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FOREIGN TECHNOLOGY DIVISION

AERONAUTICAL KNOWLEDGE
(Selected Articles)

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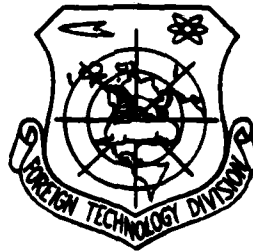
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A large number of military directors in the People's Liberation Army work hard on the modernization. The photographs shown here reflect their efforts to successfully launch missiles and satellites, and so to accomplish the assigned jobs in the high technologies for defense. (Photographed by D. S. Chang, Y. T. Ju, J. S. Yang, D. M. Liang, C. H. Chen, and D. Liu.)

1. Examine test results from a wind maker - a team effort.

2. Enforce technical training to accomplish tracking and measurement for missiles and satellites

3. Operate the electronic computer to handle various data accurately.

4. Search every unknown factor, overcome every difficulty.

5. Maintain apparatus delicately.

6. The night before the launch.

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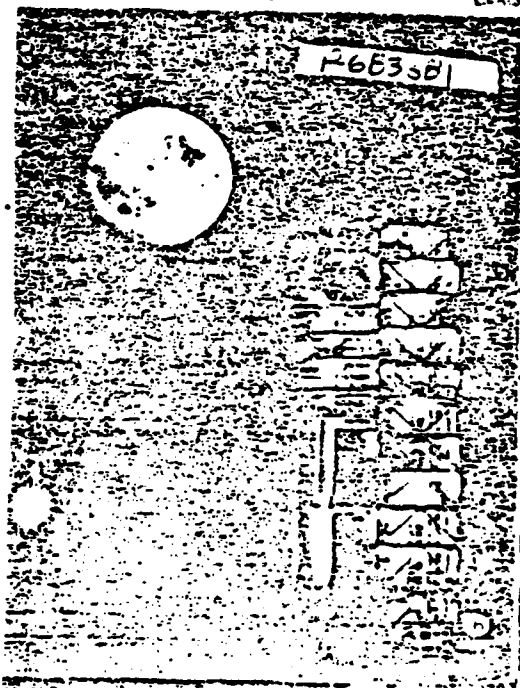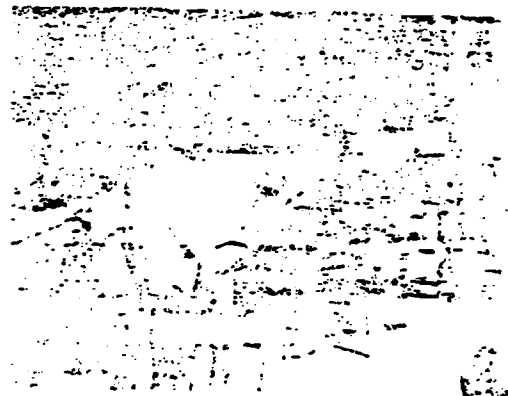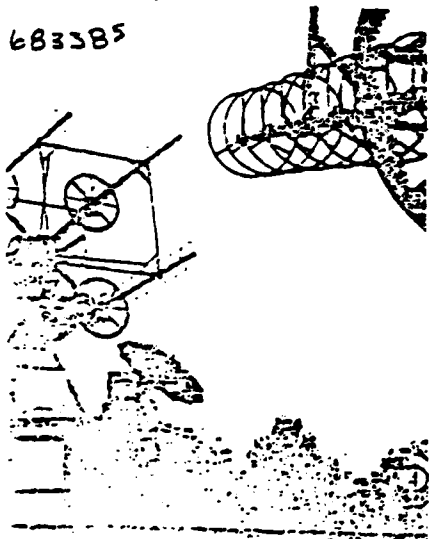
NEW MATERIALS FOR AIRPLANES AND SPACECRAFT

Guong-Liang Jou

Spacecrafts normally face many severe space conditions
when they enter space. The materials used for spacecrafts
must be less susceptible to environmental influences.
The stability of internal function must be easily main-
tained. The development of spacecraft certainly pushes
material science ahead.

Progress made in space technology is tremendous nowadays.
We now not only require excellent reliability of a spacecraft
during launch, flight   and re-entry, but also want to make a
light spacecraft which has a large volume, a heavy payload and
can be reused. To satisy these requirements, the spacecraft must
accommodate a very complicated and very severe space environment.
For example, a spacecraft, when launched, experiences intense
vibration incurred by the huge engine in the rocket; while in
 flight   , it experiences collisions by various charge carriers
and ions, a high vacuum environment, and an extensive range of
temperature variation. When the spacecraft re-enters the atmos-
phere, it must withstand a pressure of 40 $\sim$ 100 atms and a
heat current in the range of 50 $\sim$ 100 large calories/m^2-second
(the surface temperature of a spacecraft may reach 1,000 $\sim$
2,000°C); it also experiences forces and ablation due to ultra
high-speed air currents and ion currents.

How can a spacecraft survive in such an unfavorable environ-
ment and still function reliably? First we have to consider its
materials. The materials chosen for the main body must be the
ones with small specific gravity, high modulus of elasticity,
low natural frequency, low coefficient of expansion, low material
ablation, low susceptibility to radiation and low velocity. They
must not be damaged through corrosion, irradiation, etc. The

materials used for the exhaust nozzle connected to the combustion chamber in the rocket engine must endure high temperature and high heat stress, while those used for the point of the re-entry vehicle, which withstands the high heat stream, (such as vehicle nose, etc.) must endure high temperature and must be hard enough. In the meantime, those materials must be characterized by low heat stress, high ablation temperature and low ablation rate.

Beryllium has been used for new satellites. The development of fiber-enhanced materials will certainly improve the structure of spaceships and space shuttles. Carbon and tungsten alloy have been used for the combustion chamber and exhaust nozzle in the rocket engine. Some re-entry vehicles and front part of space shuttle are made from carbon-carbon materials, while niobium alloys have been used for certain parts of the space shuttle.

The development of new materials for airplane and spacecraft is very fast and very extensive nowadays. We will introduce a few important materials below.

FIBER-ENHANCED COMPOSITE MATERIALS

The modern fiber-enhanced composite materials are in two categories: metallic and non-metallic.

Boron fiber and carbon (or graphite) fiber are two popular fibers. The melting point of a regular boron fiber is as high as 2050°C. Its specific gravity is 2.63 gm/cm^2, tensile strength 340 kg/mm^2, modulus of elasticity $10^4 kg/mm^2$. The tensile strength for a graphite fiber is as high as 200 $\sim$ 300 kg/mm^2 with a modulus of 20,000 $\sim$ 30,000 kg/mm^2.

To fabricate a fiber-enhanced composite material of high quality , we normally combine the above mentioned fiber with a

metallic base of high electrical and high thermal conductivity and low volatility , or with a plastic base of low specific gravity, high strength and high thermal endurance. The metallic composite materials which have been developed successfully and have been on the market include boron/aluminum and boron/titanium, while non-metallic composite materials include carbon-oxygen resin, carbon/polyamide, carbon/carbon, etc.

The specific gravity for aluminum alloy is very close to that for boron/aluminum composite material. However, the modulus of elasticity for boron/aluminum (along fiber axis) is triple of that for aluminum, while its strength is more than double. If we use composite materials in airplanes or spacecraft, the weight is expected to be reduced 30% to 40%.

It is needless to say how important it is to reduce the weight of a spacecraft or an airplane. Take the Apollo spaceship as an example. If we could reduce its weight 30%, we would be able to load additional 907 kg of instruments or supplies which could be consumed by an astronaut over a few weeks. For a space shuttle, a reduction of 1 kg means a reduction of 30 kg of launching weight.

Then, why does a fiber, as thin as a silk thread, have that unusual strength? The reason is: a fiber does not have many defects and impurities. For example, the tensile strength for an iron fiber is 60 times that of an iron block. The graphite fiber is fabricated with the following procedures:

(1) Heat strained poly-propane fiber in the air to 200 ∿ 300°C for oxidation.
(2) Heat it to 1000°C for carburization.
(3) Inject in 3000°C inert gas. The graphite crystallizes.

For boron fiber, the processes are:

(1) Reduce the BCe_3 at high temperature.
(2) Deposit the boron from reduction onto the tungsten filament.
(3) Deposit SiC.

It is much easier to fabricate the carbon fiber and resin base. However, the techniques for fabrication of boron fiber and aluminum or its alloys etc. are relatively complicated. There are several approaches to accomplish the fabrication, including ion sputtering, electric deposition and continuous forging.
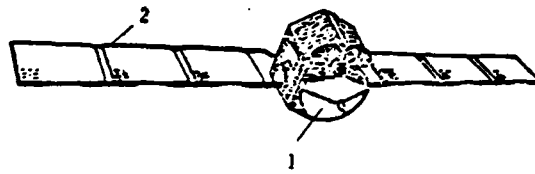
Figure 1. Parts of European Communication satellite which are made up of composite materials.
1 - parabolic antenna; 2 - solar collector.

