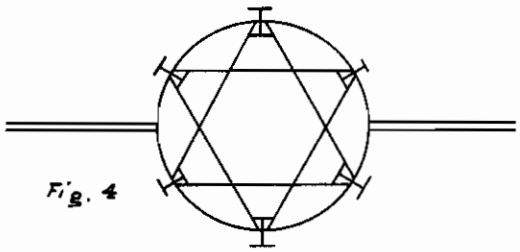

Fig. 4

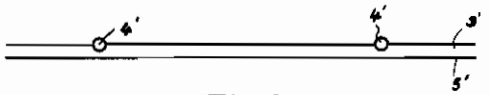

Fig 5

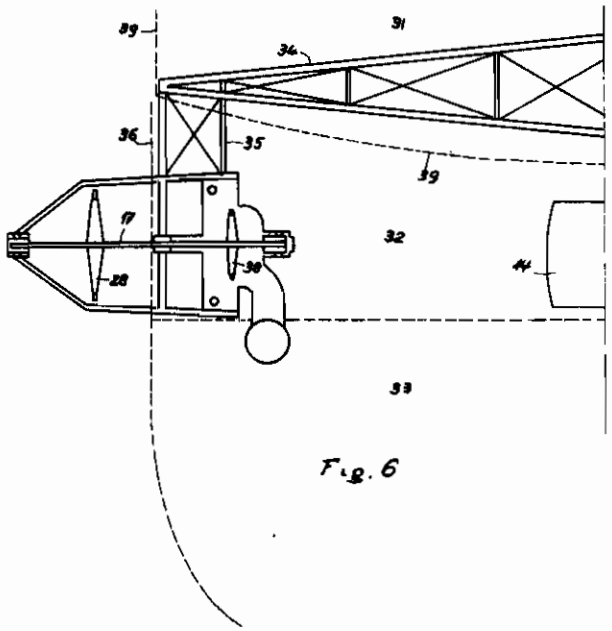

Fig. 6

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ALIEN PROPERTY CUSTODIAN

ASTRONAUTIC VEHICLE

Luigi Gussalli, Brescia, Italy; vested in the Alien Property Custodian

Application filed October 3, 1939

The present invention relates to vehicles capable of going through intersideral space. All the systems which have been studied heretofore for this purpose are based on the assumption that the apparatus possesses, when starting from the earth, a given reserve of fuel, with no possibility of being fed in the space. Said reserve must be calculated in relation to the initial mass which must be employed to bring a final mass equal to one out from the action of the earth field, which gives, abstracting from the resistance afforded by the air, an enormous mass, according to the actual theory of the ratios of masses. According to this theory the apparatus at start ought to be given such a weight, that it could not be realised by known means; upon this fact depends the apparent impossibilty of the solution of astronautic problems.

The system according to this invention meets this difficulty owing to its possibility of being fed with energy in the space.

Said system is based upon the employ of double-reaction propulsion apparatus, of the Gussalli type, wherein the jet issuing from the tube is directed on the vanes of a turbine wheel, which, instead of taking the energy from the gases, abandoning the same at a reduced speed, turns said gases in an opposite direction and rejects the same with an increased speed, communicating energy to the same. This energy, which must be supplied, therefore, in addition to that developed by the gases issuing from the tube, to feed the machine, is taken, according to the invention, from the sun, in order to reduce the mass consumption to a minimum; the system is thus characterised by the combination of at least two of these propulsion apparatus with a system of two generators comprising particularly:

(1) A closed-cycle solar generator, without losses, which feeds the motors to maintain the rotation of the vane wheels, the vapour which feeds the motors being conveyed again to the generator through a condenser.

(2) A second open-cycle solar vapour generator which feeds all the tubes acting on the vane wheels.

Advantage is taken from the property afforded by the double-reaction propulsion apparatus, according to which it is possible to subdivide their total power within a very wide range between the motors for driving the vane wheels and the tubes so as to give the open-cycle generator the most reduced power in relation to the open-cycle generator, so as to reduee as much as possible the consumption of the fluid transformed and, thereupon, the quantity of fluid to be supplied to the vehicle at the start.

