Space INTELLIGENCE NOTES

SPACE SYSTEMS INFORMATION BRANCH, GEORGE C. MARSHALL SPACE FLIGHT CENTER

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FROM THE WORLD PRESS Page

FROM THE WORLD PRESS

ROCKET FIRING STEP TOWARD TESTS IN INDIA. Engineers, preparing for a series of rocket firings in India late this year, launched an instrumented package to an altitude of 106 mi (170 km) at Wallops Island on Sept. 10.

The 1605-lbm (730-kg) Nike-Apache vehicle, 28 ft (8.5 m) tall and only 6 1/2 in. (16.5 cm) in dia, carried its 70-lbm (32-kg) payload on a flight of 6 min and 40 sec.

The instruments were designed to measure the Earth's magnetic field, cosmic radiation, and vehicle altitude and to send back the information by radio.

NASA said the flight was part of the preparation for project Electrojet, the cooperative rocket-launching program to be conducted from a launch site now under construction by the Indian government near the geomagnetic equator at Thumba, on the southwest coast of India. (Source: The Chicago Tribune, September 10, 1963)

NEW PRESIDENT ELECTED. Professor Dr. Karl Thalau, business manager of Heinkel Flugzeugbau, G.m.b.H., has been unanimously elected President of the Bundesverbandes der Deutschen Luft-und Raumfahrtindustrie (German Federation of the Aviation and Space Travel Industry) BDLI.

He succeeds Dr. L. S. Rothe, who has retired after completing 9 yr in this position. (Source: Flugwelt (Aviation World), August 1963)

GERMANS RENEW ROCKET FIRINGS. The first three-stage rocket fired in West Germany since 1945 reached a height variously reported as 60 (96 km), 62 1/2 (100 km), and 65 (104 km) mi above Cuxhaven on May 2.

It was designed and built by a company formed by Dr. Berthold Seliger, with limited support from the government. It employed solid propellants and incorporated telemetry, and all three stages were recovered by a new parachute technique. (Source: Flight International, May 9, 1963)

US, USSR EXCHANGE MEASUREMENT EXPERTS. Early in June, a seven-man team of measurement experts from this country traveled to Russia for a month-long tour of various measurement laboratories. Later in the year a similar team of Soviet metrologists will make a visit to the US. These visits are being conducted under the terms of a US-USSR agreement, signed in March 1962, for the interchange of information and the exchange of visits by teams in 13 fields of technology. The US State Department, under whose general control the exchange program is conducted in this country, requested that NBS arrange for the exchange of persons from the area of high-precision measurement standards.

The American team, headed by William A. Wildhack, Associate Director of the National Bureau of Standards, was comprised of members representing various areas of the measurement field. The others on the team were L. Guildner, F. K. Harris, D. P. Johnson, H. Lance, and A. G. McNish of NBS, and G. Toumanoff of the Airborne Instruments Laboratory, Long Island, New York.

While in the USSR, the American group visited installations in Moscow, Leningrad, Kiev, and Kharkov, including laboratories specializing in pressure, length, temperature, electrical, and many other types of measurements. A preliminary itinerary for the Soviet visit later this year includes stops at NBS Washington and Boulder, Colo., a state weights and measures office, and an industrial calibration laboratory.

This agreement, the third of a continuing series, provides for exchanges in the fields of science, technology, and construction, trade, agriculture, and many others. (Source: NBS Technical News Bulletin, August 1963)

THE INTERNATIONAL EXHIBITION OF TRANSPORT AND COMMUNICATIONS 1965.
Dr. Wernher von Braun will serve as honorary chairman of the astronautics committee of the first International Exhibition of Transport and Communications (IVA - Internationale Verkehrsausstellung). The exhibition will be held at Munich from June 25 - October 3, 1965.

Transport will be given pride of place, although industry will have plenty of opportunity to advertise its products. About two-thirds of the 110,000-yd^2 (92,000-m^2) exhibition area at the Theresienwiese, Munich, will be used by Aviation and Space. The remaining third will be allocated to Rail, Road, and Water Traffic; Postal Services and Telecommunications; Energy Supply; Tourism; and the raw material groups— Iron and Steel, Aluminum, Plastics, and Wood.

Ernst Siemens will serve as the President of the exhibition; J. F. G. Grosser as chairman of the Aeronautics and Astronautics Committees; and Claude Dornier as honorary chairman of the Aeronautics Committee. (Source: Interavia, October 1963)

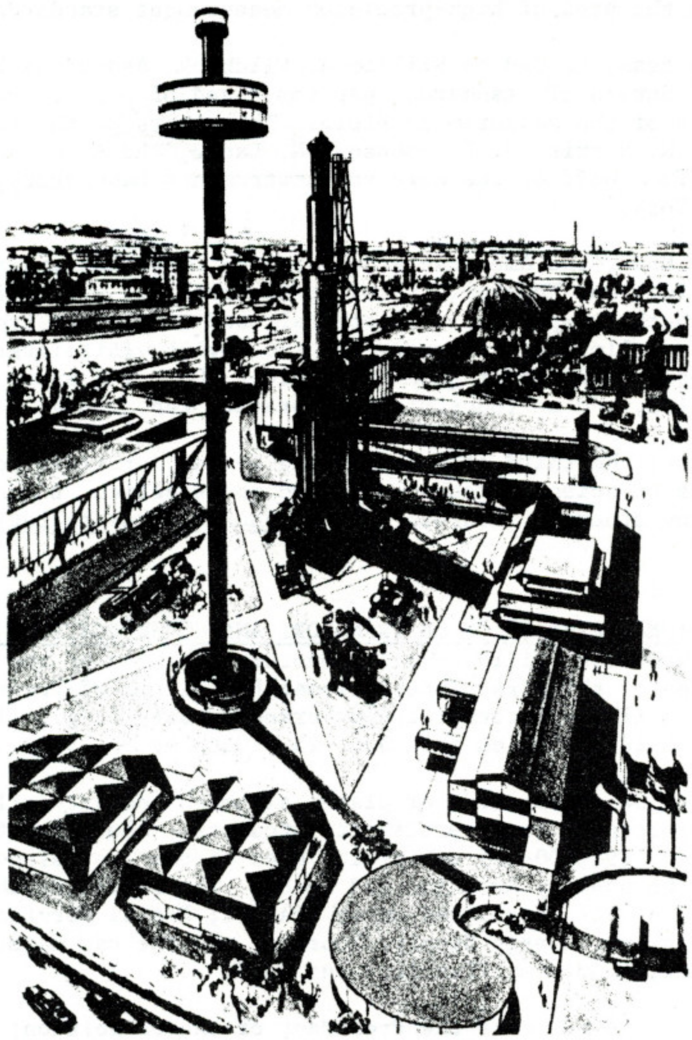

FIG. 1.
International Exhibition of Transport and Communications (IVA - Internationale Verkehrsausstellung)

BOOSTER CONSTRUCTION IN ISRAEL. Prof. Marder, director of the Israel Research Department for Rocket Systems, reports that Israel is building multi-stage solid fuel booster rockets.