Graphite/cyclic oxygen composite materials have been used for the connection support between earth observatory and antenna installed on NASA's satellite "AFSF". The support is composed of eight HM-S graphite/cyclic oxygen pipes. The pipe of a 3.6 kg weight can support nine tons of compressed load. Its weight has been reduced 50%, compared to a similar high strength support. The boron/aluminum composite materials have been used for the frame of middle part of a new space shuttle under development in the United States (Figure 2). The carbon fiber composite materials have been used for the solar collector and parabolic antenna in the European Communications satellite (Figure 1).

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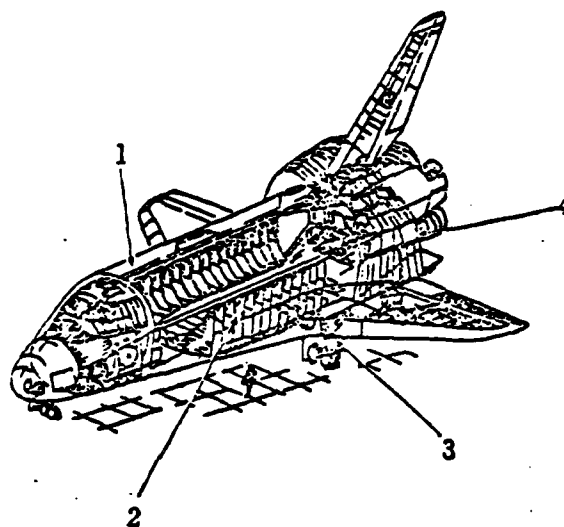
Figure 2.   The composite materials for the frame of a space shuttle.
1 - carbon/cyclic oxygen composite materials for cargo door;
2 - boron/aluminum composite materials for the frame in the middle
    part;
3 - carbon/cyclic oxygen composite materials for landing support
    storage door;
4 - carbon/cyclic oxygen composite materials for the frame of
    thrust support.

Carbon/carbon composite materials are made of carbon,
deposited using the chemical vaporization deposition method, and
carburized or graphitized resin, which are enhanced by carbon
fiber, graphite fiber or their fabric (Figure 3).

Figure 3.   Diagram for chemical evaporation deposition.
1 - carbon base; 2 - furnace; 3 - carbon vapor; 4 - industor;
5 - graphite heater; 6 - deposited carbon; 7 - fiber base;
8 - inlet vapor.

There are several ways to enhance these materials, including long fiber winding, carburizing a blanket made of stick filament or poly-propane and wool, and tri-directional fabric made of carbon fibers.

Fiber can be forced, into a part with a desired shape, then made into a carbon/carbon composite material using the method of chemical vaporization deposition.

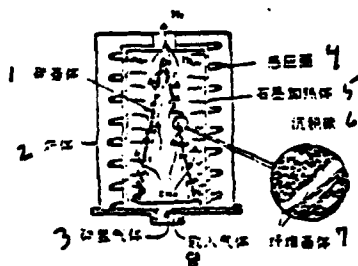The mechanical and thermal properties of these materials are excellent. Their specific gravity is only 1.6 gm/cm^2, but the tensile strength is as high as $400 \sim 1,000$ kg/cm^2. Moreover, these properties are maintained to about 260°C without any indication of degradation. Their tensile modulus of elasticity reaches as high as $3 \sim 7 \times 10^5$ kg/cm^2. The specific heat of these materials is normally in the range of $2.5 \sim 3$ cal/gm-°C, and increases as temperature does; the expansion coefficient is only in the range of $2 \sim 7 \times 10^{-6}$, which is only one fifth to one tenth of that for a metal, and is beneficial to a reduction of thermal stress. Its etching heat reaches about 10^4 cal/gm, but the etching rate is as low as 0.2 mm/sec. The defect of this material is its large coefficient of thermal conductivity. Although the coefficient is smaller than for bulk graphite, the material is not ideal to be used as a thermal insulator. Accordingly, scientists try to manage this problem. For instance, they replace the carbon fiber by a quartz fiber along the directions of thermal conductivity for the tridirectional fabric. The coefficient of thermal conductivity for quartz fiber is small. The thermal conductivity so managed can be lowered to about 1.89 $\times 10^{-8}$.

Since the carbon/carbon composite material has such outstanding properties as mentioned above, the United States has used the material for the re-entry vehicle very successfully. The material has also been applied to the space shuttle under development for the nose and the front parts of shuttle wings.

ALLOYS WITH HIGH MELTING POINT

Metals such as tungsen, molybdenum, tantalum, niobium, etc. have high melting points. Those metals can be made into alloys by merging some elements to enhance the property and degrade its susceptibility to oxidation. The alloys would have high melting point and, in the meantime, greatly improve their performance. Recently, various tungsten, molybdenum, tantalum and niobium alloys have been used in airplanes, missiles and spacecraft. Among them, nobium alloys are most hopeful for the space shuttle. The melting point for niobium is 2500°C. The temperature range for niobium application is 1,300 ∿1,600°C, which is about 300 ∿ 600°C higher than that for high temperature nickel alloys. The specific gravity for niobium is 8.5 gm/cm^3, which is very close to the value for structured steel. Moreover, niobium has excellent strength at high temperatures, very good plasticity at low temperature, and good chemical stability at room temperature. The enhancement effect can be accomplished for niobium by incorporating hafnium, titanium, etc. Niobium may best resist oxidation by alloying with nickel, aliminum, silicon and titanium. However, the brittleness may be upgraded and the strength may be reduced by doing so.

The McDonald-Douglas Company of the United States has utilized niobium alloys for its newly developed space shuttle (front part of wings and steering gear). The work temperature is 1093°C (Figure 4).

The major defect for a niobium alloy is its high susceptibility to ixidation at high temperature so that it cannot last a long time. To reduce its susceptibility to oxidation, it has been concluded, after a long study, that the more effective method is to add a protection layer.

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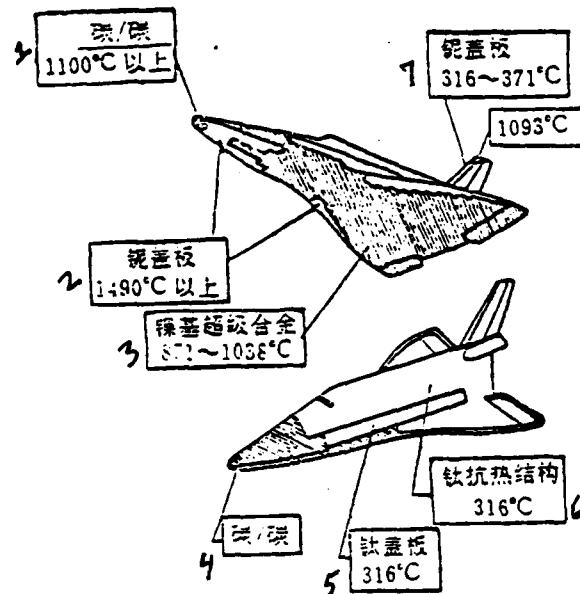
Figure 4. The surface materials and work temperature for a space shuttle.
1 - carbon/carbon over 1100°C; 2 - niobium cover plate over 1490°C; 3 - nickel super alloy 871 - 1038°C; 4 - carbon/carbon; 5 - titanium 316°C; 6 - titanium thermal resisting structure 316°C; 7 - niobium cover plate 316-371°C.

A better choice for the protection layer is silicon compound which enables the niobium alloys to survive 200 ≈800 hours at 1,300°C, 200 hours at 1,400°C. Yet such protection layer does not have sufficient potential to resist air currents. Furthermore, the metal covered by the protection layer may become brittle. These problems bear further research.

Since pure beryllium has a high modulus of elasticity (30,000

kg/mm^2, a factor of $6 \sim 7$ larger than for magnesium), small speci-
fic gravity ($1.85 \ gm/cm^3$, close to that of magnesium), high
melting point ($1285°C$, a factor of 2 larger than for magnesium),
and high strength ($50 \sim 60 \ kg/mm^2$), it is also a major candidate
material for aircraft and spacecraft. In the meantime, beryll-
ium is an ideal material for the delicate meters in the aircraft
based on the fact that, besides its ideal thermal conductivity,
parts made of beryllium are well stabilized in terms of dimen-
sions. For instance, an entire European satellite is made of
beryllium. There have been broad applications of beryllium for
meters. The deficiencies of beryllium, however, are its high
price and its high brittleness. Only high purity beryllium has
appreciable plasticity. Besides, the vapor of beryllium is toxic.
This is also a technical problem to be solved.

OUTLOOK

Space navigation technology has developed tremendously from
hte 1950s to 1970s. However, taking the long term view, the
technology is only in its initial stages. The human beings have
just stepped out of the scope of earth and have made only a few
trips to the moon. There have been very few explorations of other
planets. The goal of establishing some connection with possible
creatures on another planet seems to be very remote. Accordingly,
research and development on new materials such as composite
materials, high temperature alloys, etc. are only beginning. We
expect that, between the years 1980 and 2000, space technology
might make new breakthroughs. In addition to the use of the space
shuttle, a hugh space station will be built. Furthermore, in
order to solve energy problems, a huge solar energy satellite may
be built. There has been speculation that, due to recent extra-
ordinary progress in communications technology, the probability
of discovering creatures on other planets before the year 2000 may
be 50%. Space immigration may be possible by that time. There-
fore, as a foundation of spacecraft technology, material science

has surely made progress. Possible new materials include
(1) composite materials with fiber-poly base or metallic base.
which can survive up to 550°C, (2) high temperature hardened
alloy which can endure a temperature as high as 1200°C and also
has excellent thermal insulation, (3) beryllium alloys which
have small specific gravity, high strength, and high modulus
of elasticity.

