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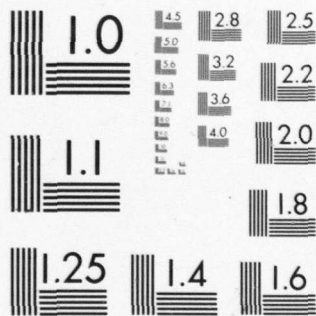
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# FOREIGN TECHNOLOGY DIVISION



A RANDOM TALK ON THE APPEARANCE OF MAN-MADE SATELLITES

by

Wu Lingyao

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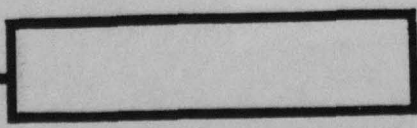


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By: Wu Lingyao

(China)

English pages: 15

Source: <sup>21 Trans. of</sup> Hang K'ung Chih Shih <sup>Vol. 4</sup>, 1977,

pp 6-9 / 1977, by [signature]

Country of Origin: China

Translated by: LINGUISTIC SYSTEMS, INC.  
F33657-78-D-0618

H. P. Lee,

Requester: PHE

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A Random Talk on the Appearance of Man-made Satellites

Wu Lingyao

Man-made satellites show a great variety of their different appearances. This article tries to investigate what are the factors that require such a variety and how to decide the appearance of a man-made satellite.

Undoubtedly, people are familiar with the appearance of airplanes. The appearances of various aircrafts, such as fighters, transporters, jet planes or propelled ones, and subsonic or supersonic ones, are generally similar only with difference in details. They are basically composed of a streamlined body with a pair of stretched wings. Nevertheless, people may not know that the shapes of man-made satellites are multifarious. They can look like a sphere, a cone, a cylinder, a spherical polyhedron or a polyhedral cylinder. Some carries huge pieces of flat boards; some shoots forth slender sticks; and some simply has an inconceivably strange form (see Figures 1, 2, 3, 4, 5, 6 and 7). In short, the variation of the appearance of man-made satellites is limitless and each of the satellites shows a unique style. Airplanes and man-made satellites are all vehicles designed to be able to fly in the sky. Why does the appearance of the former show a general similarity while of the latter one varies from the other? Now we would like to begin our talk of the essence of the difference between general aviation and spaceflight from the point of view of the "theory of contradiction".

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Once Chairman Mao said, "In any form of movement, there exists a special kind of contradiction. This special contradiction constitutes a special property which distinguishes one thing from the other." An airplane can fly in the dense air, while a man-made satellite can fly in the space where the air is thin. As the specific characteristics of these two different kinds of flights are contrastive, the factors that determine the appearance of a flying vehicle are therefore different.

#### Aviation -- Struggle Against Air

The contradiction in aviation is one that exists between an airplane and the air. The action of the air to an airplane is one which can be divided into two. For an airplane, the air can produce lift force to overcome the effect of gravity so that the airplane can remain in the air without the danger of falling down. This is the advantageous aspect of the action. At

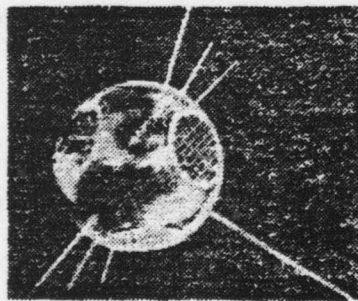


Figure 1 Spherical shape

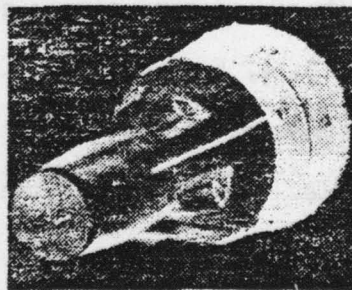


Figure 2 Conic shape

the same time, air can produce drag force which prevents the airplane from being able to make speedy flight. This is the disadvantageous aspect of the action. In the development of aviation technology, efforts have been made in

the improvement of the appearance of airplanes. This is in essence a struggle against the air and to try to make use of the advantageous aspect of its action to overcome the disadvantageous aspect. In order to utilize the lift force to support the weight of an airplane, the airplane must have a pair of wings stretching leftward and rightward. For reducing resistance and increasing speed, the body of an airplane must be streamlined. So the specific appearance of an aircraft is determined by a specific kind of contradiction between an aircraft and the air.

