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TRIUMPHANT RETURN FROM SPACE TRAVEL
-RECOVERY TECHNIQUES OF MANMADE SATELLITE-

By

Yi Lin

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By: Yi Lin

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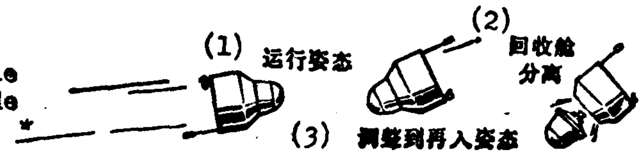
(1) Flight attitude
(2) Separation of recovery module
(3) Adjusted to re-entry attitude



Triumphant Return From Space Travel

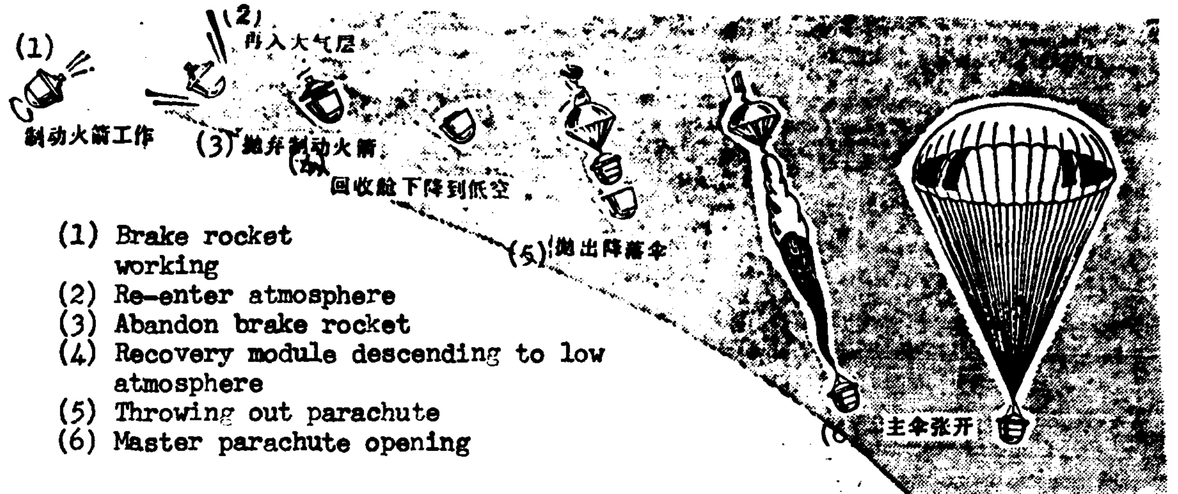
-Recovery techniques of manmade satellite-

Yi Lin

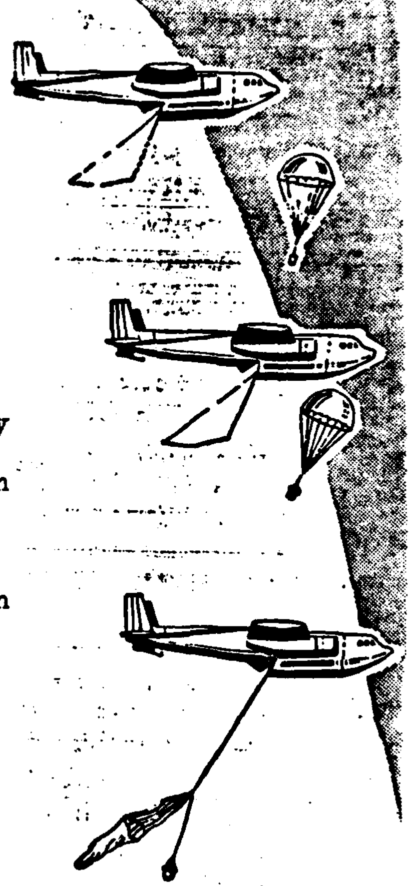
Under the guideline of Chairman Hua's strategic decision of grasping the key link to run the country, on January 26, 1978, China again successfully launched another manmade satellite, and according to the plan made in advance, after completing its mission of scientific investigation, the satellite triumphantly returned to the earth.

The successful return of a satellite to the earth marks a great step forward of satellite technology. Certainly it is not easy to launch a manmade satellite and it is equally difficult to recover it. The recovery technique is not only an important component of satellite technology and it is also the foundation for launching a manned satellite. Because man should not be sent to make space travel unless his safety in going up and coming down is guaranteed.