Graphs: C. C. Wun

THE ROAD TO A PLANET

Yi-Lin Ju

Wei-Yu: Recently, I read a few articles on planet exploration. It is not clear for me: How does a spacecraft fly to a planet? Does it look like the one depicted by a fairy tale and fly straight ahead to the planet?

Yi-lin: The navigation to a planet is a more complicated problem. We can only roughly describe it. The first step for a spacecraft to a planet is to escape the gravity of earth.

Wei-Yu: That can be easily understood. But how can a spacecraft escape that gravity:

Break the Binding force of Earth

Yi-lin: The criterion for a spacecraft to escape the gravity of earth is: the spacecraft can fly to infinitely and never come back.

Wei-yu: I throw a stone as high as possible. It falls down in just a few seconds. A shell is fired to the sky with a velocity of 1 km/sec. It can only reach a height of 50 km at most, then falls down to the ground.

Yi-lin: Suppose a body flies straight up with a first universal velocity of 7.91 km/sec. Do you know how high it can fly?

Wei-yu: It is quite easy. Following the law of energy conservation, we obtain a formula $h = \frac{v2}{2g}$ (v is initial velocity, g is acceleration of gravity). Substituting already known numbers for v and g, we find out immedia-

tely that the height, h, is equal to 3,200 km.

Yi-lin: That is not right! The height should be 6370 km, which
is equal to the radius of earth. This is due to that
the gravitational force is inversely proportional to
the square of distance between the body and the center
of the earth. As the height increases, the accelera-
tions of gravity becomes smaller. g is not a constant,
so we cannot apply $h = \frac{v^2}{2g}$ directly to this case.
According to this reasoning, we find out that, as the
velocity of a body reaches $\sqrt{2}$ times of the first
universal velocity, i.e. 11.2 km/sec, the body can fly
to infinitely. This velocity is called the second univ-
ersal velocity.

Wei-yu: Who knows! When will the body reach infinitely?

Yi-lin: Theoretically, this seems to be very remote and endless.
As a matter of fact, once the body moves to a spot far
away from the earth, say one million kilometers, the
gravitational force will be reduced to only $\frac{1}{20,000}$ of
that on the earth's surface. The body can break the
binding force of earth and fly to the sun.

Wei-yu: One million kilometers is too far. This is a factor of
150 times the radius of earth, and a factor of 2 times
the distance between moon and earth.

Yi-lin: But, compared to the distances between planets in the
solar system, that distance is quite small. Are you
familiar with the solar system?

Wei-yu: I have read a few books on astronomy, so I do have some
knowledge about our solar system.

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Yi-lin: Very good. I don't want to go into detail about it.
           However, you have got to know three common character-
           istics for planet orbits. Our discussions on the
           planet orbits are based on these three characteristics:

           1. All planet orbits are elliptical with small
               eclentricity. We may consider them as circular
               orbits with the sun located at the center.
           2. The angle between a planet orbit and earth's orbit
               is relatively small so that all orbits are considered
               coplanar.
           3. All planetary motions are in the same direction. If
               observed from Polaris, they are counter-clockwise.

                      THE MOST ECONOMICAL PATH

Wei-yu: When a planet and the earth are located on the same
           radius of a circle centered at the sun, the distance
           between the planet and earth must be smallest. We
           should pick th's path for flight to the planet. This
           must be the fastest one (Figure 1)!

Yi-lin: Not really. When a spacecraft escapes the earth, it
           becomes a new artificial planet in our solar system.
           Its motion must obey Kepler's law for planetary motion,
           its path is elliptical with the sun as the focus. The
           scope of the ellipse is dependent on the relative velo-
           city of the spacecraft to the sum after it escapes the
           earth.

Wei-yu: How large is the velocity of a spacecraft when it escapes
           the earth with the second universal velocity?

Yi-lin: Its relative velocity to the earth is zero, while its
           relative velocity to the sun is equal to the velocity
           of the earth's motion, i.e. 29.8 km/sec. Its path is
           exactly the earth's orbit.

Wei-yu: Our goal is to make the spacecraft fly away from the
           earth's orbit, either to an inner planet or to outer
           planet. How can we manage this?

Yi-lin: The key point is to change the velocity of a spacecraft
           in our solar system. We have got to give the spacecraft
           appropriate velocity relative to the sun and it will move
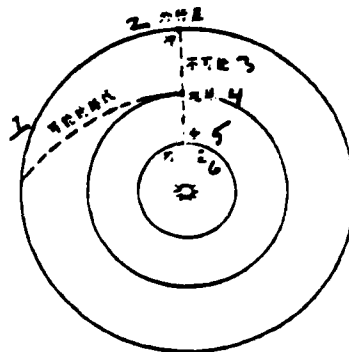
Figure 1. 1 - possible path; 2 - outer plant; 3 - impossible; 4 -
earth; 5 - overlapping; 6 - inner planet.

along the path. Its starting path must be tangential to
the earth's orbit, while the other end of major axis must
be tangential to the orbit of the planet of interest.
For example: when the relative velocity to the sun
reaches 38.6 km/sec, the major axis of its orbit will
extend to Jupiter's orbit; when the velocity is reduced
to 27.3 km/sec, the major axis is also reduced and
tangential to Venus' orbit (Figure 2). This orbit is
the fundamental path for possible planetary flight,
since it is sumultaneously tangential to the earth's

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orbit and the planet's orbit. The orbit is also called
"double tangent orbit" or "Hohmann orbit".

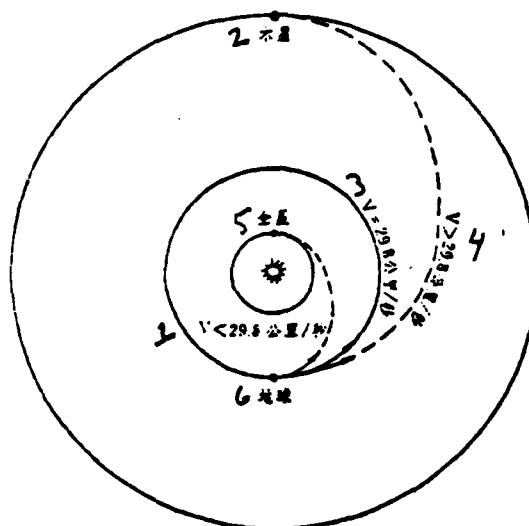Figure 2. 1 - V<29.8 km/sec, 2 - Jupiter, 3 - V - 29.8 km/sec,
4 - V>29.8 km/sec, 5 - Venus, 6 - Earth.

Wei-yu: See! Fly to a planet along the double tangent orbit.
          The object will cross almost half of the ellipse. This
          means billions of kilometers. It is certainly a long,
          long way to go!

Yi-lin: Don't think this is a long way. The velocity required
          for a spacecraft to move along this orbit is minimum.
          As a matter of fact, the double tangent orbit is the
          most energy-saving one.

                            THRUST

Wei-yu: As you just mentioned, the velocity needed to fly to
          Jupiter is about 8.8 km/sec greater than that of earth's
          motion, while that required to fly to Venus is about
          2.5 km/sec smaller than the velocity of earth's orbital
          motion. Does this mean that a flight to a planet

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requires two steps of acceleration: first accelerate
it to the second universal velocity, then, after it
escapes the gravitational force, it will be accelerated
once more?

Yi-lin: It is not necessary. Let us assume first that a space-
craft flies away from the earth with a velocity above
the second universal velocity, say 14.24 km/sec. After
it escapes the earth, what will be its net relative
velocity to the earth?

Wei-yu: The initial velocity is 14.24 km/sec. To overcome the
gravitational force, it takes 11.2 km/sec. Subtract-
ing 11.2 from 14.24, we obtain a net velocity of 3.04
km/sec.

Yi-lin: This is not correct. We should follow the law of energy
conservation. The magnitude of net velocity is equal
to $\sqrt{14.34^2 - 11.2^2} = 8.8$ km/sec, while the direction
of the net velocity is that of the initial velocity.
In the case where the spacecraft moves along the direc-
tion of earth's motion, the net velocity must add to
29.8 km/sec. On the contrary, if the spacecraft moves
opposite to that direction, its net velocity must sub-
tract from 29.8 km/sec.

Wei-yu: If that is true, the launch direction must be a very
important factor. We should launch a spacecraft to an
outer planet along the direction of earth's motion; to
an inner planet in the opposite direction.

Yi-lin: Your conclusion is quite right. Take the flight to Venus
as an example. The initial velocity for the spacecraft
should be $\sqrt{11.2^2 + 2.5^2} = 11.5$ km/sec opposite to earth's

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motion. Thus, when it escapes gravitational force, its net velocity is 2.5 km/sec. Subtracting it from the velocity of earth's motion, we obtain a velocity of 27.3 km/sec. Now you can compare the single time acceleration with double accelerations, and find out which way is best.

