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# CHINESE SPACEFLIGHT SATELLITE COMMUNICATIONS SYSTEMS

Zhang Liyu

Translation of "Zhong Guo Hang Tian Wei Xing Tong Xin Xi Tong"; Aerospace China, No.11, November 1991, pp 37-39

## I. SATELLITE COMMUNICATIONS

Satellite communications are a type of new model communications technology which has developed recently along with space technology. Satellite communications, satellite television, and satellite broadcasting possess a good number of advantages such as long communications range, large coverage areas, high reliability, maneuver flexibility, as well as large system capacity, and so on. At the present time, satellite communications development is very fast. Application ranges grow more extensive by the day. Various countries of the world are all paying extremely great attention to it. In conjunction with this, large amounts of technological strength and funding have been put into it. China's aviation and spaceflight industry departments are--at the same time as developing launches of applied communications satellites--fully bringing into play the advantages of spaceflight technology, exploiting the development of satellite communication earth station equipment and setting up China's spaceflight satellite communications system. In conjunction with this, a structural system associated with "the combination of satellites and earth, the integration of satellites and earth" has been formed step by step.

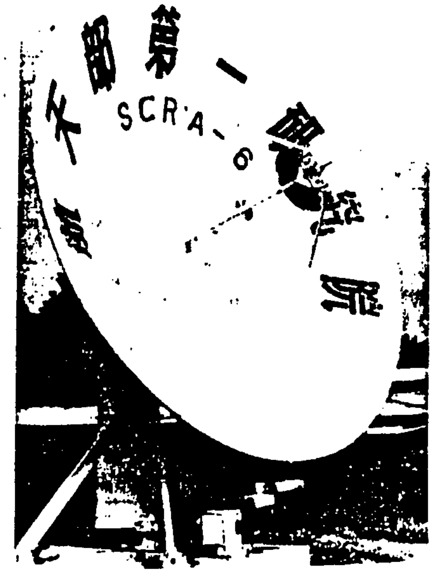


Fig.1 Satellite Communications Antenna

[The author of this article is a deputy chief engineer at the Beijing telemetry technology research institute.]

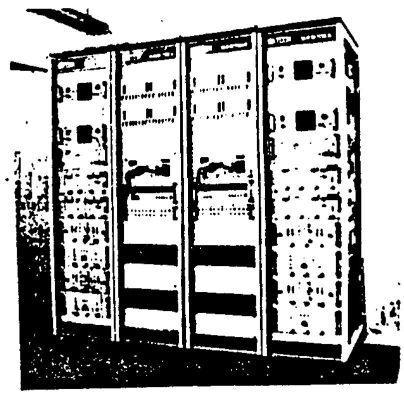


Fig.2 Satellite Communications Equipment

It is common knowledge that China depends entirely on our own strength. Use was made of the Long March No.3 carrier rocket to successfully launch an experimental model of communications satellite and 4 models of communications satellites for practical use.

On 8 April 1984, an experimental model of communications satellite--the East Is Red No.2 (Dong Fang Hong-OB)--was launched for the first time. The satellite in question was positioned in equatorial airspace at east longitude 125°. It was used in communications technology experiments.

On 1 February 1986, the first practical model of communications satellite, DFH-OC, was launched. The satellite in question was positioned in equatorial air space above 103° east longitude. It was used in satellite communications, broadcasting, and television transmissions.

On 7 March 1988, the second model of practical communications satellite, DFH-AA, was launched. The satellite in question was positioned in equatorial air space above 87.5° east longitude. It was used in satellite communications, broadcasting, and television transmissions.

On 22 December 1988, the third practical model of communications satellite, DFH-AB, was launched. The satellite in question was positioned in equatorial air space above 110.5° east longitude. It was used in satellite communications, broadcasting, and television transmissions. /38

On 4 February 1990, the fourth practical model of communications satellite, DFH-AC, was launched. The satellite in question was positioned in equatorial air space above 98° east longitude. It was used in satellite communications associated with government departments.

Following along with increases in the numbers of Chinese communications satellites, satellite television and satellite communications earth stations developed like bamboo shoots after a spring rain. At the present time, China already has several tens of thousands of domestically produced satellite television ground stations and several hundred satellite communications and satellite data ground stations used in China's hinterland regions, government agencies and departments, industrial enterprise units, as well as institutions of higher learning. The development and production of satellite television and satellite communications earth station equipment has already become another large new type of production associated with Chinese spaceflight.

## II. SPECIALIZED SPACEFLIGHT SATELLITE COMMUNICATIONS NETWORKS

China's spaceflight satellite communications network opts for the use of interchangeable international and domestic technical standards and designs. Specialized spaceflight satellite communications networks are primarily composed of the central station set up in Beijing, regional stations in various places throughout the country, and various mobile stations. The central station has an 11 meter antenna. It possesses several tens of secure telephone, ordinary telephone, secured data, and facsimile channels. The 6 meter antennas at regional stations are set up at spaceflight bases associated with various provinces and cities throughout the country. They are equipped with secure telephone, ordinary telephone, secured data, and facsimile channels.

Specialized spaceflight satellite communications networks, in terms of design, also have their originalities. They possess multiple frequency signal command ports, single frequency signal command ports, and direct current signal command ports. They opt for the use of real time multiple task operating systems. In conjunction with this, they make use of C language programming. The systems in question apply Demand Assigned Multiple Access (DAMA). They realize autoadaptive dispatching. Voice and data terminals have increased encryption and decrpytion equipment. They opt for the use of a one time pad, unbreakable encoding technology. The whole station is automatic monitoring and automatic tracking.

After specialized spaceflight satellite communications networks are constructed, they are not only capable of star shaped net working. They are also capable of net shaped links. Without doubt, the nets in question possess important economic benefits and social benefits with regard to the development of China's spaceflight enterprises.