The closed-cycle generator consists, according to the invention, of two parallel plates disposed very near to one another, facing one another and having a suitable surface area, one of said plates being of metal, whilst the other is made of an athermanous material such as spun glass, asbestos or the like, of a very little weight. The surface exposed to the sun, or anterior surface of the metal plate is completely black to absorb all solar radiation which it receives and bears a great quantity of very light thin metal tubes soldered thereupon, connected at one end to the supply conduit of the vane wheel motors and at the other end to the conduit from the condenser into which the fluid utilised by the motor discharges; the back side is coated by a very thin layer of an athermanous material and behind the same, with respect to the direction of the sun beams is disposed the plate completely made of athermanous material whereof the surfaces are bright white or silvered; this plate may be placed either in contact with the metal plate, or somewhat removed from the same, the interspace between the two plates assisting in preventing the metal plate exposed to the sun from growing cold. This construction affords a slightly lower efficiency than that of a generator wherein the metal plate is shielded against the action of ventilation, also on the front surface side, by glass or like plates adapted to be traversed by the sun radiations; this drawback, which, however, is not much considerable, the vehicle being intended most for travelling in the vacuum, is largely compensated by the enormous reduction of weight, which only allows to attain the results which will be described further.

For the open cycle generator, wherein a very high pressure is to be given to the vapours in order to reduce the supply thereof for a predetermined power, it is preferable to have resort to an arrangement with parabolic cross-section cylindric mirrors, wherein the centre line of each black surfaced tube of the generator coincides with the focal axis of one of the mirrors, said arrangement permitting to considerably surheat the vapour. The tubes of this generator are connected at one end to the feeding tubes of the nozzles and at the other end to a conduit from a tank placed on the vehicle, adapted to supply to the generator a quantity of fluid corresponding to the vapour discharged by the vane wheels into the atmosphere on the space. According to one of the features of the invention, the tubes may

be protected against cooling due to ventilation by thin glass shields forming with the tubes and between one another two annular chambers, the outer chamber being filled, if desired, with argon, krypton, or other similar gases capable of preventing obscure heat dispersion, and the inner chamber with gases adapted to accumulate the heat, such as air or the like.

The apparatus being for the purpose of operating in the intersideral space, that is to say in exceptional conditions as to vacuum and temperature, the material which appears to be the most suitable to be transformed in the above two cycles is ether; which does not prevent, however, that another convenient fluid, such as sulphurous anhydride be employed, without exceeding thereby the scope of the invention; thus, for instance, by placing on the vehicle apparatus for the gathering air, it is possible to feed with this air during stratospheric flight, the open-cycle generator, which allows to eliminate all consumption. According to another feature of the invention the open-cycle solar generator may be replaced by a combustion chamber into which hydrogen and oxygen are fed from two separate tanks, acting at the moment of their combination, on the vane wheels by means of nozzles.

The invention will be better understood by referring to the attached drawings whereof:

Fig. 1 is a diagram of the combined arrangement, according to the invention, of a double-reaction propulsion apparatus, by the system of the two generators.

Fig. 2 is a diagrammatic side view of an embodiment of the vehicle according to the invention, provided with six double-reaction propulsion apparatus.

Fig. 3 is a partial similar view, enlarged, of the same vehicle.

Fig. 4 is a plan view thereof.

Fig. 5 is a diagrammatic sectional view through the line A—B of Fig. 3.

Fig. 6 is a detail diagrammatic view of a portion of the propulsion chamber.

For a fuller comprehension of the reach of the invention it has been deemed convenient in the following description of the vehicle represented of citing some practical data on the construction of said vehicle.

Fig. 1 represents diagrammatically the vapour circulation in the two above mentioned circuits. In this figure, 1 is the mirror sector, 2 is the plate sector, 12 is the driving motor for the vane wheels, 13 is the condenser, 14 the tank, 15 the double-reaction propeller, 16 the assembly of the nozzles of the propeller, 17 the driving shaft, 20 the feeding pump of the closed-cycle circuit and 21 the feeding pump of the open-cycle circuit. The two circuits are represented in the drawing respectively, by a dotted line (18) and by a dot and dash line (18),

The circulation in the two circuits takes place as follows; the circuit 18 is firstly followed; this is completely closed and no loss of transformed fluid has to take place. This fluid comes from the condenser 13 which also constitutes a small reservoir. This fluid is sucked by the feeding pump 20, by which it is forced through the generator 2; in the generator said fluid is vaporised and surheated, after which it reaches through the conduit 18 the motor 12 and discharges into the condenser after having exerted its action on the wheel of the motor. This circuit must have no losses; the only cap 25 comprised therein glycerine-tight or the like; the tube 18 which connects the generators with the motors gives place to no condensation, on the contrary it surheats because, as it will seen, if is placed on heating surface of the two generators.