Wei-yu: According to the foregoing discussions, a flight to Jupiter requires a velocity of 14.24 km/sec for one time acceleration, and requires 11.2 + 8.8 = 20 km/sec for two accelerations. Similarly, a flight to Venus requires a velocity of 0.3 km/sec greater than the second space velocity for one time acceleration, while for two accelerations, it requires 11.2 + 2.5 = 13.7 km/sec. Apparently, "one time Thrust" is superior to a two stage effort
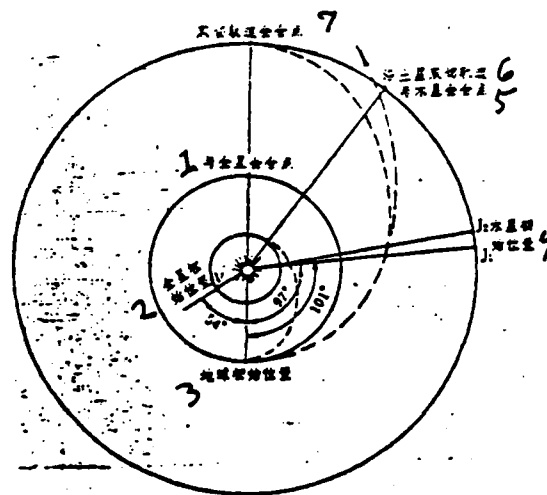

Figure 3. 1 - meeting position with Venus, 2 - initial position of Venus, 3 - initial position of earth, 4 - initial position of Jupiter, 5 - meeting position with Jupiter, 6 - along Saturn double tangential orbits, 7 - intersection of double tangential orbits.

Yi-lin: The following table lists velocity and time required to fly to each planet along the double tangential orbit.

This table may serve as a good reference for your study.

Planet	Initial Velocity	Relative Velocity To Sun	Flight Time
Escaping Earth	11.2	29.8	
Mercury	13.5	22.4	106 days
Venus	11.5	27.3	146 days
Mars	11.6	32.7	259 days
Jupiter	14.2	38.6	996 days
Saturn	15.2	40.2	6.05 years
Uranus	15.9	41.1	16.1 years
Neptune	16.2	41.5	30.8 years
Pluto	16.3	41.7	45.7 years
Escaping Solar System	16.7	42.1	

WHEN DOES THE LAUNCH WINDOWS OPEN?

Weiyu: I think the above discussion is the only solution for the spacecraft rendevousing with the planet's orbit and not with the planet itself.

INERTIAL GUIDANCE SYSTEM

Su-chuong Yam

The key point for an inertial guidance is to
measure the acceleration of a carrier accurately.
Accordingly, we must install an accelerometer on a
stable platform to ensure it is parallel with the
earth's surface. Technically, we call such a platform
an inertial platform. This article will discuss the
structure of a platform, its stability and how it com-
pensates the rotation of earth and the motion of an
aircraft.

STABLE PLATFORM

.The so-called platform, as shown in Figure 1, is a mechani-
cal apparatus composed of directional rings. When an airplane
rolls, climbs or turns, the apparatus still allows the platform
to maintain its initial state. The stability of the platform
relies on a spinning top which has an invariable axis and pre-
cession. (Refer to the article "Spinning Top and Inertial
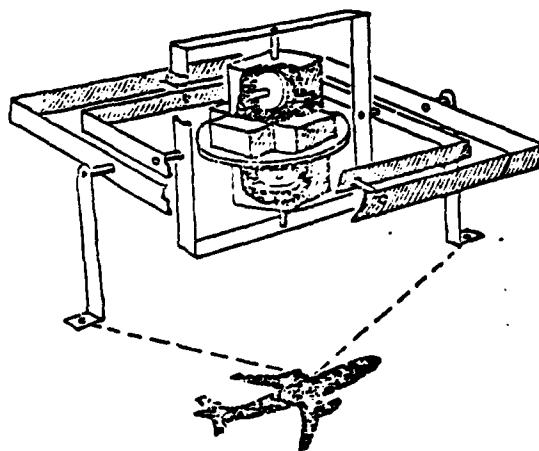Guidance" in October issue 1974).

Figure 1. A stable platform composed of directional rings.

To clearly illustrate a stabilization process, we show in Figure 2 a detailed structure. Shown in the figure is a spinning top supported by an axis with thin neck. The rotor in this spinning top performs high-speed rotation, powered by the electromotive force. Between the shell and rotator of this spinning top, we see a signal detector having two perpendicular axes. The signal detector can detect the deflection of the rotor. Beneath the rotor, there is a torque machine which contains two perpendicular axes. The torque machine can control the torque for the rotor for which a desired precession is obtained. Apparently, such a spinning top, with two control axes and two dimensions of freedom, can only control two axes XY. Generally speaking, a stable platform requires a stability for the third axis, i.e. z axis, which is perpendicular to the two XY axes. Thus, a three-axis stable platform requires two spinning tops, each with two dimensions of freedom.
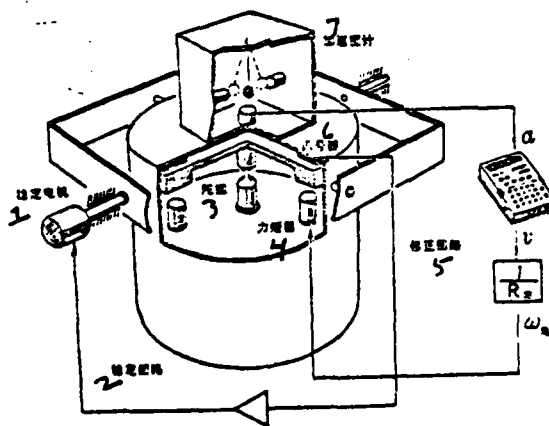
1 - stable electric machine; 2 - stable feedback
3 - spinning top; 4 - torque machine; 5 - correct feedback
6 - signal detector; 7 - accelerometer

Figure 2. An illustration of stabilization process for a platform.

To illustrate how to utilize a spinning top to stabilize components in a platform, we take the stabilization of a feedback as an example. Refer to Figure 2 again. As the directional ring

deflects around a stable axis due to external distrubances, the spinning top rotor maintains its position because its axes are fixed. Precession appears between the shell and the spinning top, and the signal detector will give a signal to reflect a deflection of the platform or the shell to the rotator of the spinning top. The signal will be reinforced by an amplifier and sent to the stable electric machine. A corresponding torque will be generated by this stable electric machine to drive the directional ring or shell back to its original direction. The signal detector will cease giving its signal when the platform or shell recovers its stable position. From the stabilization process of a platform, we can see that the rotor in a spinning top is a reference object for a stabilization process and is critical to the process.

A stable platform is involved in rotation along three axes - pitch, yaw, and roll. Therefore, in order to stabilize the whole platform, we need three stable feedbacks as mentioned above to ensure the stability of a platform.

SIMULATIVE STRETCHING PENDULM

To address the problem of a simulative stretching pendulm, let us recall some characteristics of motion of an airplane when it flies horizontally. We first want to emphasize that the topic on inertial guidance involves guidance over a global surface. It is evident that, when an airplane flies horizontally along earth's surface, it is rotating around the centre of earth. Furthermore, the velocity of an airplane relative to the surface, divided by the radius of the earth, is equal to the angular velocity of the airplace rotating around the earth. Thus, when an airplane flies along the surface of the earth with the aid of precession of spinning tops, we may try to control the spinning tops so that the platform has a precession equal to the angular velocity of the airplane around the earth. The platform will remain parallel to

the earth's surface. This is a realization of a stretching
pendulm.

    To simulate a stretching pendulm more explicitly, we integ-
rate the output signals from the accelerometer in the platform.
Then the velocity of the airplane flying along earth's surface
is obtained. Dividing the velocity by the radius of the earth
results in the angular velocity of the airplane relative to the
earth's rotation. The computations are performed by a computer.
The signal of angular velocity so obtained is then transmitted to
the torque machine in the spinning top. A corresponding torque
will be generated in the torque machine to control the precession
of the spinning top. The precession of the platform will follow
that of the spinning top through a stable feedback. The platform
rotates around the centre of earth with the same angular velocity.
This ensures that the platform will stay on a horizontal plane
all the time. We normally call this feedback for controlling the
spinning top correct feedback. Thus, if we compare this system
to a stretching pendulm, the accelerometer is equivalent to a
pendulm ball, the spinning top is equivalent to a support point,
while the computer simulates a pendulm support line of 6370 km
in length (shown as Figure 3).
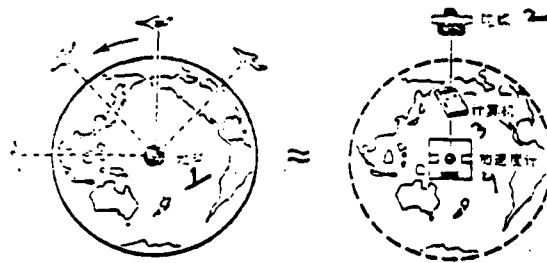

Figure 3. Illustration of a simulated stretching pendulm.
    1 - Earth; 2 - spinning top; 3 - computer; 4 - accelerometer.