Parameter Table for Technical Properties Associated with Chinese Spaceflight Satellite Communications Earth Stations

| Seq. No. | Parameter | Operating Characteristics |
|---|---|---|
| 1 | Radio Frequencies | Transmission Frequencies: 5925-6425MHz<br>Reception Frequencies: 3700-4200MHz |
| 2 | Gain-Noise Temperature | 11 Meter Antenna $G/T > 30+20\lg\frac{f(GHz)}{4}(dB \cdot K)$<br>6 Meter Antenna $G/T > 25+20\lg\frac{f(GHz)}{4}(dB/K)$ |
| 3 | Antenna Gain | 11 Meter Antenna: Transmission<br>$Gt > 54.8+20\lg\frac{f(GHz)}{6}(dBi)$<br>Reception<br>$Gr > 51.8+20\lg\frac{f(GHz)}{4}(dBi)$<br>6 Meter Antenna: Transmission<br>$Gt > 49.2+20\lg\frac{f(GHz)}{6}(dBi)$<br>Reception<br>$Gr > 46.2+20\lg\frac{f(GHz)}{4}(dBi)$ |
| 4 | Antenna Side Lobe Characteristics | Transmission Gain: $G=29-25\lg\theta(dBi)$, $1° < \theta < 48°$<br>$G=-10(dBi)$, $\theta > 48°$<br>Reception Gain: $G=32-25\lg\theta(dBi)$, $1° < \theta < 48°$<br>$G=-10(dBi)$, $\theta > 48°$ |
| 5 | Radio Frequency | Selection Made of Left or Right Circular Polarization or Vertical/Horizontal Polarization |
| 6 | Antenna Axial Ratio | 1.06 |
| 7 | Antenna Pointing Control Range | Automatic Tracking, Azimuth ±90°, Elevation 5°-90° |
| 8 | Reception System | 11 Meter Station: $T_R < 55K$, 6 Meter |

| | | |
|---|---|---|
| | Noise Temperature | Station: $T_R < 85K$ |
| 9 | Deviation Beam Radiation | Conforms to CCIR Rec524-1 |
| 10 | Stray Radiation | Outside Band: 4dB(W/4kHz); Inside Band: -50dBC |
| 11 | Frequency Spectrum Side Lobes | -26dBC |
| 12 | Omnidirectional Effective Radiated Power | Stable Value Is ±0.5dB/24h |
| 13 | Frequency Links | Up Links: Voice 300-3400Hz/Code Rate 32kbps/Intermediate Frequencies 450kHz ->47.45MHz->70±18MHz->1182.5±18MHz/Radio Frequency 5925-6425MHz<br>Down Links: Radio Frequency 3700-4200MHz/Intermediate Frequency 1042.5±18MHz/70±18MHz->47.45MHz->450kHz/ Code Rate 32kbps/Voice 300-3400Hz |
| 14 | Modulation | CVSD/BPSK/SCPC, Channel Interval 45kHz, Channel Band Width 38kHz. When Input Signal Noise Spectrum Density Is 11.2dB, the Erroneous Code Rate Is Better than $10^{-4}$. Output Weighted Signal to Noise Ratio Better than 26dB (-30-0dBm Test Measurements) |
| 15 | Signal Command Ports | M Line, ±48VDC; E Line, Supplies On Off Loop; In Addition, Equipped with Automatic Program Control Multiple Frequency and Single Frequency Commutator Ports |
| 16 | Other Ports | DAMA Ports, Encryption/Decryption Ports, Capacity Expansion Voice Channel/Data Ports |
| 17 | Environmental Requirements | Components Out of Doors: -30°C--50°C<br>Components Indoors: +5°C--35°C<br>Relative Humidity: 0--95% (when 25°C)<br>Wind Loads: Stable Level 6 Winds, Gusts to Level 8, Operations Normal. With Level 12 Winds, Stored, Will Not Be Destroyed (Antenna Toward the Zenith).<br>Electric Power Sources: 380VAC, 220VAC ±10%, 50Hz±10% |

/39 III. SPACEFLIGHT SATELLITE COMMUNICATIONS EARTH STATIONS

Spaceflight satellite communications earth stations are composed of antennas, feed sources, antenna bases, automatic tracking antenna control devices, high power amplifiers, low noise amplifiers, up/down convertors, frequency synthesizers, intermediate frequency common user equipment, pilot receivers, single channel per carrier (SCPC) terminals (including encryption/decryption components), equipment for official business, radio frequency control components, echo suppressors, signal command ports, and DAMA. These are used to construct satellite communications earth stations such as central stations, regional stations, mobile stations, and so on associated with various types of different utilization situations. The types of earth stations in question provide continuous voice channel data services associated with variable slope increment encoding/2 phase (4 phase) phase shift keying modulation/and single carrier per channel (CVSD/BPSK (QPSK)/SCPC) services. It is possible to fully satisfy user requirements. The principal technical properties of the system as a whole are as shown in the Table.

# BELTS ASSOCIATED WITH THE MONITORING OF THE CONDITION OF COSMONAUTS' BODIES

Zhang Xiaotong (Trans.) Xue Fuxing (Ed.)

Translation of "Yu Hang Yuan Shen Ti Zhuang Kuang Jian Ce Dai"; Aerospace China, No.11, November 1991, p 39

Research personnel associated with the Northern Ireland Biological Processes Center have recently developed a type of body condition monitoring belt carrying micro electrodes. Future cosmonauts wearing it during space flights will then be capable of carrying out monitoring of the conditions of their own bodies.

This type of monitoring belt is capable of adhering tightly to the cutaneous system on the body. It is one part of a system to monitor the condition of the body as a whole. The system in question makes use of electrical resistance in order to monitor the internal organs of the body.

After electrical resistance data between pairs of electrodes set up on the monitoring belt are inputed into computers, the computers are then able to graph out a type of imagery similar to maps. The discrepancies associated with the electrical resistances of different body tissues will then produce contrasts in the imagery. For example, the electrical resistance of fat is greater than the electrical resistance of muscle. Moreover, the electrical resistance of blood is even lower.