Let us follow now the circuit 19, that is to say the circuit of the double-reaction propeller; in this circuit the transformed fluid is sucked from the tank 14 by the feeding pump 21 which distributed the same in the tubes 26 of the open-cycle generator; in these tubes it is vaporised and surheated and reaches through the conduit 19 the nozzles 16 which discharge the same against the vanes of the wheel 28 which turns in the direction indicated by the arrow 29, that is in the direction opposite to the direction of gases, communicating to the same a supplementary power utilised by the propulsion of the vehicle in space and, after that, in the atmosphere.

The most suitable fluid to act in the two circuits is ether; in fact, its boiling temperature is 35° C and its vapour gives at 100° C a 6,5 Kg/cm² pressure, which is a convenient pressure for the type of generator proposed and the laval-type action turbines; as to the condenser, ether gives at −20° C a pressure of 68 mm. of mercury and at −40° C a pressure of 5 mm. of mercury, whereas at −80° C a vacuum degree is attained, which may be considered as almost absolute and which, at any rate, will never be reached in a normal condenser for which a vacuum of 25 mm. of mercury is considered as a maximum.

The very low temperature and the vacuum degree being given, the condensers 13 are very light and of very small dimensions, and in certain cases they can be suppressed and replaced by the same tubes which convey the vapour discharged from the motor 12 back to the feeding pumps of the generators, in view of the length of said tube and their positioning in the cold portion of the generator.

If the feeding and distribution are carried out by improved apparatus the vaporising tubes can be made of one piece from the lower end to the upper end of each sector, which constitutes a great advantage from the viewpoint of the strength and weight of the assembly; in this case diffusing manifolds are used consisting of transversal tubes connecting the vaporising tubes at a given height (N° 30 of Fig. 3). These manifolds balance the temperature and pressure of the vertical tubes of each sector; in the case of difficulties of circulation, other feeding pumps at the issue from the condenser may be used, according to new methods.

It is to be considered that the generator-propeller system must operate equally well both under the action of the gravity force and when said force ceases; the circulation in the two generators is so realised to meet the difficulties arising from the passage from a state to the other. In fact, in the first case when the propeller operates, as the vehicle must go forward with the chamber in front and the generator behind the same, the fluids contained in the tubes will be forced by the acceleration of the vehicle towards the low portion of each section of the generator and all circulation will be normally accomplished according the law of gravity.

In the second case, when the propeller is stopped, the fluids are more subjected to any force which should force them towards the low portion of the section and they might afford some difficulties of circulation; these difficulties are met by the employ, as it has been seen, of a forced circulation generator, by means of feed-

ing pumps and distribution apparatus in a great number of tubes of small diameter, owing to which the fluids are almost stabilised in the generator.

These difficulties of circulations, however, have no great importance as when the propeller is stopped and the vehicle proceeds owing to its inertia, the operation of all the generators is also stopped and it is sufficient to stop the fluid immovably in its position at the moment when the propeller stops; as it will be seen further, at that moment the generator is disposed in the resting position in front of the direction of the solar beams, and before stopping the driving motor of the propellers, the feeding pumps are stopped, so as to empty all the vaporisation tubes, which causes the generator to be nearly empty in the resting position, and the fluid is concentrated in the condenser.

The efficiency of such a system is very high. Upon the above, in the reduced pressure circuit **18**, the surheated ether vapour will be at a temperature from 100° to 120° C. and a pressure from 5 to 6 Kg/cm²; the condenser **13** is in exceptionally favourable vacuum and temperature condition in the intersideral space and, without need of any suction pump, it will be sufficient to open, at the desired moment, the discharge valve of this condenser to bring its inside pressure to the level of the outside pressure corresponding to the nearly absolute vacuum; its temperature will stabilize at about —80° C. In these exceptional conditions, a useful effect on the turbine shaft of 0.52 HP per square meter of generator surface will be obtainable for a determinate period of time, in comparison to the 2,1 HP per square meter theoretically supply by the sun, that is an efficiency of about 24%.

In thus appears the happy condition of this volatisable fluid thermic plant, which operates in an ambient at about —80° C. (instead of 15° C. of the normal plants), and is adapted to realise, by a convenient distribution of the heating and cooling of the fluid, a cycle which is quite similar to that of the ordinary thermic machines which operate at a normal temperature, of 15° C., but at an average temperature of about 100° C., which represents a unique condition for a cycle and has never been realised in other plants.

