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

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ATOMIC EXPLOSIONS MAY TAP MOON'S WATER.

"We'll get to the Moon and when we get to the Moon, we'll be in very bad need of water."

Dr. Edward Teller expressed this view at a recent meeting of the American Nuclear Society. Dr. Teller, one of America's top atomic scientists, asserted that there is "probably plenty of water on the Moon" tightly bound to surface layer rocks. These rocks are believed to contain chemical compounds capable of producing drinking water.

Nuclear explosions offer a logical way to extract water from the petrological formations of the Moon, according to Dr. Teller. If such a technique were utilized, he said, 100 tons of the water could be compared with 100 tons of gold.

The ponderous conveyance of suitable water by means of a rocket-propelled vehicle voyaging to the Moon from the Earth has been taken into consideration as a major problem for the planners of lunar expeditions that will be manned by people. (Source: Washington Post, November 29, 1962)

INERT APOLLO LAUNCH ESCAPE MOTOR DELIVERED. The first Apollo launch escape motor (Fig. 1), delivered on schedule by Lockheed Propulsion Company to North American Aviation, will not be fired but will still make a highly significant space flight early in NASA's flight test program, it was revealed recently.

The full-scale motor, many times larger and more powerful than the similar escape rocket Lockheed provided to NASA for Project Mercury, is loaded with inert propellant. Configuration of the solid propellant grain is identical to that of a "live" motor, except that the oxidizer is missing.

After vibration tests and various mock-up and "fit" operations, the first inert motor will be returned to the rocket firm in Redlands for late changes that may be required for its flight.

These are scheduled to be mounted atop the escape tower for early unmanned flight tests of the Apollo command and service modules. In these tests the Apollo units will be launched by a Saturn C-1 vehicle while space scientists study the effects of aerodynamic conditions approximating those of a manned launch. The escape rocket will ride as a "passenger."

In the later manned missions, the launch escape motor's job will be that of a space age lifeguard. It will be ready to fire instantly, to pull the command module with its three occupants free of the remaining Apollo assembly in event of trouble with the launch vehicle. For its few seconds of life, the motor will develop well over 45,200 kg (100,000 lb) of thrust, leading the module to a safe position from which its parachute can lower it gently to Earth. (Source: Data supplied by Lockheed Aircraft Corporation)

FIG. 1

ADVANCED FIBERGLASS ROCKET FIRED. An advanced lightweight fiberglass rocket engine with unconventional cooling and throttling systems has demonstrated exceptional durability in a 20-min static firing test at United Technology Center, Sunnyvale, California.

The 43-kg (95-lb), 76-cm (30-in.) long engine (Fig. 2) was operated at 1800 kg (4000 lb) of thrust for 1147 sec. Thrust chamber temperature was approximately 3000° C (5000° F)--hot enough to melt the toughest of metals. Upon examination afterward, engineers found that the engine could have been fired for another full 5 min.

Instead of a standard liquid cooling jacket, the engine depended upon the technique of "ablation cooling." In this process, the engine automatically expels heat which otherwise could burn through the combustion chamber walls and destroy it. An "ablative" plastic liner slowly melts, absorbs the heat, and is ejected with exhaust gases.

The company's scientists feel that the unusually long life of the engine, however, was due to the throttling system. It employs an "aeration" concept recently perfected by the company. It was this throttle that held the engine at 1800 kg (4000 lb) of thrust, although it is capable of levels up to 7000 kg (16,000 lb).

Extensive previous testing by the company has demonstrated that aeration-throttled engines have longer lives because they operate, in effect, more smoothly, and are not subject to a harmful condition called "unstable combustion."

The new test engine was subjected to unusually harsh punishment by being fired in four bursts of 10, 30, 702, and 405 sec. The engine was allowed to cool between each burst. This procedure ordinarily has a drastic shortening effect on an engine's life.

Principal advantage of ablation cooling is that it eliminates the need for heavy, bulky coolant tubing.