This is nothing else than what people understand as externally added electrical voltage tomogram method (APT) imagery technology. The technology in question was developed by scientists associated with the U.K.'s Xiefeierde (phonetic) city Royal Halemu (phonetic) Hospital. At the present time, it is used clinically. This type of technology is not only low cost. It is, moreover, also capable of letting the human body avoid damage associated with harmful radiation.

In order to apply this type of technology in space, research teams associated with this hospital also produced a micro APT system the same general size as pocket recorders. The system in question is equipped with a pocket computer unit used in order to store electrically collected data. The system in question is capable--at the same time that the monitored subject is breathing--of monitoring the status of air and blood movements in the lungs. Besides this, it is also able to carry out adjustments while the bodies of cosmonauts are adapting to the space environment as well as monitoring the amount of liquid inside thoracic cavities when returning to earth.

Due to the fact that the monitoring belt in question opts for the use of design software packages associated with computerization, it is, thus, capable of carrying out specialized designs on the basis of the condition of each person and the characteristics of different sites on the body. Electrically conductive solid viscosity aqueous gels are used in order to maintain a good electrical conduction contact between electrodes and the skin.

This type of small model, light and handy, comfortable, and flexible APT system also has a good number of uses in other areas. For example, putting the monitoring belt system on the heads of premature infants or on the abdomens of patients, it is then possible to check abnormal phenomena associated with infant brain blood flow or observe the gastric function of patients. In order to monitor the conditions of patients' hearts and lungs, a completely portable system is capable of being continuously worn by ordinary patients or intensive care patients who cannot get up from their beds. Ordinary patients also need not take it off even during physical exercise.

# SPOT IMAGERY COMPANY WILL SELL SOVIET SATELLITE PHOTOS TO THE U.S. AND CANADA

Xie Fuxing

Translation of "SPOT Tu Xiang Gong Si Jiang Xiang Mei, Jia Xiao Shou Su Wei Pian"; Aerospace China, No.11, November 1991, p 39

On the basis of a contract signed with the Diamond company (subsidiary of a commercial spaceflight company set up in the U.S.) at the end of August, the SPOT company will sell in the U.S. and Canada imagery taken by the Soviet Union's Diamond-1 synthetic aperture radar (SAR) satellite.

At the present time, the commercial spaceflight company has already obtained large numbers of orders relating to Soviet Union data. The commercial spaceflight company and the SPOT imagery company believe that the unstable political and economic situation in the Soviet Union will not block this business. It is projected that this trade will reach at least half of the annual marketing quota objective of 10 million U.S. dollars.

The price, after radar imagery processing, of a standard dimension 40x40 kilometer sheet taken by the Diamond-1 is 2400 U.S. dollars.

One of the primary advantages of SAR technology is the ability to take imagery of regions covered by smoke or cloud strata in the daytime or at night. The French SPOT satellite, however, opts for the use of optical telemetry technology. During cloud or smoke cover, the imagery taken will show a blank. At the present time, the SPOT imagery company is the only company marketing SPOT imagery in the U.S.

# U.S. ASTRONAUTS WILL CARRY OUT LONG TERM FLIGHT ON SOVIET UNION'S PEACE

Xie Ping

Translation of "Mei Guo Yu Hang Yuan Jiang Zai Su Lian He Ping Hao Shang Jin Xing Chang Qi Fei Xing"; Aerospace China, No.11, November 1991, pp 40, 43

During Soviet talks at the highest levels, the U.S. put forward a cooperative project where at least two Soviet Cosmonauts ride the U.S. space shuttle and are replaced by U.S. Astronauts who are sent up to the Peace space station to carry out a long term manned flight.

This combined flight project is an important constituent part of the expanding of U.S.-Soviet spaceflight cooperation. This cooperative flight mission will begin around 1993. It will study a step further the reactions of human beings to microgravity. This is very important with regard to the U.S. development of future space stations and the carrying out of moon/Mars probe missions.

Previously, the time period for receiving the visit of a number of international cosmonauts to the Peace space station was only one week. However, this U.S. project, by contrast, requires sending one or several U.S. Astronauts to stay on the Peace for 60-90 days in order to carry out detailed experiments in physiology and other areas. In 1973-1974, U.S. Astronauts, respectively, only carried out 24, 56, and 84 days of Skylab missions. Before the year 2000, the U.S. will not be able to carry out 60-90 day, long term flight missions in the Freedom space station. However, the project described above will still make it possible to let the U.S. obtain this type of research data earlier and cheaper. At the present time, NASA is still in the process of studying capabilities to let one space shuttle orbiter have a continuous 9 month flight.

Only one U.S. Astronaut at a time is received on the Soviet space station. Because the U.S. space shuttle only maintains flights of 5-10 days at a time, therefore, each flight of the U.S. space shuttle will receive at least 2 Soviet Cosmonauts to carry out life science and other experiments.

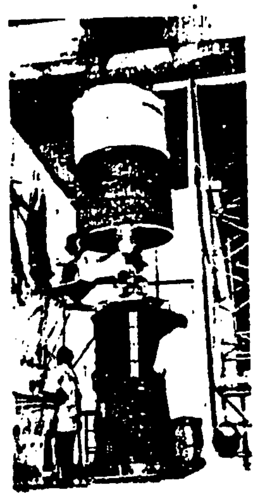
The new cooperative project also includes the several items set out below.

1. U.S. Ozone Imagery Instruments

In the first ten days of July, relevent U.S. personnel visited the Puliexiecike (phonetic) firing range (located 960 kilometers north of Moscow). In the middle ten days of August, they will mate up an ozone imagery instrument with the Soviet Union's Meteor-3 metrological satellite. On 15 August, they will launch it into a polar orbit with an SL-14 Whirlwind rocket from Puliexiecike (phonetic).

2. U.S. Cosmic Ray Detector

A cosmic ray detector is a type of passive detection device. There is no electrical connection between it and the Peace. This is the first U.S. spaceflight system launched by the Soviet Union on the basis of a 1988 mutual spacecraft agreement.