Technically, we call a platform composed of spinning tops, accelerometer and directional unit an inertial platform. Such a platform not only allows an airplane to move in any direction, but also ensures a measurement of acceleration not affected by gravitational force.

The compensation for the rotation of earth and the motion of an airplane is as discussed above. Generally speaking, an airplane always moves along the earth's surface, while the earth is a deflecting globe which rotates relative to space. A spinning top is directed relative to the space. The direction of the sensitive axis of an accelerometer is determined by the spinning top thru the function of the stable platform. Consequently, if a spinning top is not controlled, a situation like the one shown in Figure 4 may happen. When observed from the north pole, an initially horizontal platform will eventually rotate relative to earth surface. This is because the earth rotates in space with that platform. Such rotation is normally called "apparent rotation." As a matter of fact, the earth rotates with an angular velocity of about 15 degrees per hour. In order to eliminate apparent rotation, an appropriate control torque must be exerted on the spinning top to adjust the platform to rotation (relative to space) at the same speed. Under such conditions, the platform may keep its horizontal position, and the acceleration measured by an accelerometer is the one along the sensitive horizontal direction, as required for guidance.

As for the motion of an airplane along the earth's surface, it is also similar to earth rotation. Suppose the platform is in a horizontal position when the airplane takes off. If the platform is not controlled, an apparent rotation will happen to the platform because of the motion of airplane along the earth's surface. The velocity of an airplane relative to earth's surface, however, can be calculated according to the acceleration, as mentioned above. Dividing the velocity by the radius of earth, the rotation

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speed of the airplane around the centre of earth is obtained. Thus, if the spinning top is controlled with such a speed so that the platform rotates around the centre of earth together with the airplane, the platform will no longer carry out the apparent rotation.
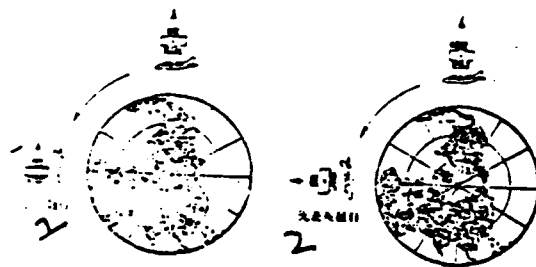

Figure 4. Apparent rotation of a platform installed in an airplane, as observed from the north pole.
1 - apparent rotation; 2 - no apparent rotation.

The apparent rotation of a platform, which is due to the earth's rotation and airplane motion, and its compensation method are discussed above. As a matter of fact, the earth's rotation and airplane motion affect the platform simultaneously. The process for compensating a platform is shown in Figure 5. Follow the numerical order in Figure 5: signals of acceleration output from the accelerometer are integrated by a computer to find the velocity of the airplane (2). A second integration of flight velocity leads to flight distance of the airplane (3); then transform flight distance to the angle around the earth's centre, to which the initial latitude of the starting position is added (4) to result in the latitude of the airplane location (5) Once the latitude is found, we may calculate the horizontal component of angular velocity of the earth's rotation for the compensation signal (6). The horizontal component of the earth's rotation on the equator is exactly the entire angular velocity of the earth's rotation, while its vertical component is zero. When the airplane flies either to the north or south, the latitude will be increased.

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The horizontal component will become smaller and vertical component will be larger. At the pole, the horizontal component becomes zero, while the vertical component is exactly the entire angular velocity of the earth's rotation.
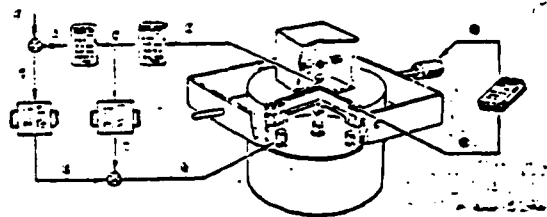

Figure 5. Compensation for apparent rotation.

In the meantime, the flight velocity (2) is treated by a computer, i.e.divided by the earth's radius, to result in the compensation signal for the speed of the airplane (7). Adding this signal to another compensation signal (6) will lead to a signal of compensation torque exerted on the spinning top (8). The signal is then transmitted to the torque machine of the spinning top. The spinning top, because of a torque generated by the torque machine, performs a precession following the compensation rotation speed. As the spinning top precesses, the signal detector in the spinning top delivers immediately the corresponding deflection signal.[9] The signal is then amplified and transformed into a current to drive the stable electric machine to generate a torque moment (10). The components of the directional ring, through the function of the electric machine, will deflect according to the compensation signal. Thus a total compensation for the earth's rotation and the motion of airplane is realized.

We should mention that the foregoing discussions only illustrate a concept of function of an inertial guidance system. In fact, there are some additional compensations which have not been discussed yet.

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A radio professional must know that, to measure an electrical resistance with a versatile meter, we must first perform zero-position calibration, otherwise the resistance cannot be measured accurately. For an inertial guidance system, calibration is also an important procedure. The inertial guidance system cannot be utilized without calibration. The inertial platform is located at a random position before the switch is turned on. Its position may neither be horizontal nor be directed to the north or any determined direction before switching. Thus an inertial guidance system, if not calibrated, loses its basis for guidance.

INITIAL CALIBRATION

The calibration is done on the ground. It is called initial calibration.

The so-called initial calibration is a process which, before the system is in the guidance status, enables the coordinates of an inertial platform to become consistent with the geographic coordinates, or at least provides a relation between them. In other words, in order to place an inertial guidance system in the normal operating condition, we must not only set its platform in a horizontal direction, but also know its direction relative to true north.

Although the inertial calibration is generally done on the ground, some sea-based airplanes or missiles may utilize the inertial guidance system on their carrier, so as to provide initial conditions for airplanes or missiles.

For initial calibration, we generally classify it into two categories: horizontal calibration and directional calibration.

Let us first review how to perform a horizontal calibration. As illustrated in Figure 6, first switch on the inertial guidance

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system, but the accelerometer is connected to a certain circuit
instead of a integration machine, so that the torque machine in
the spinning top is bridged to the accelerometer. If the plat-
form is not in a horizontal position, the pendulm in the accelero-
meter will deviate from the zero position due to the action of
the gravitational force and a signal will be delivered. Appar-
ently, as the deflection angle of the platform from horizontal
plane increases, the component of gravitational force exerted on
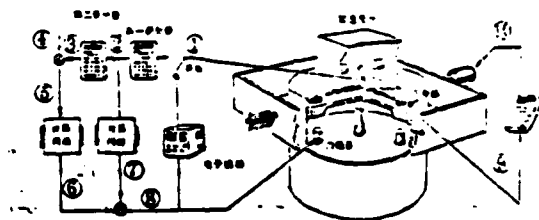the accelerometer also increases, and the output signal becomes

Figure 6.   Illustration of process of a horizontal calibration.

larger. The signal is then amplified and delivered to the torque
machine which generates a corresponding torque to drive the
spinning top in precession. The directional ring follows the
spinning top to perform precession through the stable feedback.
The platform will recover slowly to its horizontal position.
Whenever the pendulm line in the accelerometer completely overlaps
the vector of gravitational force, there is no longer signal out-
put and the platform is located along the real horizontal plane.

There are many ways to accomplish directional calibration,
but the most popular directional calibration for an airplane is
to utilize the spinning top effect to direct the platform to true
north or a certain direction form true north. The whole system
can accomplish its guidance function following the principles

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discussed previously.

THE CHARACTERISTICS AND IMPORTANCE OF
AN INERTIAL GUIDANCE SYSTEM

From above brief discussion of an inertial guidance system, we can see that the stable platform, composed of spinning tops and accelerometer and supported by directional rings, is the key part of an inertial guidance system. The spinning top enables an accelerometer to be stabilized in a horizontal plane along earth's surface. The accelerometer can then accurately measure the acceleration of an airplane relative to the ground. The velocity can be obtained by integration of acceleration through a computer. After some appropriate corrections, an accurate guidance signal is eventually provided. From these procedures we can see that an inertial guidance system is completely automatic. In other words, it does not have to receive any external signals nor does it transmit any signals to the outside to accomplish its automatic guidance function. In view of this, an inertial guidance system is essential to guide an airplane.

With an inertial guidance system, an airplane can fly over a desert or an ocean where no ground guidance stations and ground references are available.

A military airplane equipped with an inertial guidance system is not easily discovered because no electromagnetic waves are transmitted. This benefit not only enhances its security and survivability, but also upgrades its potential for unexpected attack.

An inertial platform not only provides signals for acceleration, velocity, etc., but also provides high-accuracy signals for position, which cannot be provided by other apparatus. These superior characteristics of an inertial platform allow a rocket or a missile to be launched more accurately.

SPEARS AND SHIELD IN
AN ELECTRONIC WARFARE

Jen-wu Wang

Spears and shields were popular weapons in ancient
wars. Spears are for offense and shields are for defense.
Weapons in modern war are the continuation and develop-
ment of these spears and shields. Aviation warfare is no
exception. The airplane and anti-aircraft artillery, the
missile and anti-missile were developed through a struggle
between the "spears" and "shields." The only difference
is that the modern spear and shield are more complicated.
The electronic apparatus is essential to every modern
weapon. Therefore, a struggle between the "spear" and the
"shield" surrounding the electronic apparatus becomes
inevitable. This is so-called electronic warfare. Elec-
tronic warfare is very extensive. This article discusses
some technical problems of electronic warfare in terms of
aviation electronic apparatus.