Figs. 2, 3, 4 and 6 represented, as it has been said, an embodiment of a vehicle according to the invention. As it appears from these figures, the vehicle comprises a chamber **31** under which a long band is suspended, constituting the two generators. This band is composed of an upper part **1** constituting the high pressure open-cycle generator, and six generators **2** to **7** quite similar to each other but completely independent from one another, each of which feeds one of the six driving apparatus provided in the chamber. The generator **1** is composed (Fig. 3) of eighteen parabolic mirrors made of very thin extra-polished aluminium sheet, in its upper part **10**.

Under this portion **10** the generator **1** consists of a black plate system, similar to that of the closed-cycle system as hereinafter. Each element of this portion is composed of nine small tubes **26** leading from the distributor placed in the lower part of the section to the mirror portion **10**, parallelly to the black surface of the section; at the beginning of the mirror portion these nine tubes are connected three by three to tubes of greater diameter disposed along the focal axis of the three successive parabolic mirrors. At the issue from the mirrors the three tubes are united into a single tube which conveys the vapour to the nozzles of the double-reaction propeller. In the same section **1** there are other five elements similar to the one described above each, of which feeds in turn one of the propelling apparatus. It thus appears that each propelling apparatus disposes of a low pressure circuit **18** and a high pressure circuit **19**, which constitute in its assembly a generator-propeller group completely independent from the others, even in the case of injury.

For a medium power vehicle the band of the generators is twelve meters wide and 130 meters long and presents to the sun a surface of 1560 square meters. The generator **1** is 19,5 meters long and presents to the sun a surface of 234 sq. m. and each of the generators **2** to **7** is 18,41 meters long and their assembly present to the sun a surface of 1326 sq. m. The mirrors of the generator **1** are each 8 meters long in the direction of the focal axis and have a 0.666 meters opening, each mirror being, if desired, subdivided into several sections. The generators **2** to **7** are composed each of 60 small tubes whereof the inner diameter is 6,7 mm. connected by a manifold **23** of a greater diameter. Fig. 5 represents a section through the line A—B of Fig. 3, showing the black plate **3'** containing the small tubes **4'** and the athermanous plate **5'**.

The specular athermanous plate **5'** prevents the cooling of the metal plate **3'** at high temperature, analogously to what happens in the refrigeration tanks or better in the thermos bottles wherein the combined effects of inner specular surfaces, which transmit no heat, and vacuum interspaces are utilised. In fact, as the vehicle displaces in the vacuum space the hot metal plate is in the same conditions as a hot liquid in a thermos bottle, that is: vacuum space between plates **3'** and **5'** and subsequently specular surface of plate **5'**.

The weight of each of the six generators **2** to **7** is composed as follows: 1104 m. of vaporisation tubes of 6,7 mm. inner diameter of light metal alloy of 25 grams per m., i. e. 27,6 Kg; 221 sq. m. of thin sheet metal, of 320 grams per sq. m., i. e. 70,7 Kg; 221 sq. m. of cotton fabric, of the type employed in the aerostats, silvered or bright white, of 55 grams per sq. m., i. e. 12,1 Kg. The total weight of one generator is therefore 110,4 Kg. and that of the six generators is 662,4 Kg.

The generator **1**, being provided with parabolic mirrors and thicker vaporisation tubes is heavier, the weight being about 200,4 Kg.

The tubes which supply the ether vapours from the generators to the propelling apparatus are, in total, about 400 m. long and weigh 110 Kg.

The small feeding tubes which supply the liquid ether to the generator have a total weight 5 Kg.

It follows that the total weight of the band of the generators is 977,8 Kg.

In the above example the ratio between the surface of the low pressure generator and that of the high pressure generator is 5,66, but it is obvious that other ratios may be employed. Moreover, the length of 130 m. given for the generator band may be considerably increased. With the dimensions and the arrangement of the medium power vehicle above described, the ether vapour consumption of each propelling apparatus, i. e. of a series of nozzles **16**, is about 60 Kg. per hour, which gives a total consumption for the six apparatus of 360 Kg per hour for a trail-

ing force, which will be seen hereinafter, of about 2520 Kg; it is to be remarked that to obtain the same trailing force with a rocket system it would be necessary to use several tons of fuel per hour.

It is evident, upon the above, that the consumption of the apparatus varies according to the three systems mentioned above for the feeding of the open circuit **19**, i. e.:

(1) feeding with ether or like liquids, whereof the consumption by weight has been indicated above, said consumption being susceptible of being considerably reduced by suitable improvements.