#### Spaceflight -- Struggle Against the Earth Gravity

The contradiction in spaceflight is one that exists between a man-made satellite and the gravity of the earth. The action of the earth gravity to a man-made satellite is one which can be divided into two. The earth gravity is the source of power which can make things able to stay on the surface of the earth or in the vicinity of the earth. In case that the earth gravity disappears, nothing will be able to stay on the earth any longer, and the atmosphere which the lives depend upon will vanish, too. It is the action of earth gravity that helps man-made satellites cycle around the earth and not fly away. But, however, in order not to fall down, a man-made satellite, at a certain point, has to become free from the effect of earth gravity. otherwise, the satellite simply cannot go up into space. In this sense, the earth gavity is not always useful. In developing space technology, we must first of all struggle against the earth gravity. On the one hand, we must make use of it, and on the other hand, we have to try to get rid of it. The



success in launching a man-made satellite is the result of utilizing the earth gravity as well as disassociating with it. The operation obviously involves the stages of contradiction, unity and struggle. Then, how can we get rid of the earth gravity?

#### Speed is the Key Point

Chairman Mao once said, "In order to obtain freedom from the nature, people must try to use natural science to understand the nature, to conquer it and to reform it. Then we can have freedom from the nature." So, in order to obtain freedom from the earth gravity field, people must try, through celestial observation and the study of celestial body, to understand the earth gravity field. Over a long period of scientific practices, we have come to understand that a body on the earth can become a small man-made moon if it has the first space velocity (cosmic velocity) of 7.9 kilometers per second; it can leave the earth and travel among the planets in the solar system if it has the second space velocity of 11.2 kilometers per second; and not only can it get rid of the earth gravity but can also fly out of the solar system and enter into vast space if it has the third space velocity (spaceflight velocity) of 16.6 kilometers per second. This obviously means that a body can overcome the earth gravity and have the freedom to fly among planets if it has adequate speed.

Centuries ago, people began to have the idea of flying in the space. Only because of the lack of strong power that could make a body have tremendous velocity, spaceflight remained to be a goal for continuous endeavor. "In the struggle for production and scientific practices, people

continue to advance and the nature also develops increasingly. So they never stop at a certain level." Now, as a result of the development of rocket technology, especially the success in manufacturing and launching of multi-staged rockets, spaceflight has from an ideal become a reality. Carrier rocket provides the velocity necessary for man-made satellites and other space vehicles and it is a powerful instrument to conquer the earth gravity and a foundation for the development of space undertakings.

#### Limitations Imposed upon the Appearance of Satellites by Carrier Rocket

A carrier rocket is usually of a slender body, of which the upper part is thinner than the lower part. The cowling on the head of the final-stage rocket has only limited space, so the maximum size of a man-made satellite, especially its transverse size, is strictly conditioned by it. In the earlier days, the carrying capacity of a carrier rocket is relatively small, the structural weight of a satellite is therefore required to be as small as permitted, and most of the satellites are of spherical shape. Compared with other shapes, under the condition of same capacity, the surface area of the shell of a spherical shaped satellite is the smallest, the weight is the lightest and the withstanding power to the shock, acceleration and vibration of the main section of a carrier rocket is the strongest. In order to make full use of the limited space in the cowling, some satellite is made in a conic shape similar to the cowling, and in some cases, the cowling is directly used as the shell of a satellite. But, because it often contradicts with the research requirements, structural design, attitude control and the installation of solar battery of a satellite, generally it



is not used except for a recovery satellite.

Sometimes, due to the hugeness of the transverse size of a satellite, the cowling of a carrier rocket has to be heavier. As a consequence, the rocket becomes "big-headed". Such a "top heavy" appearance is easy to make the carrier rocket instable in flight and to cause trouble in reinstalling. Compared with man-made satellite, the technology of manufacturing carrier rocket is much more complicated, the cost is higher, and the time used in preparation and manufacturing is much longer. Moreover, a carrier rocket is

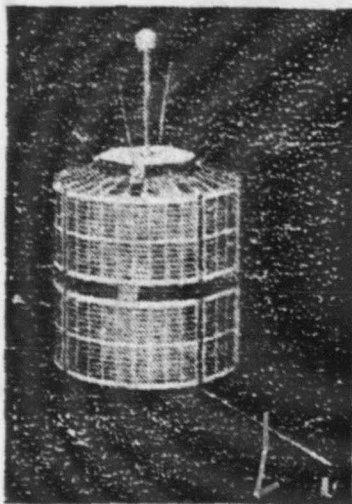


Figure 3 Cylindrical shape

often transformed from a ground-to-ground missile which has been made ready for launching. On the other hand, however, before the designing of a satellite, the carrier rocket has already been completed without much necessity to make any change. So the design of a satellite is always in accordance with the ready-made rocket. When the size of a satellite is found contradictory with that of a carrier rocket, it is generally to change the size of the satellite to adapt to that of the carrier rocket.