Applications for an engine of the type tested include lunar landing craft and various upper-stage vehicles designed for use in space. (Source: United Technology Center)

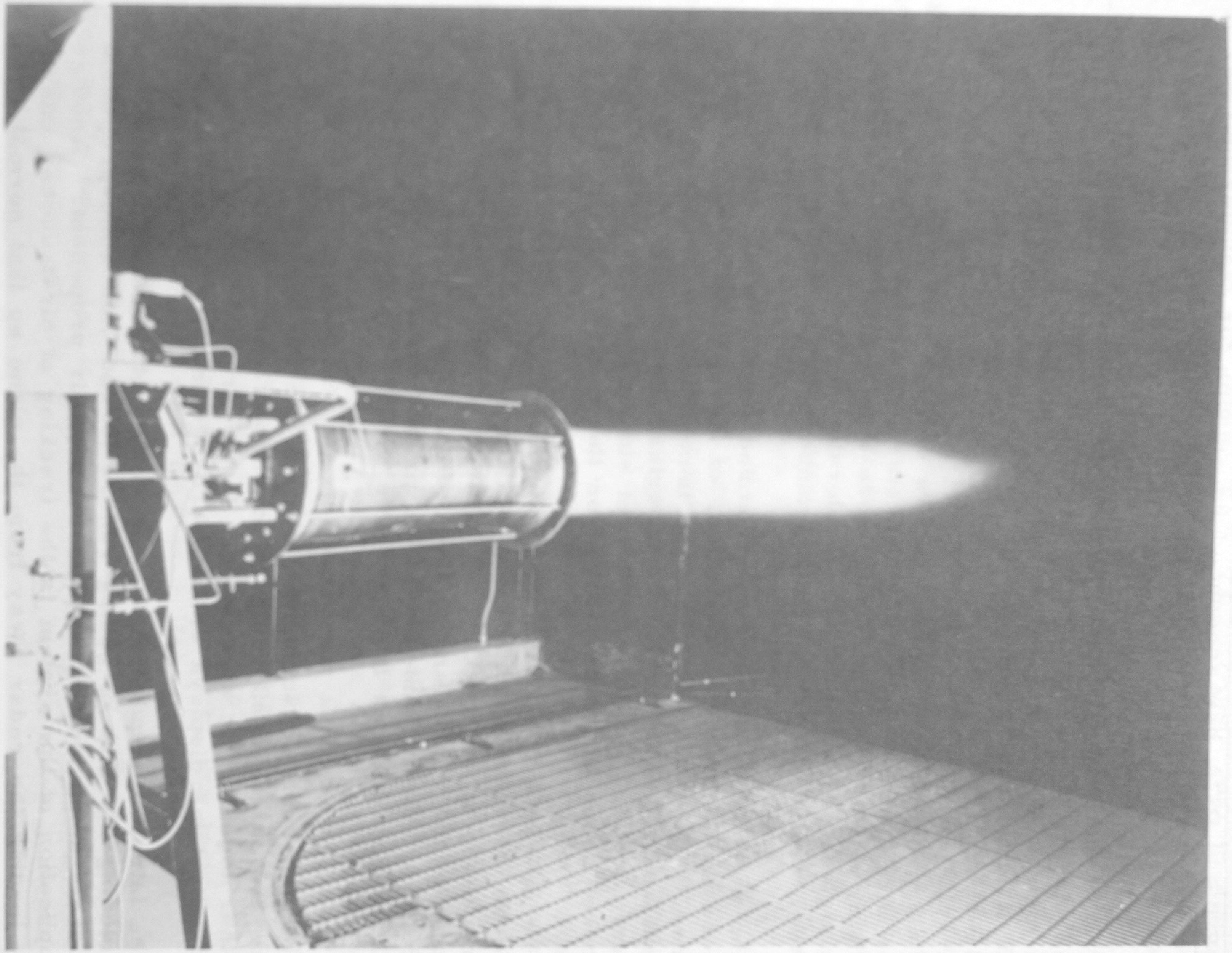

FIG. 2

RADAR PROBLEM SOLVED FOR FAST TAKE-OFF ROCKETS. RCA has announced its solution for instantly locking tracking radars onto fast rockets leaving the launch pad, which has been a "trouble spot" in our launching program.