This is the first official acknowledgment by Israel that it has its own rocket industry. Furthermore, Prof. Marder stated that Israel is completely independent in the basic field of rocket production and does not have to rely on foreign manufacturers. (Source: Flugwelt (Aviation World), September 1963)

FROM THE SEMITECHNICAL LITERATURE

SOVIET AIMS IN ASTRONOMY AND SPACE RESEARCH. Professor Sir Bernard Lovell, Director of Nuffield Radio Astronomy Laboratories, Jodrell Bank, England, visited radio and optical astronomy observatories in the Soviet Union in July. He spent 3 wk traveling to 9 observatories, at which time he had discussions with Soviet scientists and was permitted to see important equipment never before seen by western eyes. He worked out specific schemes with the Soviet Astronomical Council for collaboration between Jodrell Bank and Russia's secret deep-space tracking station in radio astronomical work.

Professor Lovell has announced the Soviet intention of building a radio telescope that will have 550 plates, each 15 m by 6 m, having an effective aperture of 2 km. If it is built, it will be sited in the Caucasus along with the proposed 6-m optical telescope, which will be the largest in the world. Initial ground work for the latter instrument has been laid, and the construction has begun of the approach road up to the 2000-m mountain site chosen for it.

B. E. Markarian of Byurakan Astrophysical Observatory is engaged in optical work that is directly relevant to one of the questions exciting most interest among radio astronomers — the nuclei of galaxies. As suggested by Academician Victor Ambartsumian, the powerful radio sources formerly attributed to the collision of galaxies more probably owe their unique properties to the peculiar nature of their nuclei. Markarian has studied 400 galaxies and found that the light from the nuclei of 32 of them cannot be explained by emission from stars, so that there is some other mechanism involved, probably "synchrotron" radiation. Ambartsumian believes that these galaxies may be less extreme examples of the peculiar radio galaxies, such as 3C273, that radio astronomers have recently been studying. A design study has been made of a 200-m steerable telescope at Byurakan, although there has been no indication of an early start on its construction.

Professor Lovell also visited the radio astronomy observatory at Serpuchov near Moscow. The biggest instrument in service there is a 25-m dish, which, for its work in recording millimeter waves from the planets, is sighted on the planet by an observer looking through an optical telescope mounted in the center of the dish. A large "cross" instrument is also located there that is not yet complete—its main aerial is 40 m wide and 1 km long.

The most expensive radio observatory in the Soviet Union is the deep-space tracking station in the Crimea. It belongs to the Institute of Radiotechnics and Electronics, directed by Academician V. A. Kotelnikov. Professor Lovell estimated that the equipment there was worth about $57 million.

The primary purpose of this station is the tracking of lunar and planetary probes—the abortive probes of Venus and Mars were commanded there.

There are 3 identical aerial systems—one a transmitter, the others receivers—spaced out over 10 km. Each has eight 16-m fully steerable dishes arranged in two rows of four, which are equivalent to a 150-ft (46-m) aerial.

Radio astronomical work in progress there has also been of value. These facilities were used for radar echoes obtained from Venus, Mars, and Mercury. Radio observations of the occultation of sources by the Moon, and of the intensities of the emissions from the galaxy M31 and from the planets are also in progress.

Professor Lovell and Academician M. V. Keldysh, president of the Academy, discussed the possibility of collaboration in radio astronomy on three projects.

The first is the study of "flare" stars, the original individual stars from which radio signals have been detected. Individual stars of a particular type must be observed for optical evidence of flaring, and the radio record must be examined for increases above the background noise occurring at the same time. Simultaneous radio observations of the flare stars by Jodrell Bank and the Crimean deep-space tracking station are of particular scientific interest because it is believed that radio bursts may originate from these stars without a corresponding visible flare. However, this effect can be confirmed only by simultaneous observations from two widely spaced stations.

A second proposal is the use of Jodrell Bank and the deep-space tracking station as a "bi-static" radar to bounce pulses from one station off the planets and to receive them at the other. If this program could be carried out for Mars, Venus, and Mercury, measurements of the dimensions of the Solar System could be measured; and new information about the rotation of the planets and the interplanetary medium could be obtained. Something new also might be learned about the nature of planetary surfaces.

The third program proposed is the most difficult and the most ambiguous. It involves the measurement of the apparent sizes of radio sources in the sky. This sort of information provides clues to the distance and nature of these sources, which in turn greatly influence the interpretation of radio sky-surveys as indicators of the nature of the universe as a whole. At least two radio aerials, a considerable distance apart, are required to obtain such measurements. If the Crimean deep-space tracking station were used with Jodrell Bank for this purpose, it would afford Jodrell Bank a baseline of 1600 mi (2600 km), and a 60-fold improvement in its angular measurements.

After discussion with Academician Keldysh, Professor Lovell expressed doubt that the US-Soviet Moon race is the serious struggle it is purported to be. Keldysh mentioned plans to orbit within 5 yr a manned optical observatory at a height of 100 to 150 mi (160-260 km). The observatory will be manned by an astronomer and an engineer and will carry a 36-in. (91-cm) optical reflector. There is also interest in landing instruments on the Moon's and other planets' surfaces. On the subject of manned lunar landings, Keldysh pointed out the technical difficulties of returning the men safely and spoke of the dangers of radiation from solar flares. He also indicated the importance of international agreement among world scientists about the desirability and value of a lunar landing. He suggested that a delineation by scientists of the real purpose in sending men to the Moon would be a crucial step in putting space research on an international basis.

Professor Lovell offered to accommodate a team of Russians for study and research at Jodrell Bank. (Source: New Scientist, July 25, 1963)

UK3 SATELLITE. British Aircraft Corporation is building the first British research satellite, the UK3, which will be launched in 3 yr from Wallops Island, Va., with a four-stage Scout booster. As outlined by Sir Harry Massey, professor of physics at University College of London and chairman of the British National Committee on Space Research, the UK3 satellite will carry a five-experiment payload package.

The meteorological office, directed by Dr. R. Frith, will measure the vertical distribution of oxygen in the Earth's atmosphere at heights where molecular oxygen is destroyed by solar radiation. During periods when the UK3 is entering or leaving the Earth's shadow, measurements will be made of the intensity of direct ultraviolet radiation.

The Mullard Radio Astronomy Observatory, headed by Dr. F. G. Smith, will measure the emission of radio noise from the galaxy at frequencies that are too low to be observed from the ground. The angular resolving power will be adequate to distinguish components from the galactic plane and the galactic halo against isotropic flux.

A University of Sheffield experiment, directed by Dr. T. R. Kaiser, will measure very low frequency (VLF) radiation, its spatial and temporal variation, and its spectrum.

A University of Birmingham team, led by Prof. J. Sayers, will examine the ionosphere above the F_2 maximum by measuring the ionization density and temperature at various points along the path of the satellite.