#### Why So Indispensable is a Carrier Rocket

People may like to ask why cannot a man-made satellite, like an airplane, carry its own power installation and propellant and independently fly into the space, and why it must depend on a carrier rocket? The answer to



this question is that, at the present time, the maximum specific pulse (the thrust produced by consuming one kilogram of propellant per second) of propellant is only a little more than 400 seconds. If we want a satellite to accelerate to the first space velocity, it must carry sufficient propellant and large box enough for storing the propellant. And, in order to warrant that the satellite can accurately enter the prescribed orbit, it must have control and stabilization systems and other equipment. Consequently, the weight of the satellite is increased greatly, and correspondingly the propellant and its store-box have to be increased. Once the weight of the satellite is increased, the propellant must be increased. Thus it forms a "vicious circle" of "as the water rises, the boat rises with it". As a consequence, the propellant is plenty, but the satellite still cannot go up because a large part of the propellant has been consumed on acceleration and the store-box. Even if the satellite can go up, it carries so many empty store-boxes and most of the labor is spent in vain. There is only a lose without gaining anything. The basic solution to such a problem is to improve the specific pulse of the propellant. It needs, at least, to be doubled to reach 800 - 1000 seconds. Now, however, there is difficult to realize this.

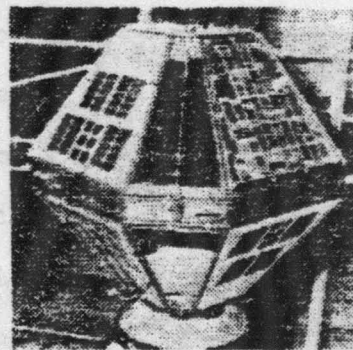


Figure 4 Spherical polyhedron

In order to solve such a contradiction, people have discussed whether it is possible to drop off one store-box of propellant when it becomes empty so to reduce the weight. The multi-staged rocket is a concrete realization of such idea. The rocket works stage by stage and it drop off the empty boxes

stage by stage. Finally it enters the prescribed orbit together with the satellite as it has become an empty shell of the final stage rocket. Even so, if we want to launch a man-made satellite of 100 kilograms, we need a three-staged rocket which can weight several tens of tons, and more than eighty per cent of the weight is propellant.

So far we have only pointed out that the maximum size of a satellite is determined by the carrier rocket. What are the factors which determine the appearance of man-made satellites? We shall investigate in the following.

#### For Utilizing Solar Battery

As food is to human body, so is the source of electricity to a satellite. At the present time, the energy of chemical battery is much limited and its lifetime is too short; the structure of fuel cell battery is all too much

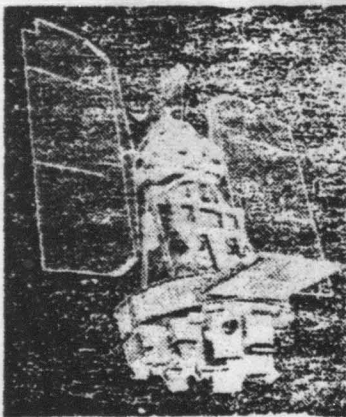


Figure 5 The complex wing plate which carries a solar battery

complicated and its volume is too big; and the atomic battery is still under experiment. So the only one that is suitable to a satellite is the solar battery, and the source of solar energy is inexhaustible. A solar battery can directly convert solar energy into electric energy and it is both simple and reliable. So it is especially suitable to a man-made satellite which usually works for a very long period of time.

The solar battery is made of semiconductor single crystal thin plates. The thickness of the plates is usually less than one millimeter, its length is about two centimeters



and the width is one centimeter or two centimeters square. In a satellite, there are always several thousands to tens of thousands of plates. Thus the surface of the satellite can have an area sufficient to attract the solar batteries. On the other hand, when the satellite is in movement, the direction from which the sun shines upon the satellite varies continuously, so every side of the satellite must be made able to attach solar battery. Consequently it forms a network of solar batteries of "all-direction". So whatever direction the sun comes from, there is electricity generated. It is therefore better to have a satellite of spherical shape or that of axial symmetry. Due to the fact, however, that the surface of a sphere is bent not plane and it is not easy to attach the battery, most of the man-made satellites are of the shape of a spherical polyhedron or a cylinder (see Figures 4 and 3). In some cases, the surface of a satellite is not good enough to attach a solar battery or the surface area is not large enough, then some movable wing plates are installed to the body of the satellite exclusively for the purpose of attracting solar batteries. They are called solar battery wing plates (see Figure 5).