Soviet Union's Meteor-3 Metrological Satellite Carrying U.S. Ozone Imagery Instrument Electronic Equipment in the Midst of Being Installed in the Satellite Shell

This detector (1 meter square) was built by the University of California. It is composed of multiple layers of phosphate glass. It is capable of recording the tracks of heavy cosmic rays such as uranium atoms. It will be placed outside the Peace module for two years. After that, it will be recovered to the surface again to be provided analysis by U.S. and Soviet scientists. This detector was carried on the Soviet Progress M-8 supply ship launched from Baikenuer (phonetic) firing range on 30 May. On 1 June, the spaceship in question reached Peace.

According to plans, in August, there will also be launched toward the Peace space station a second U.S. 10 centimeter square miniature detector of this type. This micro detector will also opt for the use of the same type of technology in order to record the tracks of comparatively light isotopes of iron nuclei. It will also--through extravehicular activity--be placed on the outside of the Peace module.

Taking the total ozone imaging spectrometer (TOMS) and fitting it into the Soviet metrological satellite is a very complicated operation. This is the first time that U.S. instruments have been loaded in Soviet spacecraft (see Fig. left).

TOMS is a type of 6 channel ultraviolet spectrometer. It has very important scientific value. It is the only large model spaceflight system capable of monitoring ozone all over the globe. In 1978, the U.S. used the Nimbus 7 metrological satellite to launch another TOMS. This TOMS is used to observe the status of development of black holes each year in the ozone layer in the air above South America as well as monitoring sulfur dioxide pollution released by volcanic explosions (for example, the Pinatubo volcano in the Phillipines). It has achieved very good results. However, the Nimbus 7 satellite operating life is about to reach its limit. Because of this, the cooperation of NASA and the Soviet Union will maintain a TOMS instrument in space, continuing to collect data in the areas of ozone and volcanos. This TOMS instrument--installed on a Soviet Union satellite--was manufactured 15 years ago. /43

Once this Soviet metrological satellite enters into a 1200 kilometer orbit with an angle of inclination of 82.5°, the TOMS instrument will then begin to record ozone and volcanic data. These data will be stored in a U.S. manufactured storage system. After that, each day's stored data will be transmited to a NASA ground station located on Walepusi (phonetic) Island in the state of Virginia and to a Soviet ground station located in the town of Aobuningsike (phonetic) southwest of Moscow. So long as satellite operation is normal, every two weeks, it is possible to obtain from this satellite orbital engineering data one time. The life of this satellite is only two years.

In order to be able to continue to obtain TOMS ozone/volcano data, NASA plans to launch a specialized, small model global detection satellite in 1993. It will have TOMS loaded on it. In 1995, the U.S. may load a fourth TOMS on the Japanese Advanced Earth Resources Satellite (ADEOS). In 1997, a fifth TOMS will be loaded on NASA's earth probe satellites. These two U.S. earth probe satellites were bought by NASA from the TRW company using 30 million U.S. dollars. They are used to carry TOMS instruments.

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# CHINA'S C801 MISSILE PROPULSION SYSTEM

Qiu Shanchang Zhou Zhongling

Translation of "Zhong Guo De C801 Dao Dan Dong Li Zhuang Zhi"; Aerospace China, No.11, November 1991

ABSTRACT The boosters and sustainer motors of C801 missiles both opt for the use of solid rocket motors--very, very greatly improving the combat performance. This article lays stress on the introduction of the structural components of C801 missile sustainer motors, design characteristics, processing methods, and the resolution of technical problems during development. Besides this, it also introduces the design of the booster charge associated with C801 missiles as well as its ignition safety guarantee structures.

KEY WORDS Solid rocket motor Sturctural design Antiship missile China

The boost stage and sustainer stage associated with C801 missile propulsion systems opt completely for the use of solid rocket motors. This is a breakthrough associated with China's maritime defense missile propulsion systems. Due to this breakthrough, C801 missiles are allowed to greatly improve combat performance compared to the last generation of missiles. Not only is ground equipment simplified, maneuverability improved, and the structure of the missile itself also greatly simplified. Propulsion system reliability is increased. Ground service, maintenance, and prelaunch preparation requirements are very, very greatly lowered. It is possible to say without any vagueness at all that opting for the use of entirely solid motor propulsion systems has already become a big characteristic associated with this generation of maritime defense missiles.

The propulsion system in question began formal development in 1978. Designs were finalized and production in large batches was begun in 1985. Developmental testing and the realization of production in large batches proved that its performance was stable and reliable, completely satisfying overall missile requirements. Production techniques are stable, supplies of raw materials are adequate, the product pass rate is high, and it has already been evaluated as a departmental product of excellence.

## I. SUSTAINER MOTORS

Solid rocket motors have a great many advantages to attract people, no doubt. However, as far as acting as sustainer motors for cruising types of antiship missiles is concerned, the required thrusts are not great (generally, a few thousand newtons). Nevertheless, operating time periods are very long (generally, one or two hundred seconds). There exist two difficulties with this--accurately controlling combustion surfaces and effective thermal protective measures.

Fig.1 C801 Missile Sustainer Motor

In situations where propellant performance and jet tube throat areas are maintained invariable, the thrusts of solid rocket motors are determined by the combustion areas of the charge columns. Small thrusts for long periods of time mean that charge column volumes are very large. However, combustion surfaces are very small. A very large part of surface areas must be covered up. Only a small part of areas participate in the combustion. Coverings must be very reliable. A very small piece of torn away surface may be not worth mentioning with regard to large thrust engines. However, with respect to small thrust engines, by contrast, it is capable of producing clear climbing of thrust. As far as internal aperture combustion engines are concerned, so long as the part of surface torn away is not linked up with the combustion chamber during operational processes, it will not then influence normal operation of the motor. However, in small engines associated with end surface combustion, combustion cavities will (illegible) almost the entire covered surface. Any part that is torn away is impermissible. As a result, precise and reliable control of combustion surfaces is the first difficulty to be faced.