A Radio Research Station experiment, headed by J. A. Ratcliffe, will seek to determine the flux of radio wave energy at the altitude of the satellite at determined radio frequencies from natural terrestrial sources, and to determine the geographical distribution of the sources at different time intervals and different seasons.

Five UK3 satellites — the initial prototype, two fully equipped models, the flight example, and a backup spare — will be built.

UK3 will enter a circular orbit — a 400-mi (640-km) altitude has been calculated to carry the five experiments satisfactorily; the chosen angle of inclination is 57 deg. The orbit will be accomplished if the satellite is fired a southeasterly direction from Wallops Island. After third-stage burnout, the Scout nose will be jettisoned, and the satellite will be left on the fourth-stage motor. The motor will then be ignited and spun by tangential rockets to maintain directional stability.

The shape of the satellite was dictated by conflicting requirements of power supplies, thermal control, aerials, the five experiments, structural strength and access. Diameter, length, and boom lengths were made compatible with the Scout rocket.

Boom design had to satisfy requirements that mesh paddles be mounted beyond a minimum distance from the satellite body, with no solid material located outside a cone generated at the center of the boom. Four hinges are connected by a universal joint so that all four booms can be erect simultaneously and prevent wobble of the satellite. Four loop aerials were provided by cables stretched between the boom tips.

Approximately 6000 solar cells will be built onto the satellite—on the body and the booms—to provide a minimum change in projected area as the satellite rotates and tilts in relation to the Sun.

The upper cone and bottom face of UK3 have been left unconcealed to allow a sufficient ion-collecting area. The body contains a central torque tube from which 4 honeycomb vanes are mounted in a cruciform layout. Vanes provide mounting area for equipment and experiments; the bottom ends are closed by a flat diaphragm, the outer edge of which carries a turned ring that mounts the de-spin mechanism. The under surface carries the four trunnions for mounting the booms.

Four ferrite rod aerials, mounted across the booms near the attachment to the body, are included on the UK3 to aid in experimentation.

A tape recorder is mounted at the bottom of the central torque tube in the satellite. The package comprises a record and play-back amplifier, playback timer, speed controller, and a phase shift oscillator to provide a 3-phase supply to the capstan motor.

Two programmers are provided. The first feeds outputs to the recorder and telemetry transmitter, putting an identification tone on the transmitter at the receipt of a command and tone marker on the tape. The second programmer provides two operation modes for the low-speed encoder at sunrise and sunset. Mode 2 accepts only the meteorological office experiment output; and mode 1 switches to all experiments except the meteorological office, 8 min after sunrise. (Source: Aviation Week and Space Technology, August 12, 1963)

FRANCE PLANS WEST EUROPE'S MOST EXTENSIVE SPACE EFFORT. The French Government is developing a national space program that promises to establish it as Western Europe's leader in this field within the next 2 yr.

After launching the first satellite, FR 1, from the US Pacific Missile Range in 1964/5 with a Scout booster provided by NASA, the French plan to launch 5 scientific satellites with their own developed booster units.

The French Space Program's organizational breakdown is comparable to that of the US. Booster development and launch techniques are largely the responsibility of the military, while payload design requirements are assigned to a new government agency, the Centre National d'Études Spatiales (CNES), whose duties are similar to Goddard Space Center. Like Goddard, CNES will contract much of the development and production to private industry.

CNES, which was organized just over a year ago, has approximately 100 technicians in its Bretigny headquarters near Paris and anticipates growth to several thousand in the next few years.

The FR 1 satellite, which will be launched in late 1964 or early 1965, will orbit at an altitude of 500 mi (800 km). It will conduct three experiments to measure the Earth's magnetic and electromagnet fields. In one experiment, an attempt will be made to measure very low frequencies emitted from three major submarine communication stations. Scientists believe that it is possible to hear these frequencies in space; and, if this hypothesis proved true, their measurements could provide new information on the atmosphere's structure.

An FR 1 payload will be launched to an altitude of between 125 and 137 mi (200 and 220 km) from NASA's Wallops Island, Va., as an initial test of the satellite's capability.

The FR 2, the first all-French satellite and launch system, is scheduled to be fired in early 1965, by the SEREB-developed Diamant three-stage booster. The launch site will be at Hammaguir, Algeria, in the Sahara near France's Colomb-Bechar nuclear test site.

The FR 2 will be essentially a flying laboratory for the French equipment involved. One feedback system will report on the booster's vibration and roll motion. The satellite itself will measure radiation and effects of radiation damage to external solar cells and will carry several transmitters operating on various frequencies as an ionospheric beacon experiment. The total payload will be 77 lbm (35 kg).

The FR 3, an advanced version of FR 2, will also function essentially as a flying laboratory. Its payload will be increased to 99 lbm (45 kg).

The FR 4 satellite will be the first French attempt to break new scientific ground. It will carry a payload designed to measure hydrogen distribution in the upper atmosphere. A measuring device was developed by Professor J. E. Blamont of CNES.

FR 5, also launched by Diamant, will study magnetic impulses in space and will be equipped as a laboratory for laser research.

The FR 6 satellite will be a solar-stabilized spacecraft, but its final payload will not be decided until earlier satellite telemetry reports are thoroughly studied.

France's Centre d'Enseignement et de Recherches de Médicine Aéronautique (CERMA) is studying the bioscience aspects of space through ballistic trajectory launches of several small animals. A rat was launched in 1962; a cat is scheduled to be placed in flight in 1964 with the Veronique booster. A monkey will be launched with the Diamant rocket in 1964.

Private industry has also proposed a number of satellite designs, which have not yet been granted government approval for final development. The Phaeton, a product of Société d'Étude de la Propulsion par Réaction (SEPR), was developed for solar and nuclear power research. The plasma jet research field has also been studied by several companies.

CNES President Coulomb has indicated that France is not interested in manned space flight due to the impracticality of such a program. He remarked that even if France did launch on a project of such magnitude, the results produced would fall behind those already obtained by the US and Russia.

The current Diamant, capable of placing a maximum 176-lbm (80-kg) payload into orbit, has a three-stage height of 53.4 ft (16.3 m) and a launching weight of 18 metric tons. The SEREB-designed first stage Emeraude uses a liquid fuel mixture, while the Topaze second stage and Sud-designed third stage use solid propellants. The Sud stage incorporates wound glass fiber construction, and both the nozzle and the body incorporate monobloc techniques.

The advanced Diamant, scheduled to be operational by 1967-8, will have four swiveling nozzles; and the first stage will have a thrust of 40 metric tons as compared with 28 tons of the current unit. The first stage will use a solid propellant, and all three stages will be SEREB designs.

By the Evian Peace Agreement, France can use Algeria's launch site until July, 1967. After 1967, a site along the South Atlantic Coast of France has been considered for construction. The possibility of establishing a second site near the town of Leucate, in the Pyrenees area, is also being considered.