#### Network of Solar Batteries of "All-direction"

Somehow, there can be one part of a network of solar batteries of "all-direction", which will, at a time, receive sun shine and generate electricity. If the solar batteries are all over the surface of a satellite of spherical shape, the sun shine, in fact, can only reach the batteries of half sphere surface. Moreover, a large part of the batteries can receive sun shine obliquely, so the electric energy generated from these batteries equals to



only half of that generated from the batteries upon which the sun can shine vertically. This means that the efficiency of the "all-direction" solar batteries is only twenty five per cent and three fourth of the batteries cannot operate fully. In order to remedy such defect, the side of the satellite where batteries are attached is made facing the sun all the time. However, this remedy proves contradictory with other requirements of the satellite, such as earth orientation. So some other measure of utilizing solar battery wing plate to face the sun singly

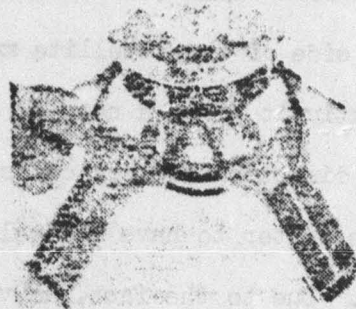


Figure 6

has been advanced. In whatever attitude the satellite can be, the solar battery wing plate which carries batteries is always facing the sun. The requirements of the satellite for axial symmetry and surface area can be thereby relaxed and there is no affect upon the earth orientation of the satellite.

#### The Stabilization of Attitude Control

The simplest method of attitude control of a satellite is spin control. A certain axis of the satellite can have inertial space orientability when it revolves. In order to prevent the shake caused by the vanishing of the orientability of the <sup>spin</sup> axis or by some interference to the spin axis from becoming more and more serious, the appearance of a satellite must be axial symmetric to the spin axis and the mass distribution of the satellite must

also be axial symmetrical. Then the revolving inertia of the spin axis of the satellite must be made greater than the revolving inertia of any spin axis which revolves through gravity. This is a very important point. Thus the orientability of the satellite can be very strong, very stable and able to resist against any interference when it revolves. So the transverse size of a spin-stabilized satellite is the greater the better. This is the answer to the question why the spin-stabilized weather satellite, communication satellite and scientific experiment satellite are always made in the shape of cylinder, drum or oblate sphere of which the length of diameter is longer than the height.

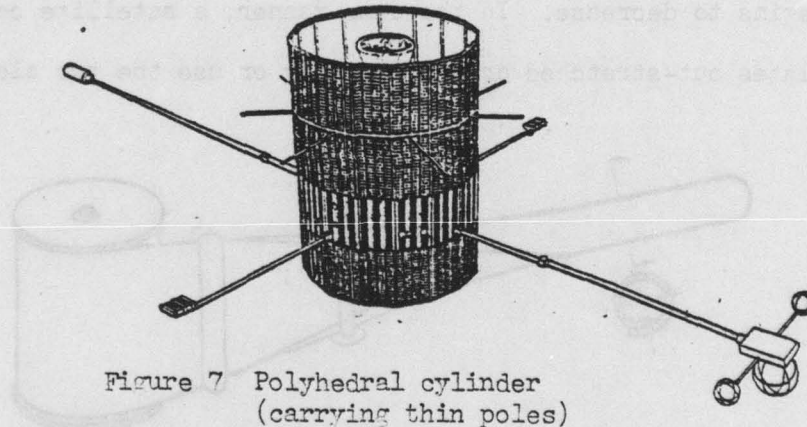


Figure 7 Polyhedral cylinder  
(carrying thin poles)

#### The Method of Reducing Revolution Without Consuming Extra Energy

To launch a medium or small type of man-made satellite often uses a three-staged carrier rocket as engine and the final stage of the carrier rocket is a solid rocket. When the engine of the final stage solid rocket is working, it depends on the spinning around the longitudinal axis to keep the thrust direction unchanged. The spinning speed is usually very high



and it can revolve more than one hundred times per minute. The satellite in front of the engine follows it to revolve. After entering the orbit and being separated from the final stage rocket, the satellite continues to revolve with high speed and the normal operation of the instruments and equipment in the satellite is thereby seriously affected, so the revolving speed has to be reduced. However, if the jet method is used to reduce the times of revolution, it needs to consume a lot of propellant and, in addition, there must also be a relatively complicated system of jet engine. As everyone knows, when a figure skater on the ice wants to stop, he must first stretch out his two arms which have folded in front of his breast, then his speed begins to decrease. In the same manner, a satellite can use the four wing plates out-stretched around its body or use the two slender poles