Solid rocket motors are not able to carry out cooling with regard to thermal structural components in the way that liquid engines do. They are only able to use insulation methods for protection. The structural dimensions of motors associated with small thrusts and long periods of operation are small. The time periods when they are subject to heat are long. Thermal protection problems are very striking. The weight accounted for by thermal protective measures is, correspondingly, comparatively large. The appearance of ablative combustion corrosion materials brings with it very great convenience to the handling of this problem. However, how to appropriately select engine operating parameters, cleverly carry out structural designs in order to correctly bring into play various types of materials, as well as doing a good job of resolving thermal stress destruction and seal failure problems brought along due to the physical properties of different materials and temperature distribution gradients not being uniform is the second problem which is met with. /42

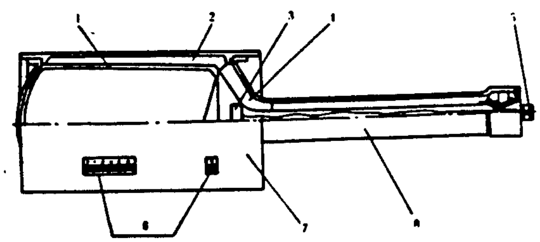


Fig.2 C801 Missile Sustainer Motor Structural Schematic

Key: 1--Charge Column Covering Layer 2--(Illegible) Component Heat Insulation Layer 3--Igniter 4--Long Tail Pipe Heat Insulation Layer 5--(Illegible) Filter 6--Missile Wing Joints (Illegible) 7--Charge Combustion (Illegible) 8--Long Tail Pipe

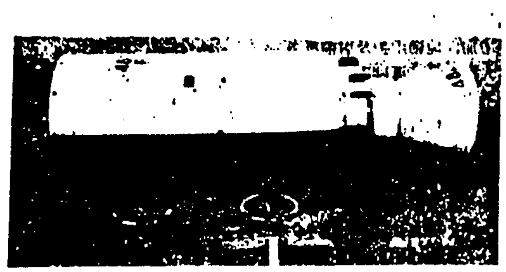


Fig.3 C801 Missile Booster

C801 missile sustainer motors are divided into three parts--charge combustion chambers, long tail pipes, and igniters. The main charge is a solid core charge column carrying a conically angled back end face as combustion surface. Side surfaces and front ends use light, very flexible covering material as a specialized technical method of covering them up. The propellant is a composite charge of polysulfides containing low amounts of aluminum. The formulation design--under a presumption of satisfying overall motor impulse and thrust requirements--gave consideration alike to combustion stability, reliability of thermal protection, and the technical characteristics of manufacturing. Levels of single properties were not pursued. However, the excellence of overall motor performance was still guaranteed. The cylindrical portions of combustion chamber shells were manufactured with the use of rotary pressure. Between joint sections, use was made of gas protection electric arc welded connections. Materials were generally structural steel alloys. On the inside walls of shells were glued adequate thicknesses of flexible heat insulation layers composed of rubber, resin, and asbestos. When engine operations are terminated, shell temperature rises do not exceed 100°C. Charge columns are glued in place on the forward seal in order to prevent the production of relative movement and the generation of friction between the charge columns and shells in low temperature situations during transport operations. The front ends of the long tail pipes are nothing else than the back seals of the combustion chambers. Inner linings are mould press formed shapes of phenolic plastic reinforced with high silica oxygen fibers. The center section has the same diameter as the combustion gas passages. Due to the fact that diameters are comparatively small, combustion gas flow speeds already reach 150m/s. Thermal loads are very large. Moreover, the thicknesses of ablative combustion corrosion materials are subject to structural limitations, and there is not way to increase them. As a result, option is made for the use of pressure formed shapes of high silica oxygen phenolic plastic layers. The ablative combustion corrosion rates associated with this type of material are not only low but stable. As a result, although thicknesses are limited, they still possess adequate reliability. The back end of the long tail pipes are jet tubes. They are the places where thermal loads are the largest. Due to the fact that throat diameters do not reach 20mm, permissible amounts of ablative combustion corrosion expansion are extremely small. Even if one uses expensive carbon-carbon ablative combustion corrosion materials, they are still not able to satisfy requirements. As a result, option is made for the use of difficult to melt metallic tungsten in order to do the manufacturing. The shapes of jet tubes and the structures of peripheral parts are comparatively complicated. This is in order to guarantee the structural integrity of motors and the reliability of seals under bad operating conditions. C801 missile sustainer motors and their structural schematic are seen in Fig.1 and Fig.2. /43

## II. BOOSTERS

C801 missile boosters (see Fig.3) are laid out in series connections in front and behind the missile's second stage. As a result, the dimensions of the missile in a lateral direction are reduced. The numbers of missiles that warships can carry are increased. However, the length of missiles is increased as a result. This is very disadvantageous. Therefore, requirements with regard to axial booster dimensions are relatively rigorous. For this reason, it is then required to increase as much as possible the specific impulses of propellants, densities, and loading densities of charges. On the basis of the concrete situation of the Chinese propellant manufacturing industry, selection was made of complex butylhydroxy propellants associated with high combustion speed and high aluminum content, a thickly packed form of charge, and a type of charge design glued to the shells. As far as the properties achieved by this design are concerned, although they are able to satisfy weight and dimension requirements, the granularity of oxydyzers contained in high combustion speed propellants is, however, small. Propellant kinetic performance is comparatively bad. Moreover, the internal stresses associated with charge columns still follow thicknesses and rapidly increase. Therefore, the structural integrity of charges is relatively poor. It is easy to give rise to the occurrence of severe charge column cracking and tearing away phenomena. As a result, at the two ends of charges, there are installed effective stress relaxation systems. The results of stress calculations and harsh environmental tests all prove that the effects of the systems for which use was opted were clear, guaranteeing the reliability of booster operation.