France is now planning to construct its own tracking network. Surveys are being made in Africa and the Canary Islands to determine the best locations for four tracking sites. (Source: Space Technology International, July 1963)

FROM THE TECHNICAL LITERATURE

COMMUNICATIONS

MYSTERIOUS RADIO EMISSIONS FROM THE PLANET JUPITER. In 1955 two

American radio astronomers, Burke and Franklin, announced that they had detected radio emissions from the planet Jupiter at a frequency of 22 Mc per sec. The emissions were characterized by a series of noise bursts constantly varying in intensity. The noise bursts were peculiar in that they did not always occur at the same frequency (Table 1).

TABLE 1.

	18 Mc/s	20 Mc/s	22 Mc/s	24 Mc/s
DAYS OF OBSERVATION	120	112	120	96
NO. OF EVENTS	40	36	38	24
NO. OF DAYS OF EVENTS	36	30	26	21
NO. OF DAYS NO RADIATION	84	82	92	75

In the previous year, B. F. Burke and F. Graham Smith discovered that though Jupiter was active at 22 Mc, there was no sign of activity at 38 Mc. Normally radiations encountered from extraterrestrial sources cover a wide range of frequencies, though the intensity may vary with the frequency. Further observations showed that these radiations were probably confined to a region between 16 and 24 Mc with a predominance at 18 and 22 Mc. Radio astronomer Shain of Australia reported that he had received the radiations also.

Since the first announcement by Burke and Franklin of their observations, the majority of measurements have been made at frequencies between 10 and 34 Mc. However, there have been two successful attempts at higher frequencies—one at 38 Mc and the other at 42 Mc. At the lower end of the frequency spectrum, measurements have been made in Australia at 2.8 Mc with some success.

There have been a multitude of theories to explain the Jupiter radiations. One theorist compared the radiation activity to thunderstorms. This is doubtful, for very special conditions would be required in Jupiter's atmosphere to provide enough energy for radiations from analogous storms to reach us on Earth.

There was an attempt in early observations to relate radio emissions to visible features on the surface of the planet, especially the Red Spot (Fig. 2), the white spots, and the south tropical disturbance. However,

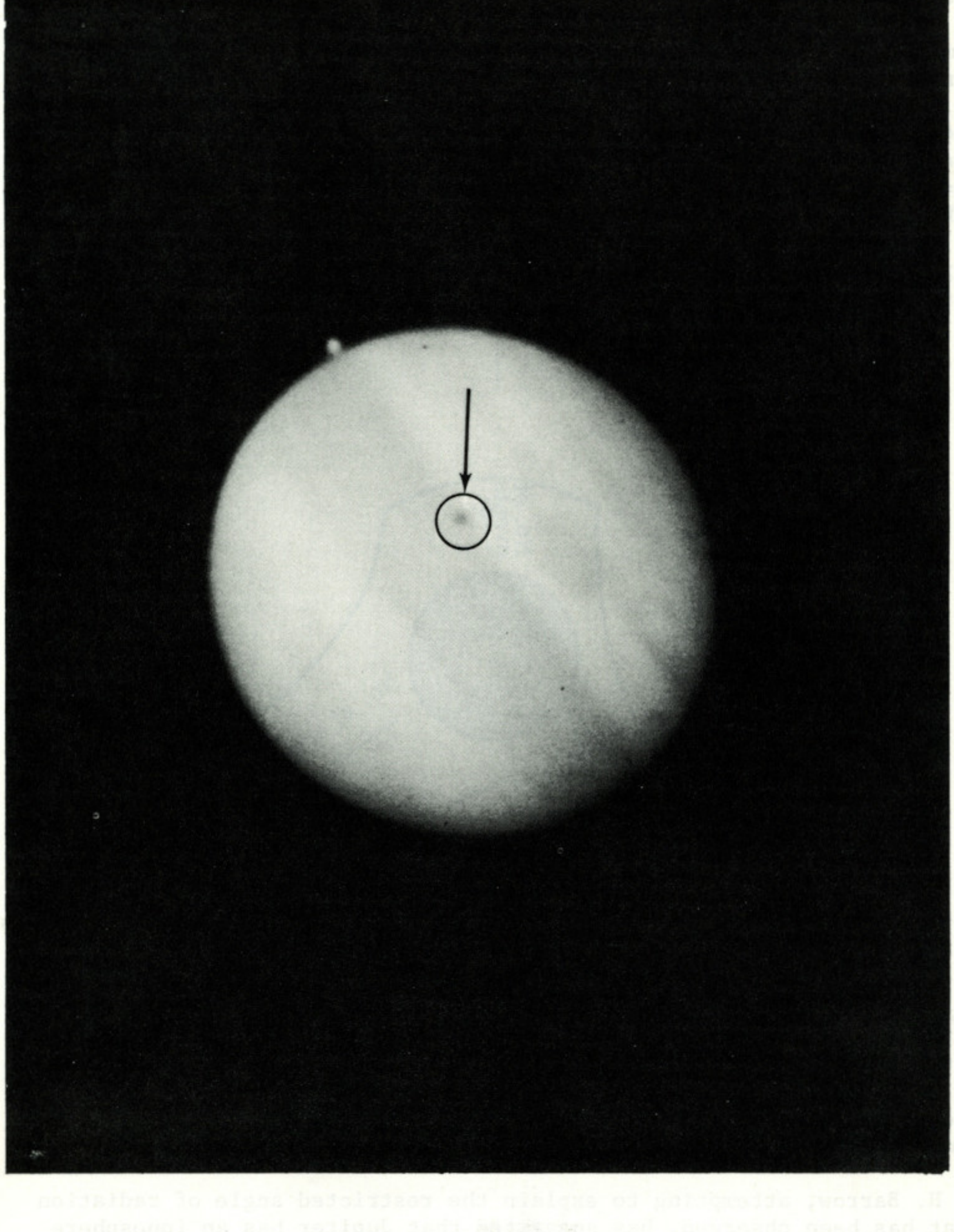

FIG. 2.

observations through the years have disproven this theory.

A method of analysis was suggested whereby a histogram was prepared of a number of occurrences related to the Central Meridian Longitude (Fig. 3). It indicated that the radio source appears to be confined to three localized regions. But simultaneous bursts at different frequencies are rare, and a great many observations at all frequencies would be necessary to test this theory adequately. A number of observers do adhere to this method, however; and it has been suggested that the rate of rotation of the planet, derived by this means, remained constant over a period of several years, so that the sources may be associated with the solid core of the planet.