THE SPEAR IN ELECTRONIC WARFARE

A spear is an offensive weapon. All offensive apparatus in
an electronic warfare are called anti-electronic apparatus. More
explicitly, those apparatus, though electronic operation, are used
to destroy electronic apparatus of rivals. The operation includes
electronic detection, electronic interference and destruction.

Electronic Detection

Electronic detection means detector in electronic warfare.
It stays busy all the time, in peace time or war time. Its major
function is to collect various technical information on tactics,
which provide the basis for command, interference and destruction.

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For instance, if we can detect the parameters. frequency. pulse width, wave beam shape and scanning status of a radar of an enemy, we will be able to justify the type, deployment and purpose of that radar. Say, we measure the wave beam width of a radar antenna being 10°, the radar is probably a long-range one; if it is about 50°, the radar could be an alarm radar; it if is under 3°, then the radar is mostly an aiming radar or a guidance radar. Such information, of course, is very useful in aerial warfare. In order to gather this information, an aviation "detector", riding on a manned airplane or an unmanned airplane, penetrates into enemy territory. The detector may also ride on a satellite and orbit the world. Why is the detector so versatile? It depends on a detecting apparatus which can receive electro-magnetic waves and selected signals. The detecting apparatus is generally composed of two major parts as shown in Figure 1. One part is a front apparatus composed of antennae and receivers which function like eyes and ears of a detector. The other part is a terminal which acts like the "brain" of a detector.
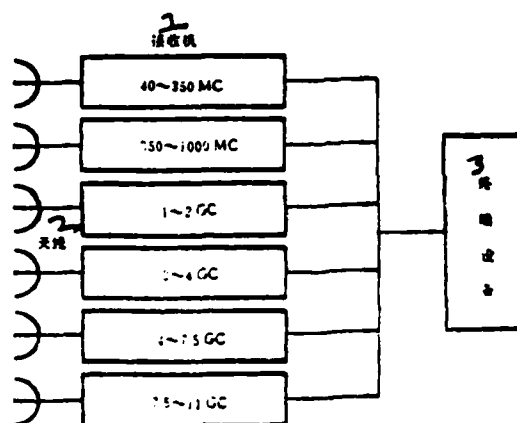

Figure 1. Composition of an electronic detecting apparatus.
1 - receivers; 2 - antenna; 3 - terminal

Front apparatus: The major function of this part is to dis-
cover a signal promptly. The signals may be distributed over a
broad frequency range and a large territory. The apparatus must
capture signals with high capture probability and within large
amounts. Accordingly, the major requirement for a detecting
antenna is to have a broad frequence band and the ability to
measure direction accurately. The detecting antenna on an airplane
must also be small in volume, light in weight so that it can be
easily installed with little air friction incurred. As for the
requirement for a detecting receiver, beside its ability to amplify
the signal, the most important one is to detect the frequency of
a signal promptly over a broad frequency range. For that purpose,
a variety of receivers have been designed. However, they can
roughly be classified into two categories: broad frequency band
receiver and narrow frequency band receiver.

A broad frequency band receiver is, in general, to measure
frequency with a non-searching method, i.e., the receiver, with a
fixed frequency, receives signals in entire detecting wave block
sumultaneously. This type of receiver can be classified into two
types: instant frequency measurement receiver and multi-channel
receiver. The instant frequency measurement receiver is, in fact,
a frequency selector with a broad frequency band. It transforms
a frequency signal into a phase signal through a frequency-phase
characteristic element. The frequency can be determined by phase
measurement. The phase can be measured either directly by an
apparatus for phase comparison or by transforming phase into ampli-
tude and then measuring frequency.

A multi-channel receiver divides the whole wave block into a
few sub-waveblocks. When a signal appears, it is received by a
certain sub-waveblock. The frequency of a signal can be deter-
mined according to the central frequency of that sub-waveblock.
Such receiver can only roughly determine signal frequency. Since
its accuracy depends on the number of wave channels. the more

accurately it measures, the larger the number of wave channels is. The apparatus must be a huge one. It is not appropriate to be installed in an airplane.

A narrow frequency band receiver in general applies a searching method to measure frequency. It can accurately measure the frequency of a signal. The compressed receiver of fast frequency searching is the one which may be extensively developed in the future. Its sensitivity is comparable to an ultra external difference receiver. However, its measurement time is even better and can be as short as about 10 μsec.

Terminal apparatus: Terminal apparatus is regarded as the brain of a detecting apparatus. It is for measurement, analysis, storage and management of parameters of electromagnetic signals. A new terminal apparatus is mainly an electronic computer. Some new terminals can analyze signals form five detecting receivers simultaneously. The data management capability for them can reach 2.5×10^5 pulses/sec.

With the tremendous development of electronic techniques, the environment for an electronic warfare becomes more complicated. The difficulties faced by an electronic detector become more severe. Improved sensitivity, quick response, and particularly capability for self-adjustment, are emphasized in computer applications.

Electronic Interference

Electronic interference is equivalent to an "unexpected attacker." It is primarily for offense. The way to offend is "suppression" and "cheating" which will make electronic apparatus of the enemy to work abnormally or lose its function. Generally, the interference can be classified into two categories: source interference and non-source interference.

Source interference is also called "active interference."
The interference source for such interference irradiates the
electromagnetic waves in order to destroy the electronic appar-
atus of enemy. Destruction methods include suppression and
cheating.

How can one exert suppression? By enforcing suppression
interference. The most popular one is noise modulation interfer-
ence, since its frequency band is very extensive and the pressure
effect is excellent. The function of suppression interference is
to make the return wave signal received by enemy electronic
apparatus merge into an interference signal so that the signal
displayed is a blurred one or part of a bright fan (Figure 2).
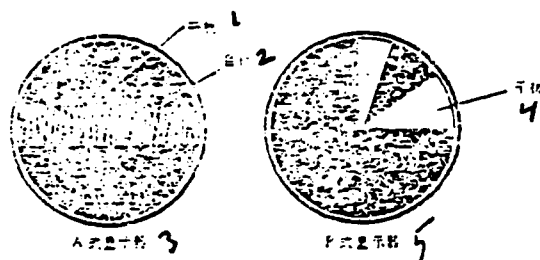
1 - interference; 2 - target; 3 - type A display; 4 - interference;
5 - type P display

Figure 2. The interference displayed during pressure interference.

If the frequency of electronic apparatus of the enemy is roughly
known, noise aiming style of interference is possible, which can
effectively interfere with the power. In the microwave frequency
range, its interference bandwidth can reach 9 G Hertz to 20 G
Hertz. In the meantime, if the frequency of the enemy electronic
apparatus is not accurately measured, a retarding style of noise
interference may be adopted. The bandwidth of the interference
can be over 100 G Hertz. The advantage of this type of interfer-
ence if its ability to interfere with many electronic apparatus
simultaneously. Moreover, it does not need additional complicated
frequency-aiming apparatus. Compared with aiming interference,

there is a defect. It requires larger interference power, and the waste of interference power is very serious. In order to intensify the energy as well as interfere over a broad frequence range, we may simultaneously operate a few noise interference machines of retarding style, each with different frequency block. Those different frequency blocks are connected together to cover entire operational frequency range. This will be equivalent to a broad band retarding interference.

How does one carry out cheating? By generating a phony target signal by artifically emitting or transforming electromagnetic waves. Such operation may confuse the enemy electronic apparatus. The electronic apparatus may receive false signals and make a wrong judgment or decision. We call this operation source cheating interference. The best source cheating interference is responsive pulse interference. An interference machine receives a signal, then responds with one or a few modulated phony pulses which have the same frequency as the signal. The enemy electronic apparatus will receive false signals. There are many types of source interference. In a modern warfare, they are mixed together for operation. Recently, a new interference machine has been invented, which not only operates noise suppression interference, but also enforces cheating interference.

Non-source interference is also called "passive interference." "Passive" means that the interference instrument does radiate electromagnetic waves, but only reflects or absorbs it. The non-source interference is also in same two categories: suppression and cheating. The non-source suppression interference is based on some materials which can reflect electromagnetic waves and generate a messy interference wave shape on a display screen. The materials include metal fibres or bands, fiber glass with a metallic layer and metallized reflective materials. The most popular one is an interference fibre with a metallic layer, with a length equal to half of the wavelength or a multiple integer of one half

the wavelength of interfered radar wave. Since the effective
reflection area for an interference fibre is very small. we
usually launch a great deal of interference fibers to generate
effective interference. For convenience, those fibers are con-
tained in a bunch. Each bunch may contain thousands or millions
of fibers. Bunches of fibers are launched from airplanes and
scattered in the air like a cloud. We call it "interference
cloud". The interference cloud will generate a longer "bright
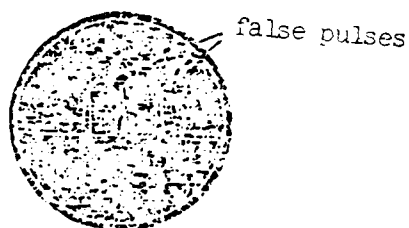band" (Figure 4).