This solution involves two devices, a heat-sensing infrared tracking system and a radar programmer. Both have demonstrated in tests at PMR that radars can immediately track rockets taking off at accelerations as high as 50 G's that would be 3050 k/hr (1090 mph) after 1 sec.

While conventional tracking radars can be maneuvered to lock onto the larger, slower-starting rockets such as Atlas, Redstone, and Titan, it has been difficult to move them quickly and accurately enough to track the higher-acceleration rockets in the midst of radar reflections from "ground clutter" in the launch areas.

The new infrared sensor is mounted on the radar antenna and picks up the exhaust, or plume, of the rocket the moment it fires. The radar is locked on immediately because of the intense heat from the exhaust; tracking begins automatically with its own servo loops. An infrared target simulator located close to the rocket keeps the radar locked on the rocket before firing.

The new lift-off elevation and azimuth programmer (LEAP), stores information concerning the angular velocity of the rocket or missile to be tracked. The firing signal is then fed simultaneously to the rocket and to the radar. The programmer automatically orients the antenna in the proper direction and rate to follow the rocket as it progresses through lift-off and early flight phases.

Both the infrared acquisition system and the LEAP programmer are said to be easily adapted to most tracking radars, when used either together or separately. However, a tracking radar using both systems displays almost zero dynamic lag characteristics.

The infrared acquisition system solves other missile range problems, including the task of getting radars locked onto solid-propellant rockets using metallic ingredients in their propellant. Another application of the system is the tracking of air-launched missiles by leading the radar away from the plane so that normal radar tracking can take over. (Source: Data supplied by Radio Corporation of America)

SOME ASPECTS OF SPACE ASTRONOMY. The limitations of ground-based astronomy and the beginnings and future of space astronomy were recently discussed by Lyman Spitzer, Jr. In a lecture delivered at the Third International Space Science Symposium, (COSPAR), held in Washington, D. C., on May 8, 1962, milestones in the exploration of space through astronomy were discussed.

The real beginning of space astronomy was in October, 1946; the first ultraviolet spectrum of the Sun was obtained by a group at the Naval Research Laboratory. A V-2 rocket carried a small spectrograph aloft and returned film that showed features in the spectrum down to wave lengths of about 2100 Å.

A second investigation of the Sun was carried out in September, 1957. A group from Princeton University Observatory used a 30-cm (12-in.) telescope that was flown to an altitude of 25,000 m (82,000 ft) to obtain the first high-resolution photographs of the Sun with about 97 per cent of the Earth's atmosphere below. Using this telescope on subsequent flights yielded important photographs of sunspots and of the solar limb.

For the near future, several experiments are planned, including a vigorous program utilizing sounding rockets for measuring ultraviolet stellar spectra. Furthermore, important gamma-ray spectroscopy from high altitudes is already in progress.

Orbiting astronomical observatories (OAO), organized and sponsored by NASA, will accommodate telescopes of about 7.6-cm (30-in.) aperture. This series of telescopes should yield important findings in the next few years concerning stellar ultraviolet spectra. Another element in the short-range program, the Stratoscope II project, is designed for theoretical resolution of a 9.1-cm (36-in.) telescope lofted by balloon into the stratosphere. With the desired resolution and pointing accuracy, this instrument should outperform the 510-cm (200-in.) Hale telescope.

Some of the problems of outstanding interest for astronomy will presumably be included in the near-future programs, and they are listed by the author:

1. Ultraviolet flux from hot stars
2. Chemical composition of the stars and interstellar gas

3. Photometry of dense clusters. With a resolving power of 0.1 arcsecond, characteristics of giant stars within globular clusters will be of interest for theories of stellar structure and stellar dynamics.

There are many possible areas for space-astronomy development in the long-range program. Research could include such problems as low-frequency radio waves, X-rays, gamma rays, infrared radiation, and ultraviolet radiation. Perhaps the most spectacular possibility--both in concept and expected results--is a telescope of very large dimensions. Spitzer considers a 10-m (400-in.) telescope in an optimum orbit, either around the Earth or around the Sun. In his analysis of such an instrument, he considers not only the obvious difficulties of construction (whether on Earth or in space) but also treats extensively of the thermal problem.