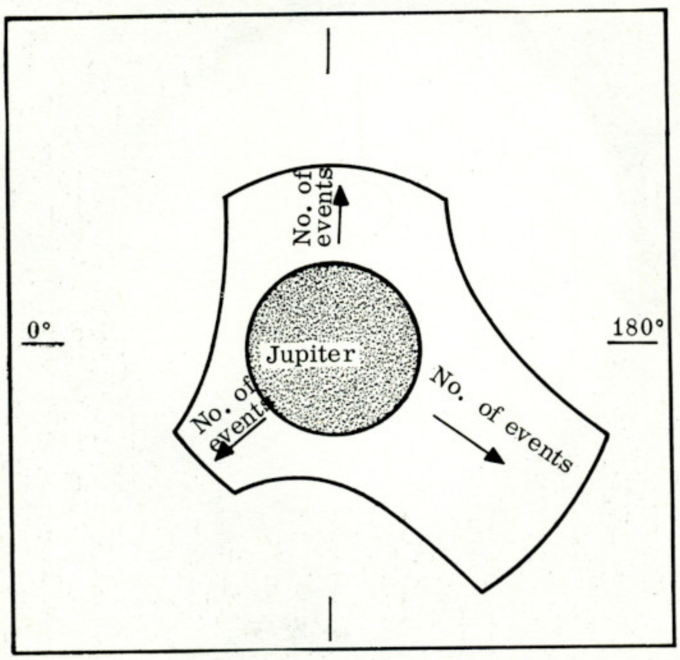

FIG. 3.

Although Jupiter may be solid and overlaid with hydrogen ice on the outside, recent investigations have indicated a possible liquid core, or at least some unstable condition of the interior. This strengthens the possibility of a mechanism for the production of a magnetic field, similar to, but much stronger than the Earth's.

C. H. Barrow, attempting to explain the restricted angle of radiation that has been observed, has suggested that Jupiter has an ionosphere similar to that of the Earth. He has calculated that such an ionosphere would have an electron density of approximately a million electrons per cu cm. Measurements have been made of the polarization of the radio waves, and these suggest that Jupiter must have a magnetic field.

As a possible explanation of the sporadic nature of Jupiter's radiations, it was suggested that ionospheres of planets act as lenses and could focus radiation from other radio sources. Quite recent observations have not supported this view, however.

J. Warwick, of the High Altitude Laboratory in Colorado, stated in 1960 that he supported the belief that a strong correlation existed between disturbances on the Sun and the Jupiter radiation. It was also observed that there was close correlation with disturbances in the Earth's magnetic field—which are also provoked by solar activity. The periods of disturbance were related (Fig. 4) in such a way as to suggest that the disturbances set in train by the Sun affect the Earth a few days before Jupiter.

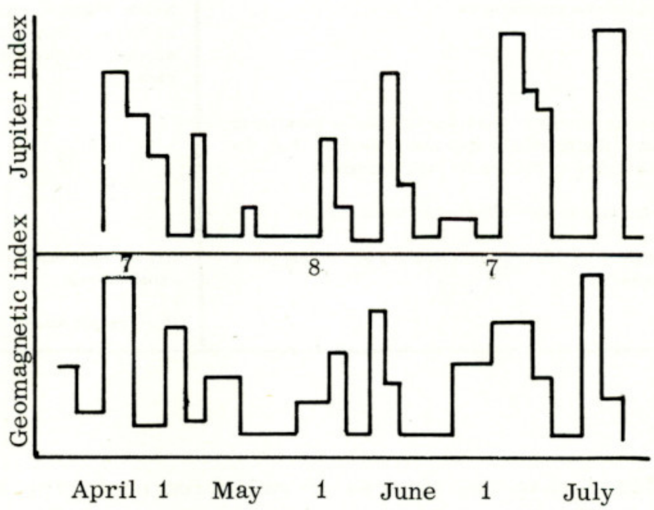

FIG. 4.

J. L. Hirshfield and G. Bekefi have formulated a theory that suggests "maser" action in Jupiter's atmosphere—a theory that purportedly accounts for all the records of radiation at 22 Mc and offers an explanation of why the same intensity of radiation at higher frequencies is so seldom recorded. They predict that at certain higher frequencies the level of radiation is very much lower in intensity.

Conversely, it should be very much greater at much lower frequencies in the range of 2 to 10 Mc. This will provide a field of future investigation, since few measurements have been made below the frequency of 10 Mc.

Various possible physical mechanisms for the origin of Jupiter's radiations are given in table 2.

TABLE 2.

Theory	Remarks
1 Plasma oscillation mechanism due to shock-wave originating on solid surface of planet by some form of volcanic action or electrical disturbance in the atmosphere.	
2 Electrical discharge mechanism due to difference of potential between the poles and the equator due to differential rotation assuming a magnetic field.	Polarization measurements support magnetic field theory.
3 Cyclotron and synchroton mechanisms	Needs a gyro-frequency greater than 22 Mc/s. Polarization observations at other frequencies now being carried out.
4 A highly asymmetric magnetic field due to a dipole parallel to the axis of rotation will give rise to sporadic emissions from the motion of solar particles or plasma through ionosphere.	
5 The radiation originates in Van Allen belts round Jupiter.	
6 Mechanism dependent on local gyro-frequency and taking place in Jupiter's exosphere	Recent work based on hydro-magnetic shock-waves.
7 Maser action	Very recent work.

It is now realized that the chances of radiation occurring at 38 Mc are so rare that they may occur only once during several months of observations. For the intensities of the radiations received between 18 to 40 Mc is in itself unusual. The lack of opportunity for continuous observation of the planet reduces the opportunity to record events at these higher frequencies.

The stations keeping a watch on Jupiter have been confined predominantly to the US and Australia. Consequently, the periods of observation have covered only a part of the rotation period of the planet. In a project supported by NASA, a station was set up at Florida State University and at St. Osyth in Essex, England, to carry out observations over at least one complete rotation (approximately 10 hr). With the establishment of these two points of observation, not only will continuous monitoring for one revolution be possible, but also a period of overlap between the two stations will exist whereby they will observe simultaneously. This duplication, it is hoped, will rule out any irregularities because of the local ionosphere and terrestrial effects, by burst-for-burst correlation between the two stations.

These methods should provide sufficient information to ascertain whether or not there is correlation between the solar activity and Jupiter activity. It is fairly well established that Earth is within the atmosphere or outer corona of the Sun. It is quite possible that Jupiter is also within this influence. This could mean that the vast amount of radiation at times of great solar activity, and the large amount of active plasma that is thrown up from the Sun may be the initiating cause of these radiations that reach us from Jupiter (Fig. 5). (Source: New Scientist, August 29, 1963)

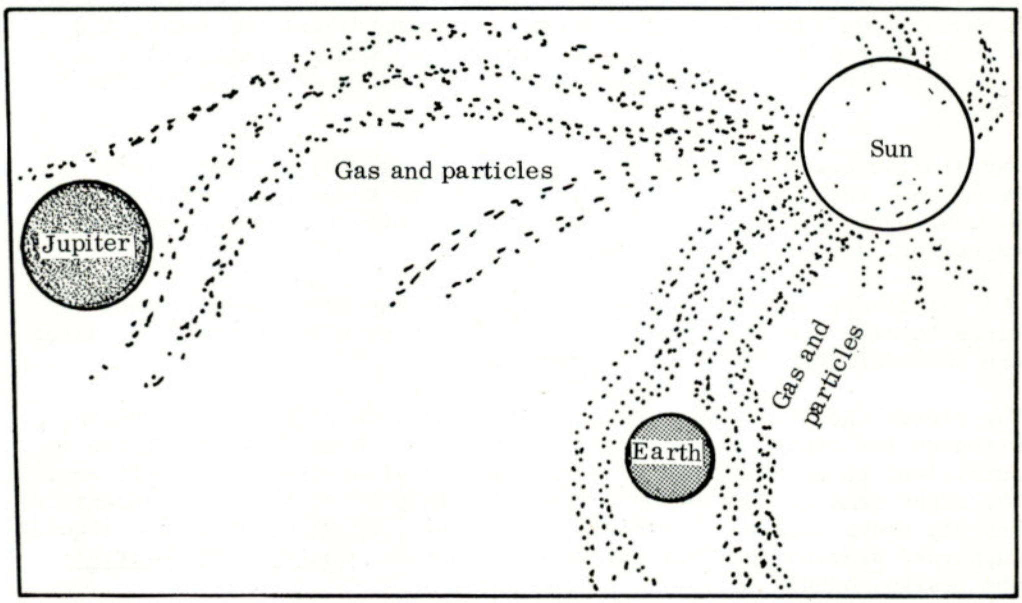

FIG. 5.