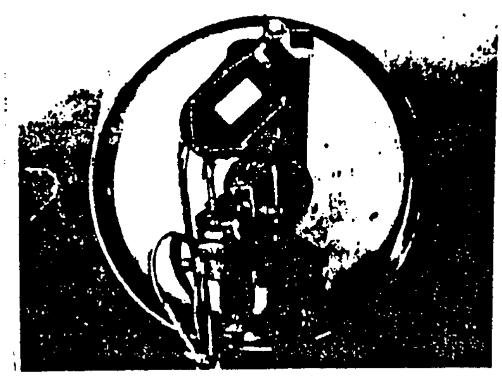


Fig.4 C801 Missile Booster Ignition Safety Guarantee Structure

## III. SAFE IGNITION MEASURES

The electromagnetic environment in modern warfare is complex. Old style electrical igniters have within them a possibility for unintentional detonation. As a new generation of maritime defense missiles, in development, consideration has already been given to this point. Sustainer stage detonators and electrical supply wiring are all placed inside the missile. Energies associated with external electromagnetic fields is very well screened and has difficulty being transmitted in. However, there are also low pass filter systems set up to play a safeguarding role. The systems in question have gone through testing in the on site electromagnetic environments on warships and been proved very effective. Booster ignition electric supply wiring is comparatively long. Moreover, most of it is installed on the outside of launching boxes. Electromagnetic environments are relatively bad. In addition, during training or testing processes, if erroneous operation is given rise to, then, the aftermath is extremely grave. Therefore, reliable mechanical type ignition safety guarantee structures have been set up (see Fig.4). A direct current electric device operated by the firing control station retracts. Safety system operated and in position signals are also sent back to the launch control station, showing indicator lights. In conjunction with this, there is connection into automatic launch control programs, guaranteeing that missile utilization is safe.

With regard to C801 missile propulsion systems, when designs were finalized, the operational reliability characteristics were high, use was safe, operation was convenient, and praise was gotten from various quarters. However, in the final analysis, it is a first generation Chinese product associated with this type of propulsion system. Weak points can hardly be avoided. Following along with a lengthening period of service use inside and outside China, product structures will receive continuous improvements. Performance will also be somewhat improved.

# C801 MISSILE AUTOPILOT

Zhan Yougen

Translation of "C801 Dan Dao Zi Dong Jia Shi Yi"; Aerospace China, No.11, November 1991, pp 44-47

ABSTRACT The C801 missile autopilot is the main control equipment for the missile in question. This article introduces the composition, functions, and main technical indices of the C801 missile autopilot, design characteristics, as well as testing processes associated with the autopilot.

KEY WORDS Autopilot Control system C801 missile

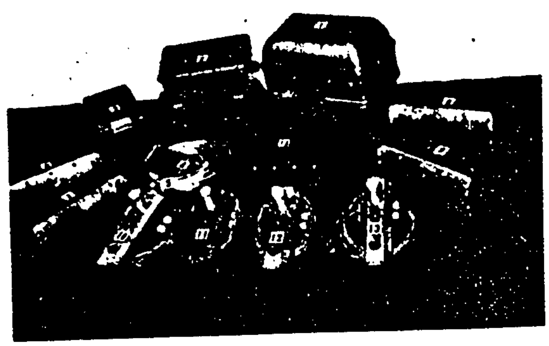


Fig.1 Photo of the External Appearance of the Complete Autopilot Set of the C801 Missile

Key: 1--Gyroscope Assembly 2--Specialized Analog Computer 3--Main Radio Altimeter 4--Radio Altimeter Transceiver Antenna 5--Radio Altimeter Transceiver Feed Line 6, 7, 8, 9--Electrically Activated Magnetic Clutch (Illegible) Steering Mechanism 10, 11, 12, 13--Servomechanism Models of Electrically Activated Steering Gear 14--General Electric Power Source

C801 missiles are a type of multiple use antiship missile which flies low nap of the sea at high subsonic speeds. It is capable of being carried in multiple rounds on various models of speedboats, escort vessels, destroyers, and submarines. They are also capable of being loaded on aircraft. Their combat utilization is primarily to strike medium types of surface warships destroyer or larger. They are also capable of striking small model surface warships associated with types of speedboats. The primary control equipment on C801 missiles is autopilots and terminal guidance radar.

## I. COMPOSITION AND FUNCTIONS OF AUTOPILOT

C801 missile autopilots are composed of a total of 6 types of 12 components (see Fig.1)--gyroscope assemblies, specialized analog computers, radio altimeters, electrically activated magnetic powder clutch steering mechanisms, servomechanism types of electrically actuated steering gear, and general electric power sources. Principal functions of autopilots are as follows. 1. Realize missile attitude stability relative to center of gravity. 2. Control missile in accordance with predetermined programs of climb and dive until stabilized in level flight at preset altitudes. 3. Receive signals from command instruments on ship or aircraft loading initial angles for pitch and bank, realizing missile launch on a moving base and mobile sector firing. 4. In terminal guidance phases, receive radar course control signals and commands, realizing two iterations of missile altitude drop and pretracking, finally diving to hit the target.

## II. PRIMARY TECHNICAL INDICES ASSOCIATED WITH AUTOPILOTS

### 1. Miniaturization

Autopilots possess the characteristics of small volume and light weight. They are composed of 12 components of 6 types. Most of the components among these are electronic products. A small number of components are mechanical type products. However, the structures are still very compact. They are capable of being installed in autopilot module sections 700mm long with exterior diameters of 360mm. /45

### 2. Successfully Opting for the Use of Specialized Analog Computers

Specialized analog computers are the core control components associated with autopilots. They are composed of such electronic components as integrated circuits and miniature relays, etc. In them, there are standard altitude programs and pitch angle program circuits. The main functions of specialized analog computers are to carry out--with regard to input attitude angles, altitudes, initial loading angles, course control signals, and so on--integration, differentiation, addition, subtraction, and control attitude conversions, producing such signals as angular deviation, altitude deviation, angular deviation integrals, angular differentials, altitude deviation integrals, altitude deviation differentials, and so on. Finally, they are put together in accordance with certain rules, forming overall signals possessing adequate power in order to drive steering mechanism operation, operating steering surface deflections to control missile flight in accordance with preset programs and final dives to hit targets.

A diagram of altitude program curves is seen in Fig.2.

A diagram of pitch angle program curves is seen in Fig.3.