An operating temperature of -140° C (-220° F) is suggested as an optimum for the fused silica mirror; at this temperature, the material reaches its minimum length. To shield the telescope from direct sunlight, several concentric shells of insulation are proposed. Heat leaking from the viewing port might be sufficient to bring the temperature down to the desired value.

The giant telescope (the mirror alone would weigh about 50 metric tons) would be capable of solving many problems. With a resolution of 0.01 arcsecond, the instrument could, for the first time, resolve surface features of some stars. Supergain stars such as α Orionis, α Scorpii, and 0 Ceti have diameters between 0.04 and 0.05 arcsecond; in addition to such resolution, parallaxes of stars as far distant as 1000 parsec could measure.

An important part of the long-range program is the detection of planets around other stars. This detection is an extraordinarily difficult problem: Not only are such planets very faint, but also they may be masked in light from the central star, scattered and diffracted in the telescope system.

Within about 5 parsecs (16 light years) from the Sun are 11 stars somewhat similar to the Sun. If the planetary orbit is taken as similar to that of Jupiter's orbit, the maximum apparent separation between the planet and the central star is one arcsecond--the problem is entirely one of distinguishing the planet from the scattered and diffracted starlight.

The actual brightness of a planet will depend on a function of its overall reflectivity (albedo), and the phase angle. To continue the analogy of Jupiter, this planet's relative brightness at 5 AU is 10^{-9} for an albedo of 0.5. Thus Jupiter would be fainter than its central star by about 22.5 magnitudes.

A better way to detect planets around other stars has been pointed out by R. Danielson at Princeton. This method makes use of a large occulting disk placed far in front of the telescope to reduce the light from a star. For best results, the edge of the occulting plane, as seen from the telescope, should appear to be about halfway between the parent star and the planet.

The use of an occulting disk poses a variety of problems. The large distances between the disk and the telescope, perhaps 10,000 km (6210 mi) to 250,000 km (157,000 mi), and the precise positioning required are two of these problems. A sheet-metal disk or a 75-m (250-ft) diameter balloon would be adequate for detecting a planet at 1 sec of arc distance; an obstacle 5 times this diameter would be required for a planet at 0.2 arcsecond.

Two other techniques are mentioned for possible use in detecting other planetary systems. The first would use infrared detection, where the luminosity of planets relative to a sun is greater. For instance, in the far infrared, where the Rayleigh-Jeans law is applicable for both the Sun and Jupiter, the luminosity of Jupiter relative to the Sun is 2.3×10^{-4}. Although this gain is on the order of 9 magnitudes, the telescope necessary to resolve Jupiter at 5 AU from its parent star from an observing distance of 5 parsecs would have an aperture of 2540 cm (1000 in.), instead of an aperture of 3000 cm (1200 in.) required for visual light observation. Most of the gain realized through the use of infrared is offset by resolution loss at the longer wavelengths.

Another method might be to search for the zodiacal light that probably accompanies a planetary system. Zodiacal light in our solar system greatly exceeds the combined luminosity of the planets; the same phenomenon might be true of other similar systems. However, the problem of detecting may well be as difficult as detecting larger planets against the scattering and diffraction of the central star.

The potentially basic problem of "poor instellar seeing" because of intervening particles is dismissed as too small to detect; another basic restriction, the flexure of a large telescope because of the Sun's gravitational force, can be made negligible if the instrument is sufficiently distant from the Sun. It is concluded that a 1020-cm (400-in.) space telescope could detect several planets if the stars within 5 parsecs have planetary systems similar to our own. A space telescope such as the instrument described, with the occulting device, is described as the optimum; in contrast, an instrument built to operate on Mars would be altogether impracticable for realizing the goals believed possible with a space telescope.

In a statement following the description of the gigantic planet-based telescope required, the author states:

"The above computation is an interesting exercise which shows how many, many orders of magnitude away we are from observing other planetary systems with enough resolution to distinguish clouds, oceans, snow-covered regions, and forests. It would probably be easier to send a probe on a manned expedition to several stars nearby than to build the equipment necessary to view these planets with appreciable resolution from close to the Sun." (Source: American Scientist, September, 1962)

WORLD'S LARGEST THERMIONIC TUBE DESCRIBED.