Generally a manmade satellite flies in space at an altitude of 200 kilometers ~~kilometres~~ from the earth. Over there the air is very thin and the air molecules there make no obstacle to the movement of a satellite and there

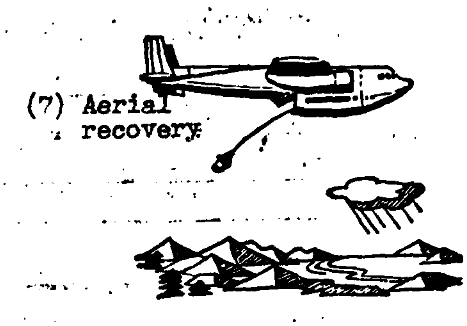


(1) Brake rocket working
(2) Re-enter atmosphere
(3) Abandon brake rocket
(4) Recovery module descending to low atmosphere
(5) Throwing out parachute
(6) Master parachute opening



is almost no resistance, so the satellite can unceasingly make its cycling around the earth one after another for years. But, as the proverb goes, "Persistant efforts can overcome any difficulty", the impact of constant attack, although very light, of air molecules unpon the satellite can make the speed of the satellite become smaller, its orbit gradually become lower and eventually the satellite comes down to enter the atmosphere. When the satellite enters atmosphere, like a meteor, it makes violent friction with air and burns itself into ashes.

If we want to recover a satellite, certainly we must let it come home safely. This means that we must let the satellite return to a specified place following a prescribed route at the prescribed time without any damage. For achieving such a goal, many technical problems must be solved and difficulties must be overcome. In the following we shall discuss five difficulties of *recovering* a satellite.



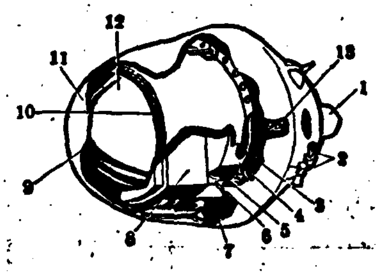
(7) Aerial recovery

First Difficulty: Separation

The first difficulty that a satellite encounters on its way home is to reduce its speed and leave its orbit. To reduce speed is done by the brake rocket to blast along flight direction. The brake rocket carried by the satellite cannot be very large, so it can only make the satellite reduce its speed slightly. In order to make the satellite come down faster, the brake rocket must have a descending thrust that can help the flight direction of the satellite to form a depression angle - re-entry angle with horizon. There seems to be nothing more difficult for a satellite to leave its orbit only if it can change its speed. In fact, however, it is not so simple. The requirement for a re-entry angle is very strict. The re-entry angle must be a depression angle with proper degree. If the re-entry angle is too large, the satellite will straightly rush into atmosphere and it will cause serious resistance and heating that can be beyond the **endurance** of a satellite. Therefore, the re-entry angle is usually *no more* than 3-5 degrees. On the other hand, if the re-entry angle is too small and without proper control, a depression angle can become an elevation angle. Consequently, the satellite cannot return but goes up and enters a new orbit instead.

When a satellite is leaving its orbit, the re-entry speed as well as re-entry angle must be controlled with high precision. A slight error can result in great difference. If the re-entry speed has a difference of six meters per second or the re-entry angle has a difference of only one degree, the landing of the satellite may have a difference of 300 kilometers If the control is not appropriate , not only cannot recover the satellite, and the satellite may fall in the territory of another nation or international seas.

1. brake rocket, 2. spin and despin nozzle, 3. parachute and metal wire box, 4. parachute cabin cover, 5. blast button, 6. flash light, 7. tail cover of plastic recovery module, 8. instruments box, 9. radio signal unit, 10. sea water colouring agent, 11. ablative re-entry cover, 12. plastic recovery module, 13. blast button.



The degree of the re-entry speed and re-entry angle is determined by the ignition time of the brake rocket, thrust direction and total pulse strength (product of thrust and action time). The ignition time of the brake rocket must be precise without any error and it is controlled by the ground remote control unit. The thrust direction is checked by the attitude control system in the satellite. When the brake rocket has worked for a certain period of time or the satellite has reached the specified speed, it must opportunely stop working. This is done by the computer program control system in the satellite. So, if we want to have a smooth separation, there must be three well prepared controls: - remote control, attitude control and program control.

In practice, however, it is often necessary to recover some module of a satellite. This module is called recovery module. Before leaving orbit, the recovery module must be separated from the body of the satellite. After separation, it depends on the spin to maintain the brake rocked direction unchanged. Then the brake rocket is ignited, speed is reduced and it leaves orbit. And the satellite remains on the orbit.