Table Primary Technical Indices Associated/C801 Missile Autopilots

| Item | Principal Indices |
|---|---|
| Amount of Gyroscope Outside Balance Ring Drift | Not Exceeding 2°/5 min |
| Radio Altimeter | 1) Linear Output Range: 0-200m<br>2) Measured Altitudes: 0.6±4%H (m) H > 10m ±1m H < 10m<br>3) Time Constant: Not Greater Than 0.1s |
| Electrically Driven Magnetic Powder Clutch Steering Mechanism | 1) Maximum Load Moment: Not Less Than 78.4 N•m<br>2) Maximum Rotation Angle: Not Less Than 20°<br>3) Maximum Empty Load Speed: Less Than 60°/s |
| Not | |
| Servomechanism Type Electrically Driven Steering Gear | 1) Maximum Load Moment: Not Less Than 14.7 N•m<br>2) Maximum Rotation Angle: Not Less Than 25°<br>3) Maximum Empty Load Speed: Not Less Than 60°/s |
| Missile Stable Level Flight Altitudes | 1) Two 20 and 30m Levels (Also Equipped With a 10m Level)<br>2) Secondary Altitude Drops: 5m or 7m |
| Range of Missile Moving Base Launch Realization | 1) Initial Loaded Pitch Angle: ±25° (Launch Range: 10°-20°)<br>2) Initial Loaded Bank Angle: ±25° (Launch Range: -6°--6°) |
| Realization of Missile Sector Angle Mobile Launch | Sector Launch Angle: ±30° |
| Autopilot Sensitivity | Course Path:Not Greater Than 0.4° |

Bank Path: Not Greater Than 1°
Pitch Path: Not Greater Than 0.4°

| | |
|---|---|
| Overall Electrical Zero Potential | Not Greater Than 0.5° |
| Preparation Time | Not Greater Than 1 min |
| Total Mass | Not Greater Than 52kg |

In specialized analog computers, the conditions associated with the formation and, in conjunction, production of "G" commands are that missile pitch angle (v) must be below 0° and missile flight altitude lower than 100m. Boosters drop off and, in conjunction with that, autopilots are sent drop off commands. Only at this time is it possible to satisfy the conditions for forming "G" commands, that is , producing "G" commands. After the commands in question are sent out, signals associated with altitude deviation series play a part in control--controlling super low C801 missile nap of the sea flight.

3. Electrical Differential Movement Control

The lay out of C801 missile steering surfaces is an "XX" shape. Realization of control of the three paths--course, bank, and pitch--is carried out through regulated deflections of 4 steering surfaces. If option is made for the use of mechanical type drive device structures in order to realize C801 missile "XX" type control--due to the fact that, in the second stage missile fuselage tail compartment, it is necessary for an engine tail jet tube associated with a comparatively large diameter to go through-- the mechanical type drive structures have no way to fit in the tail compartment. As a result, the plan in question has not way to be realized. C801 missiles opt for the use of 4 steering gear respectively driving locking systems and direct insertion steering panels that each of them possess. In order for the overall signal associated with one path to drive the 4 steering gear--in accordance with the requirements of aerodynamic characteristics--operations in different directions are used, driving steering surface deflections in different directions and realizing differential movement control. The 4 steering gear--under the effects of one overall signal--operate synchronously and in coordination. Errors are very small. Precisions are very high.

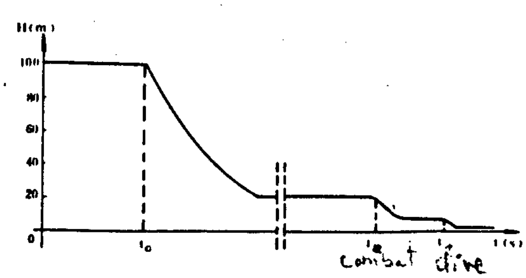



Fig.2 C801 Missile Altitude Program Curve Diagram $t_G$ -- Time of Sending Out "G" Command; $t_{combat}$ -- Time of Sending Out Combat Altitude Command; $t_{dive}$ -- Time of Sending Out Dive Command

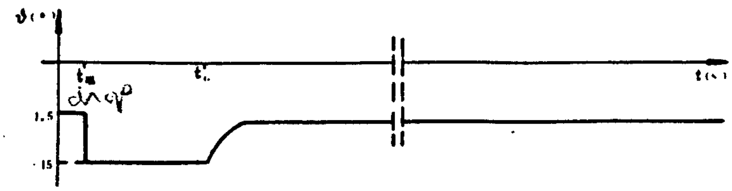


Fig.3 C801 Missile Dive Angle Program Curve Diagram $t_{drop}$ -- Time of Sending Out Booster Drop Command; $t_G$ -- Time of Sending Out "G" Command

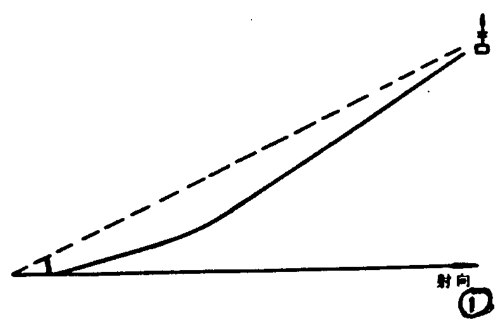



Fig.4 C801 Missile Fan Surface Angle Mobile Firing Schematic

Key: (1) Direction of Launch

4. Realizing Missile Firing on a Moving Base

The carriers for C801 missiles are warships or aircraft. Whether they are moving bodies on the surface of the water or in the air, in all cases, there are problems of longitudinal and lateral sway. As a result, at the moment of firing, the missiles follow the carriers and are put into a moving state. In order to guarantee normal attitude of missiles during flight in the air, such parameters as the angles of sway associated with the longitudinal and lateral rocking of carrier bodies as well as gyroscope frame errors produced during fan surface angle moving firings and correction quantities associated with other factors should be sent into autopilot specialized analog computers in real time by firing command instruments on platforms. When about to fire, gyroscopes are unlocked, after which, transmissions are stopped. In conjunction with this, they are stored in the computer memory. When missiles are in flight in the air, corrections of the missile attitude angle deviations make the attitudes normal. For terminal phase, radars turn on and operate, effectively and reliably acquiring targets to supply a good initial condition.