Believed to be the world's largest thermionic tube, a traveling-wave device being completed in England is 5.5 m (18 ft) long and weighs 4.5 tons. The wideband microwave amplifier will emit bursts of energy lasting 5 usec with about 100 Mw peak power.

When completed in a laboratory at Harlow, Essex, the tube will be used near Chelmsford for Ministry-sponsored research into the upper atmosphere. The tube will also test a recent prediction that traveling-wave tube efficiency should increase rapidly as the velocity of beam-width interaction approaches the speed of light.

Output pulses at 420 Mc/sec will be achieved by interaction between a radio wave traveling inside the tube and a beam of electrons moving at a similar speed. An electron gun (250 Mw input at 500 kv) will produce a 15-cm (6-in.) diameter beam traveling at 80 per cent the speed of light.

The tube structure is built largely of copper. It is 5.5 m (18 ft) long, 2.15 m (7 ft) high, and 1.8 m (6 ft) wide overall. A stainless steel tube inside, forming the vacuum tube itself, is about 3 m (10 ft) long and 1.2 m (4 ft) in diameter. The vacuum tube, whose cross section resembles a four-leaf clover, is maintained at a vacuum with a 400 liter/sec (14 ft^3/sec) vacuum pump.

The collector consists of 36 copper pipes of 2.54-cm (1-in.) diameter forming a "squirrel cage" designed to dissipate 400 kw. The output is piped from the structure by a waveguide for direct coupling into the final cavity of the tube. The magnetic field for the tube is 2.5^{-2} weber/m^2 (250 gauss), provided by 14 short sections of air-cored solenoid, each 1.2 m (4 ft) in diameter.

When in operation, the device generates much X-ray radiation. Researchers will be protected by housing the tube underground in a pit with lead walls and a 17.8-cm (7-in.) thick lead roof. (Source: New Scientist, November 8, 1962)

TECHNICAL REPORTS AVAILABLE. The following listed technical reports can be requested through the NASA library, M-MS-IPL, Bldg. 4481.

1. A THEORETICAL AND EXPERIMENTAL INVESTIGATION OF THE ACOUSTIC RESPONSE OF CAVITIES IN AN AERODYNAMIC FLOW. AD 277 803
2. PERTURBATIVE FORCES AFFECTING THE MOTION OF ARTIFICIAL EARTH SATELLITES. AD 272 830
3. A BIBLIOGRAPHY ON AEROSONICS, A. Powell, T. J. B. Smith. AD 274 208
4. BIBLIOGRAPHY OF REPORTS ON DATA ACQUISITION INSTRUMENTATION. AD 275 277
5. REMOTE-HANDLING TASK PERFORMANCE AS A FUNCTION OF INDEXING VARIABLES, D. F. Baker. AD 277 815
6. STUDY OF THE MECHANISM OF FAILURE OF ROCKET MATERIALS AND MATERIALS RESEARCH. AD 281 794
7. THERMOPILE GENERATOR FEASIBILITY STUDY - Part 1 - Summary, R. L. Gessner, Editor. AD 268 590
8. THERMOPILE GENERATOR FEASIBILITY STUDY - Part 2 - Materials Investigations, J. H. Bredt, Editor. AD 265 599

9. THERMOPILE GENERATOR FEASIBILITY STUDY - Part 3 - Performance Studies, D. L. Kerr, Editor. AD 264 926
10. THERMOPILE GENERATOR FEASIBILITY STUDY - Part 4 - Generator Design, R. L. Gessner, Editor. AD 268 591
11. INVESTIGATION FOR THE DEVELOPMENT OF CERAMIC BODIES FOR ELECTRON TUBES, H. R. Wisely. AD 277 842
12. FACTORS AFFECTING THERMAL SHOCK RESISTANCE OF POLYPHASE CERAMIC BODIES, D. P. Hasselman and P. T. Shaffer. AD 277 605