(2) feeding with oxygen and hydrogen, which presents the normal consumption of the rockets of medium power, subtracting that corresponding to the solar energy gathered in the closed circuit.

(3) feeding with gathered air, as long as the vehicle displaces in the stratosphere, which eliminates all consumption of fuel, gas of combustion and liquid transformed and utilizes only the solar energy and air for the propulsion. By this feeding, at a height of 31000 meters, that is at $\frac{1}{100}$ of the atmospheric pressure, a speed of 1080 meters per sec, is required to reestablish the atmospheric pressure of 1 Kg. per sq. cm, in the air gathered, said pressure increasing with the speed according to a known relation.

It follows from the above that in order to reach the deliverance speed of 9 km per sec, considered as the necessary speed to reach our satellite, it will be possible to utilize the air feed system until reaching the speed of 5 Km. per sec. at a height of 70000 m and successively the ether feed until reaching the speed of 9 Km. per sec. in the intersideral space with the double advantage of reducing firstly the ether consumption and reaching, secondly, the maximum speed only out of the stratosphere, where there is no more resistance to motion by the air.

Fig. 6 shows in detail a propelling apparatus: from this figure it appears that the motor wheel **12** and the vane wheel of the double reaction propeller are mounted on the same shaft **17**; the wheel **38** of the motor **12** has, in the example described above a diameter of 30 cm. and a peripheral speed of 305 m/sec., and the vane wheel **28** has a diameter of 50 cm. and a peripheral speed of 510 m/sec. The common shaft turns, therefore, at a speed of 19500 rev. per min.

Wheels of small diameter have been chosen because they afford the advantage of reducing the weight of the driving part; they are consequently subjected to a very high action by the centrifugal force, but in an appropriate measure to be supported by modern turning constructions; it is evident that the diameter of these wheels, however, may be increased to obtain the same peripheral speed with a reduction of the stresses in the materials, or else an increase of the peripheral speed.

The vane wheel is provided with 275 vanes, against one eighth of which exert their action the vapour jets issuing at a speed of about 1500 m/sec from four adjacent nozzles **16**; the vapour jets are compressed and forced back by the vanes which displace in an opposite direction at a speed of 510 m/sec, which gives rise to an active pressure on the vanes of about 8 Kg/sq. cm; the surface of each vane being of 2,5 sq. cm., the resulting pressure of the 35 vanes subjected to the action of the vapour is of 700 Kg; practically, only $\frac{1}{5}$ of the surface of the vanes is utilized and the useful traction force for each apparatus does not go beyond the 440 Kg., with the essential consequence of having a constant pressure and traction force, without falling into the intermediary normal pressure, which constitutes a fundamental principle of this propelling apparatus.

Upon the above, as each section of the closed-cycle generator has a surface of 221 sq. m. and each square meter gives 0.52 HP, the actual power on the shaft of each propelling apparatus is 115 HP, which gives 690 HP for the total actual power at disposal on the six shafts of the vehicle, except the power afforded by the nozzles.

As it results from Figs. 3, 4 and 6, the six propelling apparatus are suspended under a tubular frame **34** having six points, and outside the chamber **31**, according to radial directions, and are enclosed by a structure **36** for the only purpose of maintaining the apparatus at a constant temperature; the cylindric structure **36**, therefore, may be made of very thin sheet metal or fabric not undergoing any inside pressure.

The frame **34** is placed in the cylindric part of the chamber which has a diameter of about five meters and ends with two conical vaults and constitutes the floor of the upper part for the pilots; this part **31** is compound of several layers of cotton bias fabric, preferably rubberised, whereof the weight is not over 2 Kg./sq. m; these fabrics resist very well to the internal pressure required for the respiration of the pilots to which the chamber is subjected in the vacuum, and to the variations of the external temperatures. The outer layer of these fabrics must be painted according to alternated black and white bands, to maintain in a known manner, the temperature inside the chamber within convenient limits. If, in spite of this, the temperature would be still too high, a very thin sheet metal coating might be employed on the outer layer of the chamber wall, somewhat removed from said wall to reduce the temperature still further. The structure **33** under the cage for the propelling apparatus has the same characteristic as the structure **36** which encloses said apparatus.