MATERIAL ENGINEERING

MAGNETIC BEARINGS. The Cambridge Thermionic Corporation has developed and marketed a new device, the Lyman Magcentric bearing, whereby a shaft may be suspended in space, supported only by magnetic fields. Any rotary motion can then be considered almost completely free from mechanical friction. The only friction the rotation of the shaft would be subjected to would be the molecular friction of the atmosphere in which it is being operated. This friction may be infinitesimal because operation is possible in high vacuum. Electrical friction, effected by hysteresis and eddy currents, does occur; but these are measurable and have no stick-friction.

Two correcting electro-magnets form the heart of the bearing. They automatically compensate for the most minute variations in mechanical and electrical balance. The device is comprised of a shaft, to which a permanent ceramic magnet is mounted at each end. In the center of the shaft a ferrite disc is securely fixed. The permanent magnets always have a magnetic field surrounding them without external magnetizing force being applied. The ferrite used is able to be magnetized by a magnetizing force but is capable almost immediately of losing its magnetism upon removal of the exciting force, which consists of two ring type electro-magnets——one placed at each side of the ferrite disc.

Two similar coils are used for the electro-magnets, the parameters being such that, with the ferrite disc of the rotor centered equally distant between the two coils, each of the coils is resonant with a capacitor, at a suitable frequency.

The inductance of a coil will increase when any force or unbalance tends to move the armature of that coil, because the ferrite disc raises the permeability of the path of magnetic flux.

The closer the disc comes to this coil, the weaker it becomes and the stronger the other coil becomes. Ultimately, it will exert a force sufficient to withdraw the disc into a neutral position. In this way, the rotor remains centered and free of sticky friction. The Magcentric bearing opens entirely new horizons in fields in which solid and liquid supported bearings are not suitable. (Source: Engineering Materials and Design, August 1963).

SPACEFLIGHT

RETURN OF MANNED VEHICLES FROM SPACE. Controlled return of spacecraft from interplanetary flight is one of the biggest problems in space operations. If the vehicle is to be set down gently on a planet's surface, the high kinetic and potential energy of the craft must be entirely, but gradually, nullified.

Rocket thrust can both absorb kinetic energy and lend the vertical lift force required for a slow, controlled descent. (This technique will be used in Project Apollo to establish the lunar excursion module on the Moon's surface.) However, effective deceleration of a vehicle in space from such high velocities demands such a tremendous amount of fuel that the associated weight problem often prohibits the use of this method.

Some of the planets have an atmosphere substantial enough to dissipate the energy by aerodynamic drag, as the Earth.

Aerodynamic braking is possible in two forms—lifting (winged) reentry and non-lifting (ballistic) reentry. The latter implies a simple free-fall trajectory and is effectively an automatic descent once the reentry maneuver has been initiated. Ballistic reentry has been used for the recovery of all manned space vehicles to date.

The ballistic capsule, which is simple, compact, and light in weight, represents the minimum possible structure to do the required job. However, it poses serious problems. There is a lack of control during the reentry maneuver that limits the choice of a landing site; and, if reentry is from orbit, the landing site can be only in the plane of the orbit. The approximate distance traveled during reentry is 8000 mi (13,000 km), and one small error in the angle at which reentry is made can result in the capsule's return to Earth hundreds of miles from the desired point. Also, the vehicle is subjected to deceleration forces that are relatively high (8 G) even for reentry at satellite speeds and that become much more critical at higher entry speeds.

The proposed solution to these problems is lifting reentry. If it is fitted with wings and aerodynamic controls, the vehicle is converted from a "capsule" to an airplane. After reentry the vehicle can glide to its landing site, and by using its wing lift can minimize penetration and reduce the peak acceleration on the vehicle. Although outweighed by the stated advantages, there are several disadvantages to using this technique: the structural weight of the wings and controls; the increased heat load experienced by the vehicle as a result of the increased duration of the reentry maneuver; and the aerodynamic destabilizing effect of the lifting surfaces during the initial boost phase of the flight, when the vehicle is mounted on the nose of a large booster.

The highest heating rates experienced by a body occur at the stagnation points on the body—the nose and wing leading edges in the case of a lifting reentry vehicle. Since the stagnation-point heating rate is inversely proportional to the square root of the radius of curvature of the surface, the nose and the wing leading edges will be blunt and rounded. The stagnation point heating rate for a two-dimensional surface has proven to be roughly proportional to the square of the cosine of the angle of sweepback; therefore, as a further means of reducing aerodynamic heating, a reentry vehicle will have sharply swept wings. The usual inefficiency of a sharply swept planform at low subsonic speeds is greatly alleviated by the blunt-rounded leading edges.

A fin or fins will be needed normally for stability and control within the atmosphere. If shielding of the fins in a partial vacuum at high speed and high incidence is to be avoided, a pair of fins will be positioned on the wing tips; to satisfy aerodynamic heating considerations, they will be placed on top of rather than below the wing tips.

The fuselage generally will be located below the wing, because this arrangement minimizes the wetted area subjected to the high-pressure region below the aircraft, thus minimizing both the skin-friction drag and the heat input to the aircraft.

A series of braking ellipses, in which the vehicle made temporary grazing contact with the atmosphere, was once thought of as a satisfactory way to reduce vehicular speed for reentry. However, passage through belts of high radiation (Van Allen belts) that exist close to Earth was necessary, and repeated passage through these would be extremely hazardous for a crew on the vehicle. Attention is now being focused on "single-pass" entry maneuvers, which are more critical because of the high speed involved but take less time and are much easier to predict.