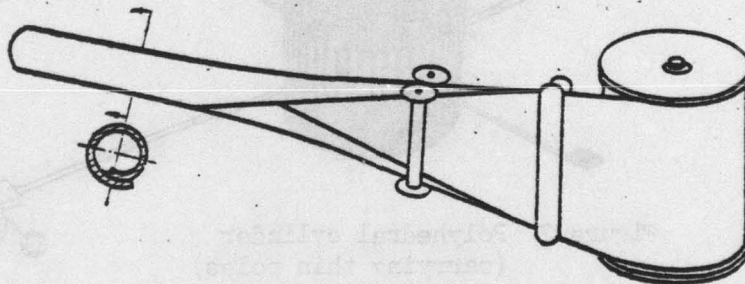


Figure 8 Diagram of slender poles on the antenna of the satellite

which stretch out symmetrically from inside along the ends of the diameter to achieve the purpose of reducing the time of revolution. The reason is that the product (moment of momentum) of the revolving inertia of the satellite multiplied by the revolving speed is conservative. When one is increased, the other is automatically decreased.



When the satellite opens its wing plates or stretches out its slender poles, the revolving inertia increases and the revolving speed decreases immediately. This set of wing plates is the solar battery plates and they are fixed on the satellite, before opening, like human arms raising up and hanging down. Some of the slender poles used to reduce the revolution are whip antenna and some are supporting poles and on their tops, they are equipped with magnetometer or particle collector (see Figure 7). The supporting poles can help the searching instruments to search in the space as far as possible from the satellite. When the satellite enters its orbit and opens its wing plates and stretch out its slender poles, the plates and the poles can, on the one hand, complete their required performances, and, on the other hand, they can help to reduce the times of revolution. They both can achieve two missions by a single move. The poles used as antenna, in fact, carry steel bands which have good elasticity and, before stretching out, they like steel ruler tie tightly around an axis inside the satellite, so their volume is very small. When a band is released from the axis, it depends on its own elasticity along the direction of its width automatically to roll into strong pipe (see Figure 8).

#### Changing Air Resistance into a Help

Perhaps people think that air resistance is always detrimental. In fact, however, air resistance, like everything else, has its aspect of usefulness and that of harmfulness. For satellite recovering, air resistance is an indispensable help and so are in heat-preventing and deceleration.

The specific contradiction in the process of letting a returning satellite re-enter the atmosphere is the impetuous heating of air against the satellite. "Different contradictions can be solved only by methods of different nature". In order to reduce the aerodynamic heating, a satellite must have a head that is very blunt. When reentering, the blunt head is forward to meet the airstream. In front of the blunt head, an area of air molecule concentration is formed. The boundary surface between this area and that where the air is thin is the so-called "shock wave". The shockwave, like a layer of screen, can block the incoming air molecule to touch the satellite. Thus the kinetic energy of the high speed air molecule changes into heat, which diffuses in the airstream between the shock wave and the blunt head. So the heat the satellite receives reduces greatly. Consequently, the satellite can have a bottom with a radius of great curvature. When the satellite reenters, the bottom turns forward to function as a blunt head.

The returning satellite comes down by a speed of 7000 meters per second and, under the action of gravity, the speed is increasing. If the speed is not reduced at a proper time, the result will be a disaster. Under such a condition, it is a good opportunity to make use of air resistance. The blunt bottom goes forward, and it can both prevent the heat and reduce speed. As a result, before the satellite reaches low space where the air is dense, its speed has reduced to subsonic and the lower speed further reduces the aerodynamic heating. Of course, the speed-reduction that helps a satellite return to the earth safely depends mainly upon the unboosted rocket and



parachutes.

Ever since the solar batteries begin to use the orientation wing plates, and the attitude control of satellite realizes triaxial stabilization, the appearance of satellites has broken the various restrictions of axial symmetry and has had greater freedom. The novel appearances of the inter-stellar explorers, which can fly to the Moon, the Venus and the Mars, have been developed on such a basis.

Pictures drawn by

Zu Shaoxian