5. Realizing Missile Fan Area Angle Moving Firing

C801 missiles do not need to directly aim at targets and carry out firing afterwards. They are capable of carrying out fan area angle moving firing. The range of the fan area angle is ±30°. On the basis of acquired target information, firing command instruments carry out calculations in real time, sending out voltages in proportion to fan area angles. Through course loading systems, this information is sent into specialized analog computers associated with autopilots. Waiting until after missile launch, boosters drop away, and fan area angle signals use changes associated with exponential rules to control missile rotation. The angular numerical value associated with missile rotation and the fan area angle value loaded by command instruments are the same. The turning process is sketched in Fig.4.

6. Controlling Super Low Altitude Missile Nap of the Sea Flight

C801 missile fuselages possess good stability and controllability. This is a prerequisite for the realizing of super low altitude nap of the sea flight. In order to realize C801 missile super low altitude nap of the sea flight, successful development was done of fully solid state radio altimeters with comparatively good low altitude performance. Use is made of the instruments in question as altitude measurement components of autopilots. They are capable of measuring the distances of missiles relative to the sea surface (altitude), sending voltage signals forming direct proportions with altitude to the specialized analog computers in autopilots. Comparisons with altitude programs are carried out, producing such signals as altitude variances, altitude variance differentials and integrals, and so on--controlling missile super low altitude nap of the sea flight. All previous tests demonstrate that, as far as a level flight altitude of 20m loaded in missiles is concerned, the optical results are 19m. Secondary altitude drops are 5m or 7m. Results actually measured and theoretical values are basically in line with each other. The longitudinal trajectory associated with C801 missile low altitude nap of the sea flight is as shown in Fig.5. /47

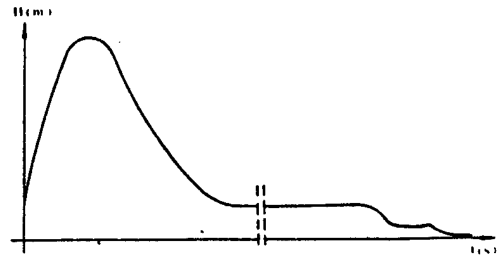


Fig.5 C801 Missile Super Low Altitude Nap of the Sea Flight Longitudinal Trajectory

7. Realizing Missile Single Plane Guidance

On the basis of relevant data, it is possible to know that, at the present time, cruising type combat missiles used by equipped units all opt for the use of dual plane terminal guidance radar, that is, using control signals associated with course and altitude to control missile target hits. However, C801 missile terminal guidance heads are single plane radars. They only send course control signals to autopilots. In terms of altitude, radars send altitude combat commands and dive commands to autopilots, using this in order to control changes in altitude programs. Moreover, radio altimeters measure in real time missile flight altitudes, in conjunction with this, sending out altitude signals. Comparisons are carried out between altitude signals and altitude program signals, obtaining a series of signals associated with altitude differences. After going through overall amplification, they drive steering gear operation, powering steering surface deflections to control secondary missile altitude drops and dives to hit targets. In guidance phases, C801 missile flight altitudes gradually go down. Missile concealment characteristics are good, improving survivability of the missiles themselves and guaranteeing the safety of missiles when approaching enemy targets, thereby effectively hitting the targets.

## IV. AUTOPILOT TESTING

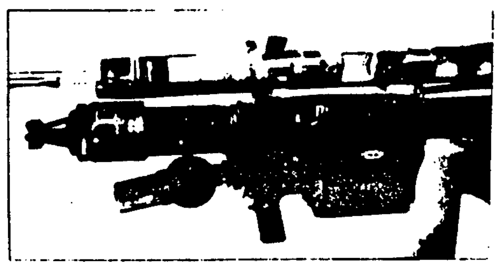
After completing installation of autopilots, use is made of specialized test measurement equipment to carry out checks and adjustments on autopilots. After products leave the factory, they are installed on C801 missiles. Making use of automated test measurement equipment, single element and comprehensive checks are carried out on autopilots. Check time is approximately 20min. In conjunction with this, test measurement data is stamped. Among the data, those having the "check" mark show that they conform to the requirements of technical prerequisites. Those having the "x" mark show that they do not measure up. When autopilots on C801 missiles show the appearance of malfunctions, the malfunctions should be eliminated in accordance with the principles specified in the users manuals. So long as users grasp the basic operating principles of autopilots, eliminating malfunctions is very easy. As a result, autopilots possess characteristics of convenient use and maintenance.

# SOVIET UNION'S SA-16 SURFACE TO AIR MISSILE

Xu Xing

Translation of "Su Lian De SA-16 Mian Kong Dao Dan"; Aerospace China, No.11, November 1991, p 47

In this year's Manila exposition at the beginning of the year, the Soviet Union displayed the SA-16 portable surface to air missile. During the Gulf War, Iraq used this type of missile to shoot down 2 U.S. Navy AV-8B (illegible) aircraft.



Soviet Union's SA-16 Surface to Air Missile System

The maximum range of the missile in question is 5000 meters. It is capable of intercepting targets at altitudes of 10-3500 meters. Its maximum speed is 570 meters/second. The missile weight is 10.8kg. Included in this is 2kg associated with a high explosive fragmentation antipersonnel warhead equipped with contact and instantaneous fuses.

The missile has a two stage motor. The first stage makes the rocket fly away from the launching system. The second stage makes the missile accelerate and fly toward the target.

The warhead is positioned behind 4 canard type wings. The aiming device is installed on the side of the launching system. The fragmentation nose cone is similar to the Matela (phonetic) Northwest Wind. Gas bottles and thermal batteries are installed in front of the trigger.

Deployment time for the system in question is 13 seconds. Launch time after target acquisition is 5 seconds.

The Soviet Union has already exported the missile system in question to Iraq, Nicaragua, and Angola. The SA-18 follow on model to this has already gone into service.