Unless a flight has been timed accurately, the reentry point may be a long way from the pre-determined landing site, with the expenditure of a great deal of fuel. Thus there is a need to achieve very-long-range glides within the atmosphere (Fig. 6), and to this end a four-phase technique has been postulated: (1) An initial penetration of the atmosphere, followed by a pull-up to the fringe again. The penetration is taken to sufficient depth and is of sufficient duration such that, when the vehicle is again established at the fringe of the atmosphere, the excess velocity above satellite speed has been destroyed. The vehicle is pulled into a sensibly horizontal flight path and is then effectively in a low orbit just on the edge of the atmosphere. (2) An orbital glide to take the vehicle to within striking distance of the pre-selected landing site. The vehicle attitude (incidence) is so chosen that the drag slows the vehicle in the required distance. (3) A second and final penetration of the atmosphere, during which the vehicle loses the remainder of its velocity and approaches the landing site in a long subsatellite glide. (4) The landing maneuver proper.

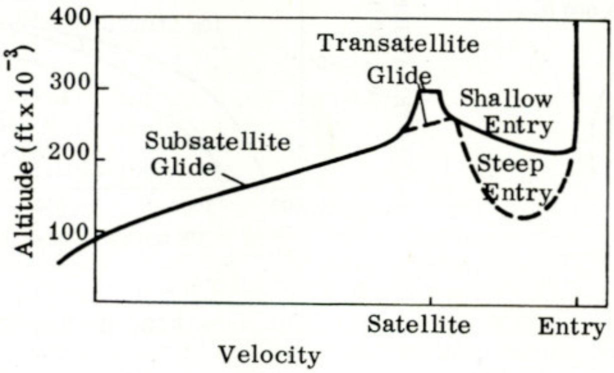

FIG. 6

For return to Earth, the order of magnitude of the first three phases, in terms of distance and duration is: entry, 1 1/2 to 10 min (usually less than 3), 450 to 2300 nm; transatellite glide, 3 to 150 min, 900 to 35,000 nm; subsatellite glide, approximately 40 min, 7000 nm.

The vehicle should have a high drag capability during the initial penetration of the atmosphere. This enables the vehicle to decelerate fairly rapidly in low density air and minimizes the kinetic energy to be absorbed lower down, where the heating rate and acceleration are higher.

The initial penetration of the atmosphere—effective at an altitude of approximately 400,000 ft (120,000 m)—is carried out with the flight path at a shallow angle to the local horizontal. For successful return, the flight-path angle must fall in the reentry corridor (Fig. 7 & Fig. 8), whose limits are called <u>overshoot</u> and <u>undershoot</u>. Overshoot occurs when the angle is too steep. The vehicle penetrates too deeply into the atmosphere and exceeds one or other of the two design limits (aerodynamic heating or acceleration).

The "width" of the reentry corridor depends on vehicle-design limits, type of reentry maneuver employed, and speed at reentry. Generally the corridor is only a few degrees at satellite speed and decreases rapidly in extent as reentry speed is increased.

Deceleration and heating are dependent on vehicle velocity with respect to the atmosphere. Therefore reentry is less critical if it is carried out in the direction of the Earth's rotation.

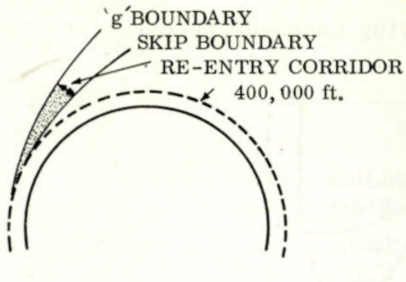

FIG. 7.

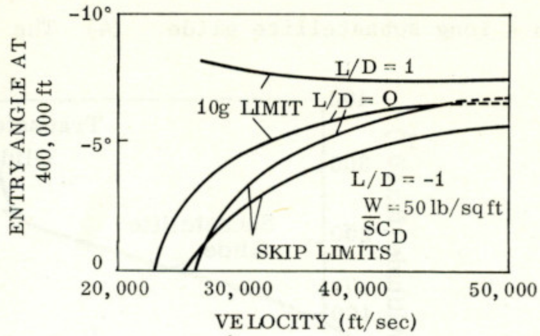

FIG. 8

Although the altitude at which maximum deceleration occurs varies considerably with the vehicular drag, for a given entry angle the actual value of the maximum deceleration varies only slightly; for the ballistic case, it lies between 7.4 G and 9.4 G over a wide range of drag levels. These slight variations are attributable to the change in atmospheric temperatures with altitude; and this temperature/altitude relationship is greatly dependent on latitude, season, solar activity, and time of day.

For a given drag level, however, it is good for the ratio of pressure drag to skin-friction drag to be fairly high since this reduces kinetic heating. Thus external drag devices (airbrakes, balloons, parachutes, and rotors) can be used to advantage since they predominantly give pressure drag. If a large-drag auxiliary body is towed behind a lifting vehicle during a 7 G entry from orbit, the total heat load can be reduced to 75 per cent.

The auxiliary body is jettisoned as soon as the vehicle achieves an equilibrium glide trajectory and reduces high lift/drag. Segmented flared-skirt and umbrella configurations have been suggested as more sophisticated variable drag devices.

A vehicle's deceleration will be extremely small when it first comes in contact with the very thin upper atmosphere, unless the drag is very high. If a variable drag device is used, it will be held in fully open position at the beginning of reentry and will be closed gradually as descent is made into the denser lower atmosphere. Peak deceleration for ballistic reentry—4 to 5 G—is poor when compared to that for lifting reentry, because high drag in ballistic cases automatically produces a steeper trajectory. Nevertheless the benefits are useful and lend the advantage of trajectory control when such a device is fitted to a ballistic reentry vehicle.

An Avco brake has been designed reputedly capable of providing ±150-mi (240-km) variation in landing site just after the start of reentry. This device has shown that for reentry from a low orbit (about 100 mi or 160 km) the drag obtained by merely opening the brake is sufficient to cause the commencement of reentry.

For winged reentry vehicles capable of fairly high lift, the need for external drag devices is greatly reduced because the wings themselves can form a useful high-drag surface. This indicates that initial penetration can be made at very high incidence and that a high pressure-drag can be obtained from the wings. It has been suggested that reentry might be effected at 90° incidence—with the planform at right angles to the flight path. However, drag at 90° is not significantly higher than that attained at maximum—lift incidence or 55°. Also normal aerodynamic controls are adequate for use at 55°, but a completely new reaction system would be necessary to provide control at 90°. Neither does entry at 90° provide the vehicle with a vertical lift component necessary for maintaining desired flight control and preventing overshoot and undershoot.

Lifting reentry is usually started by an initial penetration at an incidence of 55°. However, with the vehicle in the upright position, the magnitude of the lift component tends to reduce penetration of the atmosphere. The problem is obvious for supersatellite speeds, for here negative (downward) lift is necessary to hold the vehicle within the atmosphere. Reentry should begin, as suggested above, then gradually reduce incidence as required until the incidence is negative and the necessary downward lift is attained. There are two disadvantages to this "altitude modulation" method—a thermally insulated structure is required on the top surface as well as on the lower surface; and as the incidence is reduced through zero, the drag level falls off, thus defeating the object of reentering at high incidence.