Figure 3. False pulses appear on a display screen during cheating
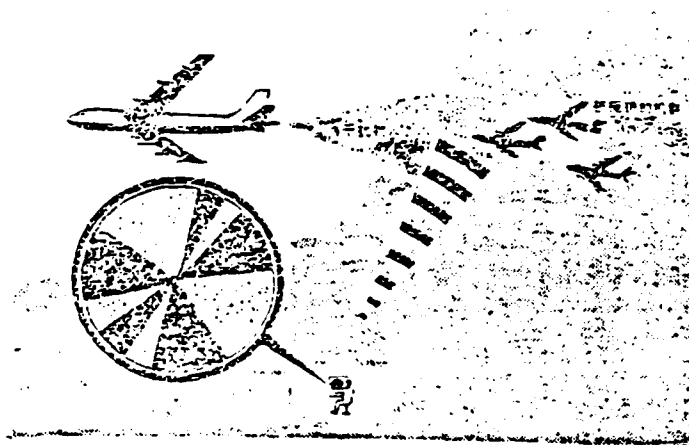interference.

Figure 4. Non-source suppression interference.

Non-source cheating interference mostly utilizes radar bait.
The bait is also called a "false target." The popular false tar-
gets currently used by foreign countries include bait missile,

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remote control aircraft, unmanned airplane, etc. Such false targets, once launched, can mingle with real targets. For instance, the "Fire-bee" -2 used by the USAF is a false target aircraft, which has been used to cheat and interfere with x-band wave radar. The effective reflection area for "Fire-bee" -2 is over 30 m^2, which is equivalent to that of a light weight bomber. The characteristics of velocity and reflected waves for a "Fire-bee" -2 are very similar to that of a real target. Besides the crafts mentioned above, an angular reflector is also an effective non-source apparatus for cheating interference. The reflector is composed of three perpendicular conducting planes to generate composite reflections. The reflector reflects electromagnetic waves from various directions along their original directions and generates very intense reflected waves. A very large target can be simulated by a relatively small angular reflector.

There are varieties of electronic interferences. Currently, we can list over 100 types of source interference and over 40 types of non-source interference. Unfortunately, none of them is perfect. In air combat we probably will mix many types of interference to generate the best effect.

THE SHIELD IN ELECTRONIC WARFARE

A shield is for defense. Every defensive apparatus in electronic warfare is called electronic defensive operation, i.e., electronic anti-interference. The content of electronic anti-interference is very extensive. Strictly speaking, every electronic apparatus has its problems regarding anti-interference, particularly for military electronic apparatus. In modern warfare, an electronic apparatus cannot be operated without an anti-interference installation. This article only introduces several radar anti-interference operations in terms of air warfare. The shield is developed for a certain spear. Similarly, anti-interference operation is developed for an interference operation.

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ANTI-SOURCE INTERFERENCE

Noise interference is most popularly used, and is a source interference which is more difficult to overcome than others. Its interference characteristic is to enlarge the noise level and to blur a target on the display screen of a radar. In order to circumvent such interference, we may carry out two types of operations:

1. Intensify the reflected wave from a target;
2. Make it hard for the enemy to detect the frequency we use.

In order to intensify the reflected wave, we should enlarge the radiation power of the radar. Phase-controlled radar is a new apparatus which has a potential to increase power. On the other hand, in order to escape the detection of the frequency we use, current methods of operation include frequency jumping frequency branching and frequency block expansion. To rapidly transform an operational frequency of a radar into either a different or the same frequency block is called frequency jumping. Recently, a new type of radar called "swift frequency transformation radar" has been designed. Its function is to transform an emitted pulse into a substantially different frequency located in a broad frequency band. The time required for the transformation may be as short as a few micro seconds. With the use of a radar of this type, the enemy will be unable to perform aiming interference in time and be forced to apply broad frequency band retarding interference which will dilute its interference power and degrade its interference effect.

What is frequency branching? This involves operating many transmitters and receivers at the same time to transmit and receive electromagnetic waves of different frequencies. Each transmitter transmits high frequency pulses with different carrier frequency. However, all pulses have the same width and same repetition frequency. The transmitters are controlled by a timer to transmit

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electromagnetic waves in a consecutive time order. Each receiver receives corresponding high frequency reflected wave signals. All return signals received by every receiver are collected by a signal transaction instrument which synchronizes all signals and delivers them to a display. The transaction instrument can also add or multiply signals to upgrade anti-interference capability.

In addition, an expansion of radar operation frequency range may contribute to anti-interference too. When a frequency block is jammed, we can use other blocks for operation.

Anti-non-source Interference

Since non-source interference has different characteristics from source interference, it may not be effective to use operations such as transmitting power enhancement or frequency jumping to suppress non-source interference. As mentioned before, its advantages are extensive distribution area and low speed for the interfering object. In view of this situation, a mobile target display technique may be used. The major function of a mobile target display technique is to exploit the velocity difference between a mobile target and a fixed target, then to distinguish a high speed mobile target from a fixed target or a low speed target. However, a pulse Doppler radar may serve the same purpose. We will not discuss it in detail here.

Following the development of new techniques for anti-electronic operation, the anti-interference capability for an electronic apparatus must be reinforced, otherwise the radar will miss its target, communications will be broken and weapon will lose its control. In addition to some technical operations, it is necessary to have other preparations in warfare. For example, prepare different types of electronic apparatus, rarely operate those apparatus if not necessary, prepare different frequency ranges, etc. These protective arrangements certainly upgrade the defensive capability for the apparatus.

A shield is designed against a spear. The development of electronic techniques initiates the development of anti-electronic operation. Similarly, the anti-electronic operation in turn helps a new development of electronic techniques. It looks like a struggle between a spear and a shield, and upgrades electronic warfare. In some sense, future warfare must be an electronic one. Particularly for an air warfare, it depends heavily on electronic apparatus of which the quality determines the survivability of an airplane. Many countries have regarded that an edge on electromagnetic in future warfare is just as crucial as controlling the sky in World War II. In order to solidify our national defense, we must keep our eyes on new developments in electronic warfare and develop new techniques for electronic warfare.

Plots by J. A. Chang

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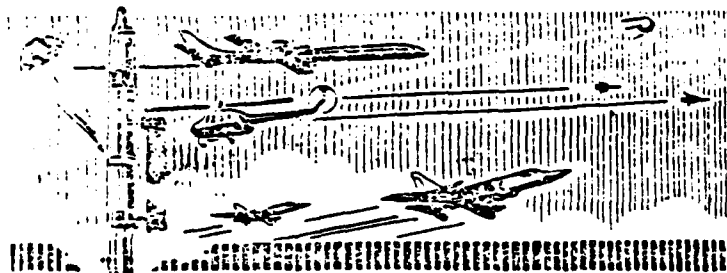
There are thousands of events related to aviation
and space activities in the world each month. Here is
some news which the editor considers relatively important
and interesting.

The 30th International Annual Meeting on Space Navigation

One thousand representatives from over thirty countries
attended the International Space Meeting in Munich, West Germany.
This meeting is the 30th International Annual Conference on Space
Navigation, held from September 17 to September 22. There were
over 450 research and development reports presented at the meeting.
The contents of the presentations are very extensive, including
communications satellites, orbital solar cell stations and prob-
lems on whether there are civilizations existing in outer space
or not.

The Minister of Bavaria, West Germany, Mr. Strauss, held the
open session. He discussed more international cooperation in
space science techniques.

The Carrier pigeon "Deep Rain" won the championship. On
September 15, the Fourth National Athletic Meeting was held in
the Beijing Worker Stadium. In its open session, two thousand
carrier pigeons were launched. Among them, one male pigeon named
"Deep Rain" is less than one year old. He has pretty eyes. His
wings were stamped with "Flying Competition, National Athletic
Meeting." At 4 p.m. on September 15, he left the stadium. Then
he flew over four provinces and two district cities in 4 days and
18 hours and 45 minutes. The total trip is 1058 km. The average
speed is 9.2 km/hour. He was the first to arrive at Shanghai at
10:45 a.m. on September 20, and won a championship for the Beijing-
Shanghai's carrier pigeon competition. His accomplishment broke
a record set up at the Second National Athletic Meeting held four-
teen years ago. The old record was a little over nine days.

Expenses on R & D in the World - Recently, the World Obser-
vatory Research Institute located in Washington, D.C., published
a research report. It pointed out that current expense on R & D
for the whole world is about 150 billion and there are about 3
million scientists and engineers involved in it. The expense
for military R & D is largest and is approximately a quarter of
entire R & D expense. The percentage of budget for each category
is: military 24%, basic research 15%, space technology 8%, new
energy source research 8%, health research 7%, information
research 5%, transportation 5%, air pollution control 5%, agri-
cultural science research 3%, others 20%.

The World Observation Research Institute is a private organi-
zation. The author of the report also said: "The above percen-
tages are only rough estimates. However, it is certain that the
manpower and resources spent on military research is more than
that spent on health, agriculture, energy and environmental protec-
tion together.