Second Difficulty: Re-entry

After leaving its orbit, the satellite begins to slide downward along a path toward the earth. When it reaches a point about 100 kilometres from the earth, the air molcule becomes remarkably more. When it reaches an altitude of 60-70 kilometres, although the air density over there is only less than one per thousand of that on the earth, as the speed of the satellite is twenty times faster than sonic velocity, it inevitably makes violent friction with the air and produces a great amount of heat energy. As a result, the surface of the satellite begins to burn as if the whole satellite is surrounded by fierce flame. So the difficulty of re-entry is high temperature and it is the most dangerous one among the five difficulties.

In order to reduce the degree of being heated, a satellite is always made in a shape with an obtuse head but not a streamline pointed-head. When such an obtuse-headed article is flying by supersonic speed, in its front there is an area where the air molcules are densely accumulated. Such an area like a buffer zone can prevent the air molcules brought here by the high velocity from direcly contacting the satellite and help to transfer them to the buffre zone by high heat energy transformed from kinetic energy, thus the heat on the satellite is reduced greatly. Even so, the temperature on the surface of the satellite is still 7000-8000°. So the surface of a satellite must be made of heat-resistant materials. But so far there is no material which can stand such high temperature without being melted. In facing such a problem, a strategy of protecting the whole at the expense of some part has been adopted. The head part of a satellite is covered with materials of high molecule - "ablative material", which has greater heat of vaporization. This means, when necessary, to let the head cover burn and absorb a great amount of heat and the satellite body can thereby be saved.

Due to the fact that a satellite is made in a shape with an obtuse head, the air resistance it encounters is doubtlessly tremendous. But for the sake of its return, this has proved meritorious without any disadvantage. It can make good use of air to reduce velocity. If the velocity of a satellite is reduced from about 8 kilometers per second to a subsonic speed by using brake rocket, the size of the brake rocket must approximate to that of a launching rocket.

Third Difficulty: Opening Parachute

After the fierce struggle of re-entry, when a satellite reaches a low altitude of 10-20 kilometres from the earth, its vigorousness begins to diminish and its speed becomes only 2% of the re-entry speed. Although the satellite has become exhausted, the absolute value of its speed is still about 200 metres per second equivalent to the speed of an ordinary civil plane. If it makes landing by such speed , it is bound to be crashed and become a pile of scraps. So for having a safe landing, it must further reduce its speed by utilizing the air.

When the satellite reaches a point of about 10 kilometres from the earth, the altimeter or a clockwork it carries will issue instructions. First a small parachute opens to stablize the attitude of the satellite. This is a preparation for opening the master parachute. At the same time, the speed is further reduced so as to avoid the happening of too much overloading to break the master parachute when it is open. As the satellite reaches an altitude of about 5 kilometres, the master parachute opens and the speed of the satellite is reduced to about 10 metres per second, then the so-called soft landing can be achieved.

In order to make it easier to be discovered on the ground, parachutes are usually made very colourful.

Fourth Difficulty: Searching

It must be found out whether a satellite has triumphantly overcome the re-entry difficulty or has been burned up, and whether it has entered the specified place or has deflected from the prescribed route. A satellite, therefore, must have a way to indicate its position to help the ground personnel who are in search of it. This primarily depends on radio search. The position signal unit in the satellite begins to send a radio signal when the satellite is at a point of 20-30 kilometres from the ground, and the ground personnel can forsee its direction and distance according to the signal received. One serviceable way to indicate position is to use light, for a strong flash light from the satellite can easily catch attention of the ground personnel. Another way is to cast out thousands of thin metal wires from the satellite to form a metal wire cloud in the sky, which can be quickly discovered by the ground radar searcher.

Fifth Difficulty: Recovery

After having been discovered on the ground by a position search system, the satellite must be recovered immediately without delay. There are three different recovery ways. One is land recovery. By this way, often the satellite falls on mountains or into a jungle and sometimes it may crash against some rocks. Consequently it is full of bruises and wounds. So there is a second way of sea recovery, which is used rather often. Because a satellite is always closely sealed and its specific weight is smaller than water, so when it drops into the sea, it can float up. Moreover a satellite often carries sea water colouring agent which can be dissolved easily and make the water around the satellite become orange yellow. This will help a searching plane from high above to catch sight of its target. Then the searching plane informs the standby ship to go to recover the satellite.

The third way which is comparatively advanced is to recover in the air. When a satellite supported by a parachute is descending from the sky, it can be recovered by a plane. There is a hook connected to the bottom of the plane by a rope. The hook can catch the satellite and slowly pull it up into a cabin on the plane. This way is not only quick and simple and can also free the satellite from crashing on ground or being soaked in sea water. It is therefore the most secure and reliable way.

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