In order to achieve the required positive or negative vertical lift component without sacrificing drag level, the banked flight procedure has been suggested. During the first part of reentry, the pilot maintains a high angle of incidence but undertakes a rolling maneuver. If the angle of bank is altered in this manner, the vertical lift component is adjusted to maintain the proposed flight path. For reentry at supersatellite speeds, most of this phase will be carried out at bank angles greater than 90°—the vehicle will be inverted.

A stage is reached, after the vehicle has penetrated deeper into the atmosphere, when the resultant force of the vehicle is of such magnitude that the limiting acceleration is reached. The altitude modulation is now brought into use to prevent this limit from being exceeded. The incidence is progressively reduced from the nominal 55°, so that the lift and drag are reduced and the resultant acceleration kept within the design limit. The reduction in lift will cause an unwanted change in the vertical component of that lift, and therefore, the bank angle must be altered to compensate.

This procedure uses banked flight and altitude modulation to achieve an effectively wider entry corridor than could be achieved by simpler techniques. (Sources: Flight International, July 4, 1962)

TRACKING

STUDY OF STANDARD EQUIPMENT FOR PHOTOGRAPHIC OBSERVATION OF ARTIFICIAL EARTH SATELLITES. The standard equipment for photographic recording of artificial Earth satellites (photocamera NAFA-3S/25-S, printing chronograph 21-P, pulse adapter 1P-M and radio-receiver PRV) was examined with the aid of photo-cell SPV-3 and an 8-loop cathode oscillograph. The time of opening of the shutter is delayed by 0.0022 ± 0.0002 sec; the time of closing lags by 0.0002 ± 0.0002 sec. For the chronograph the amount of delay depends on the voltage, which must be firmly stabilized; for instance, the delay in the beginning of recording at 210v and 230v is 0.0268 and 0.0254 sec, respectively, and the same takes place at the end of recording. The total correction to the moment of observation is equal to half the difference of chronograph corrections minus half the sum of shutter corrections. (Source: Dept. of Defense Intelligence Info., Report No. 1521678463, 19 June 1963, from Astronomicheskiy Zhurnal, Moskva No. 5, May 1963)

VEHICLE ENGINEERING

SOVIET RADIATION-RESISTANT FOAM GLASS. Soviet glass laboratories have recently concentrated considerable efforts on the development of special glasses that are capable of withstanding neutron and other types of radiation without loss of mechanical strength. The latest work has focused attention on foam glasses with very low densities.

Foam glass, though a high grade insulating material, is heat resistant only in conditions where the temperatures are below 300°C. Above that, failure may result from strength reductions and fusing or impaired conductivity when the glass softens and densifies.

The powdered glass is mixed with gassing agents and ground finely before being charged into the moulds and heated in a furnace. The glass particles soften and stick to each other, trapping inside the products of the gas formation generated by the foaming agents. This bloats the mass and produces pores.

Glass technologists S. M. Brekovskikh and Ye. Z. Zhitomirskaya added certain oxides—zirconia, titania, and chromium oxide—to the mixture and conferred radiation resistance to the finished foam glass. These oxides partially or completely dissolve in the starting glass at the foaming temperature and alter the composition of the glass.

The Soviet technologists produced several types of foam glass for technical purposes with bulk densities of 0.25 - 0.60 gm/cm^2, high heat resistance, low thermal conductivity, and good dielectric properties.

Radiation resistance of some of the foam glasses obtained in laboratory conditions was tested, based on starting formulae for two types—ordinary window glass containing 71.5 per cent SiO_2, 1 - 1.5 per cent AL_2O_3, 7.5 - 8 per cent CaO, 3 - 3.5 per cent MgO, 15 per cent Na_2O; and a non alkali glass of the composition: 60.5 per cent SiO_2, 14.6 per cent AL_2O_3, 16.2 per cent CaO, 8.7 per cent BaO, and 2 per cent F_2.

Compositions of the foam glasses, obtained on the basis of these glasses and their relative heat resistance, are listed in Table 3. Five to 30 per cent of the special oxide additions were added with the foaming agents (0.5 - 4.0 per cent silicon carbide, MnO_2, and carbon black).

The foam glass was subjected to radiation with hot neutrons—a stream of approximately 10^{18} neutrons/cm^2—in an atomic reaction for 84 hr. After irradiation the specimens were tested for compression. The results are shown in Table 3.

TABLE 3.

SOVIET FOAM GLASS

Foam glass No.	Batch composition for foam glass						Deformation Temp., °C	Approx. service temp., °C
	Original glass		Addition		Gassing agent			
	Type	%	Type	%	Type	%		
1	Window	95	Al_2O_3	5	SiC	1	900	600
2	Window	90	TiO_2	10	C	0.5	---	---
3	Window	90	TiO_2	10	SiC	1	900	600
4	Window	90	TiO_2	10	MnO_2	4	900	600
5	Window	90	ZrO_2	10	C	0.5	900	600
6	Window	90	ZrO_2	10	SiC	1	900	600
7	Window	90	ZrO_2	10	MnO_2	4	800	500
8	Barytes	80	Cr_2O_3	20	C	0.5	1200	800
9	Barytes	80	Cr_2O_3	20	SiC	1	1200	800
10	Barytes	70	Cr_2O_3	30	SiC	0.5	900	600
11	Barytes	70	ZrO_2	30	C	0.5	1300	850

After irradiation, the foam glasses' mechanical strength was barely altered. Only no. 1, which contained 1 per cent silicon carbide, showed an appreciable change — of the two specimens tested with radiation treatment, one did not have any resistance to pressure, and it crumbled; the other had only a compressive strength value of 0.8 kg/cm^2.

The Russian investigators found that sometimes an irregularity occurs and that there is an increase in the mechanical strength of the material. They attribute this increase to the influence of bulk density. Table 4 shows the bulk density values of the specimens and the standard factor which excludes its influence — strength applied to unit volume weight (or bulk density). Specimens of SiC have the highest relative mechanical strength.

TABLE 4.

RADIATION-RESISTANT FOAM GLASSES

Irradiated Specimens				Non-irradiated Specimens		
Foam glass No.	Bulk density g/cm^3	Compressive strength kg/cm^3	Strength applied to unit bulk density	Bulk density g/cm^3	Compressive strength kg/cm^3	Strength applied to unit bulk density
1	0.21	0.8	4	0.24	10.4	43
2	0.33	17.7	54	---	---	--
3	0.36	31.7	88	0.47	36.7	78
4	0.58	38.0	65	0.61	55.0	90
5	0.37	23.2	61	0.35	24.3	70
6	0.44	55.2	125	0.43	51.8	120
7	0.40	22.8	57	0.41	15.3	37
8	0.33	29.9	91	0.23	22.8	97
9	0.50	48.2	97	0.52	50.5	97
10	0.57	74.4	131	0.61	52.4	86
11	0.89	79.3	89	0.51	36.5	71

Thus radiation resistant foam glasses have been developed from window glass with additions of TiO_2, ZrO_2, Cr_2O_3, and ZrO_2. These materials provide heat-resistant insulation in equipment working at relatively high temperatures under the action of gamma-neutron radiation. (Source: Nuclear Engineering, August 1963)

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