The chamber described above has a very low weight which results from: the weight of the rubberized fabric, i. e. about 132 Kg, the weight of the tubular frame with tank and condensers, i. e. 98 Kg; the weight of the light structures **33**, **36**, i. e. 20 Kg; which gives comprchensively 250 Kg. The rotating masses of the propelling apparatus consisting of the driving shaft **17**, the vane wheel **28** and the driving wheel **38** weigh only 34 Kg. The casing of the driving apparatus and the supporting frame of the propelling apparatus, as well as the supports and nozzles weigh only 26 Kg. and the complete propelling apparatus weighs, therefore, 60 Kg, which means 360 Kg. for the six apparatus comprehensively.

The electric plant and the feeding pumps weigh about 80 Kg. and increase, therefore, the total weight of the propelling apparatus up to about 440 Kg.

The total weight of the vehicle is composed of the following elements:

	Kg.
Weight of the band generator	977
Weight of the chamber, frame and light structures	250
Weight of the propelling apparatus	440
Weight of the two pilots	140
Weight of the ether in the tank	480
Total	2287

The traction force exerted by the six propelling apparatus equal to Kg. 420×6 i. e. 2520 Kg. exceeds, therefore, by about one tenth the total weight of the vehicle, which affords a sufficient buoyancy to allow the apparatus to travel in the intersideral space. This in the case of normal operation; in case of fault of one of the six propelling apparatus, the power of the other five apparatus, is increased by increasing the issue of the nozzles **16** to the maximum, so as to have still a provisional safety buoyancy for the vehicle.

The favourable temperature for the operation of this vehicle are found only in the intersideral vacuum, but in the stratosphere above 16000 meters of altitude with an atmospheric pressure about one tenth of the normal sufficient conditions for the operation of the vehicle are already found. Below 16000 meters of altitude the power of the propelling apparatus decreases considerably owing to the decrease of the solar radiations and to air ventilation.

It is for this reason that the apparatus according to the invention cannot start from the earth by its own means. To lift the vehicle up to 16000 m. of altitude external means must then be employed, such as stratospheric airplanes or simply stratospheric balloons. A stratospheric balloon of the type FNRS used by Piccard, of 14000 cu. m. deprived of the spherical chamber and other weights which are not necessary, can lift up to 16000 meters, according to Piccard's data, a useful weight above 1200 Kg. and can be sufficient for the vehicle of the above example, utilizing the power, reduced to about the half, of its propelling apparatus. With a balloon of 124000 cu. m. of the type "Poland Star" it will be possible to bring to 16000 m. a weight of several tons and consequently a vehicle having double dimentions in comparison to that described above, with the propelling apparatus at rest.

For the departure from the earth it is necessary, of course, to take in consideration the latitude, the season, the altitude, the hour, the meterological conditions and the periodicity of the solar activity lasting 11 years. Under certain points of view it will be convenient to chose high mountain places or arctic zones. The starting and the arriving must be performed by an anchoring mast; the length of the vehicle being given, the height of the anchoring mast might be equal to about the half of the total length of said vehicle, as the other half of the vehicle might be received in a well at the bottom of the anchoring mast.

The return on the earth can be effected by the pilots by a parachute after having abandoned the vehicle at a suitable altitude for the supporting of the parachutes, as it is provided by nearly all the plans for intersideral travels.

It is to be noted that at the return the vehicle has lost nearly all the weight of the ether and it will be possible, subsequently, to study some subsidiary heating and supporting means for landing by the own means of the vehicle.

The driving of the vehicle presents some particularity: the vehicle must proceed in the space with the chamber in front and the band of the generators behind, except in the case of oblique proceeding owing to the unfavourable direction of the solar radiations. For modifying the direction of advancement it is necessary to increase or decrease the power of one or more adjacent propelling apparatus as on the four-propeller ships. For decreasing the speed or stopping the vehicle the direction will be modified by 180°.

A gyroscopic system of known type, might be useful to keep the exact direction and to control slight rotational displacements of the vehicle around its longitudinal axis. This rotation around the axis can be obtained also by displacing by 90° in either direction a group of the nozzles **16** in front to the vane wheel **28**. By this system of rotation around the longitudinal axis it will be possible to dispose and maintain the band of the generators in the most suitable position to receive the solar radiations in the normal direction to its front surface, so as to obtain the maximum power from the generators. The same rotation can be utilized to suitably decrease the power of the generator; thus, by turning the band of the generators by 90° with respect to the position corresponding to the maximum power, the stopping of the operation of the generator will be obtained, the solar radiations striking then the edge of the band of the generators, producing no heating of the tube surfaces.

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