Two British Jet Fighters Crashed - on September 21, two jet
fighters of the British Royal Air Froce crashed in Cambridge
County, southeastern England, during a training flight. Two pilots
landed safely with parachutes. One fighter fell to a non-residen-
tial area, while the other one crashed in a suburban area. Three
houses were destroyed and two persons were killed.

A Group of Members of the Chinese Aviation Association
Attended AIAA Annual Meeting - A group of 7 members representing
Chinese Aviation Association, led by Mr. Jui Wun-mei (group
leader) and Mr. Chang Guei-len, attended the American Institute
of Aviation Association (AIAA) Annual Conference beginning on
August 20. Our members presented two papers on the conference,
which drew much attention. The conference lasted three days.
There were 200 attendees from the United States and other countries.
Most of them are aviation scientists and engineers. Our members

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were also invited to visit AIAA headquarters, Grumman Aircraft Company, New York University, University of Pennsylvania, etc.

Mammals Participate in Space Procreation Test for the First Time - On September 26, Russia launched a biology satellite "Universe-1129" which was scheduled to stay in space for 20 days and then return to the ground. The satellite carries eight mice, six of them are female and will be pregnant in   ew days after launch. In addition, the satellite also carrie. some eggs from Japan which will be hatched by an incubator. This is the first time the development of embryos of mammals and fowl are being studied in an environment of no gravity. There has been only one procreation test in space for drosophilia before. The scientists in the United States, France, Romania, Czechoslovakia, Hungary and Poland participated in this "space mice" research.

USAF Starts to Develop MX Mobile ICBM - The U.S. President, Jimmy Carter, recently announced that he had approved development and production of 200 new large MX mobile ICBMs. He also decided to deploy those missiles in a desert located in Utah and Nevada. On Spetember 13, the USAF, following Carter's announcement, signed contracts with four big companies with a total budget of 97,840 million. An extensive development of MX missiles thereby pushes ahead.

The MX mobile ICBM is a new strategic weapon system of the U.S., which is developed to counter a Russian ICBM strike. The characteristic of the system is its mobility for which Russia could not determine the exact location of each missile. In case Russia initiates an unexpected strike on the United States, those missiles may not be all destroyed at their sites. The current project suggests the building of special railroads with many branches which connect 4600 sites. Each missile can be stored in one of 23 sites. The missile is carried by a train which runs in a tunnel to confuse the enemy. The U.S. plans to deploy the MS to replace the existing fixed ICBM.

Four-step solid fuel rocket engine will be installed in the
MX missile. Each missile has a weight of 36 tons and carries 10
warheads for different targets. The first test is scheduled in
1983. In 1986, some MX missiles will be deployed. The 200 miss-
iles will be completely deployed in ten years. The total budget
is 33 billion. However, this project has been criticized in the
U.S. Congress for its excessive expenses.

Glider Flew over English Strait - On August 26, a British
glider trainer, Gary Burlin, flew a dynamic glider over the English
Straight through a storm. The weight of his glider is about 53
Kg; the length of wing is 22 m. He took 50 minutes to fly from
England to France, passing a storm with a speed of 24 km/hr. He
said to reporters after landing: "I passed a cloudy and foggy
Strait and almost lost my direction. I was scared. Fortunately,
an accident did not happen."

A Group of American Science Writers Visited China - Early in
September, a group of American science writers visited China.
The group, with 11 members, was led by Carlston (Group Leader),
the news editor of the "Scientific American" magazine, and Perlman
(Assistant Group Leader), a science editor for a San Francisco
newspaper. The group includes science editor, column writers and
science reporters with well-known newspapers and magazines such
as the New York Times, Time, etc. Some of them write or edit
reports on aviation and space science for "Aviation Week" and
others. On September 9, Chinese science writers exchanged infor-
mation with them and held a dinner party for them. The Chinese
Science Writer Association was founded in August of this year.
The first conference was held in Beijing. An executive committee
was organized during the conference. Mr. Chun-tsai Duong was
elected as chief executive; Mr. Ji-Jer Wun, Mr. Wun-da Wang were
elected as deputy executives; Mr. Chung-lin Wang was elected as
secretary in general.

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Russian ER-86 Jumbo Jet - According to a report of "Moscow Evening News" on September 15, the first Russian wide body Jumbo Jet "ER-36" will be in service in the coming spring. The jet is currently performing test flights from Moscow to New Siberia City, Tashkent and Alma-Ata. The jet can carry 350 passengers. There are two stories, upper one for passengers, lower one for cargo. The flight range is 3600 km.

Wide-body jet plane is a new product civilian aviation. The United States has been leading in this technology for a while. Boeing-747, DC-10 and L-1011, all made in the U.S.A., have been in service for many years. The A-300 Air Bus is an European cooperative product, and also a wide-body jet. Although the Russian ER-86 was tested three years ago, the jet was delayed for service bacause of technical problems, particularly of the problem on the high power turbine fan engine. The Russian government has been trying to buy engines from the British or the United States, but the deal was not made. The western aviation professionals perceive that the goal for ER-86 was originally set to 400 passengers and 4600 km range, which have been reduced due to engine problem.

The World Radio Administration Meeting was held at Geneva - On September 27, the World Radio Administration Meeting, sponsored by the International Communication League, was opened in Geneva. The attendants are over 1700 representatives from 150 countries including China. The meeting will last 10 weeks. The main purpose of this meeting is to revise international radio regulations.

For a long time, highly developed countries, in particular the two super-powers, with their advanced technology, occupy advantageous radio frequencies and positions of synchronous satellites. Many underdeveloped countries complain and oppose this tendency. They request, based on eaual rights, a new arrangement of frequency range and position of synchronous satellites. The meeting is to discuss these problems.

It is conceivable that a better arrangement of radio frequencies and position of synchronous satellite is crucial to many countries. If frequency channels could not be well distinguished, scientifically, the radio communication for aircrafts, boats and satellites would be jammed and disasters could happen. The locations for synchronous satellites are very limited. For some advantageous locations, such as those over the Pacific, Atlantic and Indian Oceans, a communication satellite or a meteorological satellite can work better than over a desert. The struggle for a new arrangement of frequency channels and satellite locations is one of many aspects to set up a new international economical order.

"Pioneer II" Explores Saturn - "Pioneer II" spacecraft was launched by the United States in April, 1973. In early September this year, it passed by Saturn. An exploration of Saturn has been performed. This is the first spacecraft to reach the second largest planet in our solar system. The pictures taken by "Pioneer II" for Saturn have been transmitted to earth. An American scientist said in a press conference on September 6, "Our information on Saturn has been increased over one thousand times because of this exploration."

The "Pioneer II" discovered a new satellite and two new rings for Saturn. It also discovered a very unusual magnetic field in Saturn.

USAF F-15 Fighters Have Been Deployed in Asia - On September 29, 16 USAF F-15 Hawk fighters flew over 12,000 kilometers from continental U.S. to Okinawa USAF base. The USAF Commander at Pacific Ocean, Lieutenant General James Hughes, was at the USAF base to welcome the arrival of those fighters. This is a beginning of the U.S. - Japan joint efforts to replace old fighters by new models in the Asia - Pacific area.

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The F-15 fighter is a product of McDonald-Douglas Company in the U.S., mainly to replace current F-4 fighter. F-15 is a supersonic fighter designed to take control in air warfare. The assumed rivals include Russian MIG-21, MIG-23, MIG-25, S-15, etc.

F-15 airplane is equipped with two turbo-fan engines, each with a propulsion force of 11, 340 Kg. The body structure includes a great deal of titanium alloys, more than one quarter of the airplane weight. At high altitude, its maximum speed can reach 2.5 times of sound of speed. Its range is about 1000 km. The F-15 was developed and designed since early 70s. The first flight test was in July 1972. Beginning in 1975, F-15s were used to replace the F-4. However, this is the first time F-15s are being deployed in the Asia-Pacific area. According to reports, in view of continuous reinforcement of Russian military force in the Asia-Pacific area, the U.S. and Japan are taking action to enhance their air force and naval capabilities. There will be 72 F-15 USAF fighters deployed in Okinawa next summer, while Japan Air Defense Force has decided to procure 100 F-15 fighters in a few years to replace its old F-104 Star fighters.

Currently, there are two models of the F-15, i.e. F-15A, a single pilot fighter, and F-15B, a double pilot training fighter (can be used in air warfare too). There are approximately 390 F-15A and F-15B fighters in service now. The improved model F-15C is in the testing stage. McDonald-Douglas Company has decided to stop production of the F-15A and F-15B this year. They are going to produce the improved F-15C (single pilot) and F-15D (double pilot) which are expected to have larger fuel loads.

Eyewitness of UFO - According to a report of AP, a fifty-three year old Japanese pilot saw and photographed three different unidentified flying objects (UFO) on August 17, located approximately 80 km north of Tokyo. The pilot is a member of the Japan Air-Defense Force. He was returning to a base near Tokyo when he

saw the UFOs. Among the three UFOs, two are orange colored objects, one is a white ball. They followed his airplane for almost 15 minutes. AP has distributed those UFO photographs. Also reported by a western communication association, there appeared a bright flying disk in the south of Spain in September. It stayed for a few minutes and then flew away. Some eyewitnesses also took pictures of it.

Editor: C. Hsieh
Pilots: H. Kao and H. Y. Wu

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