Space TECHNICAL INFORMATION DIGEST

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

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METAL-FORMING TECHNIQUE TERMED BREAK-THROUGH. The advanced Saturn first-stage booster, the S-1C, will be part of a 3-stage vehicle designed to carry the 3-man Apollo spacecraft on NASA's Earth-orbital and circumlunar missions. The Boeing Company is to develop the 3,400,000-kg (7,500,000-lb) thrust first-stage booster.

The S-1C booster requires four huge, dome-like bulkheads, each about 10 m (33 ft) in diameter. They are being fabricated here in curved, pie-shaped segments (gores) made of special aluminum alloy. Sheets used to make the Saturn V gore sections are 5.8 m (19 ft) long, 3 m (10 ft) wide, and about 1.27 cm (0.5 in.) thick. Precision forming these large and heavy sheets by use of liquid pressure in a rubber bladder "represents a manufacturing breakthrough."

Reduced-scale experiments conducted simultaneously at Wichita and in Seattle, Washington, proved the hydraulic bulging method both physically desirable and economically justifiable. To perform this task, company tool makers at Wichita used 170 tons of high-strength steel to build the dies and related fixtures. One die base alone weighs 55 tons and is 7.5 m (25 ft) long. A series of hydraulically operated clamps around the perimeters of the dies are designed to withstand 590 tons of pressure (Fig. 1).

When one of the big blanks is ready for forming, it is placed over the rubber bladder on the convex die base. In the upper concave die member, there is a plastic liner of the desired contour. When the upper unit is lowered to meet the base unit, a series of notched jaws fit together at each end. Then the hydraulic clamping is activated, and approximately 2380 Kg (630 gal) of water are forced into the bladder by a powerful pump. As the bladder expands, it forms the aluminum against the plastic liner at a maximum of 105 kg/cm^2 (1500 psi).

Each pie-shaped gore segment is formed in two parts on separate dies, then welded together. Even so, accurate results with metal sheets of this size are not easy to obtain, and the installation had to be specially designed for uniform pressure and minimum shrinkage. (Source: Data supplied by the Boeing Company)

WEATHER SOUNDING ROCKET PROVIDES WIND, TEMPERATURE DATA. A rocket-sounding system for obtaining weather data to altitudes of 76,000 m (250,000 ft) has been outlines by The Marquardt Corporation. The system (Fig. 2) includes a separable payload launched by a rocket-booster "dart"; a semiportable launcher is used to fire the "Roksonde" either from the land or from a ship.

The payload includes a self-contained instrument package that is deployed at high altitudes and suspended from a metallized parachute. The radar-reflective parachute provides wind direction and velocity, as shown in Fig. 2. (Other Roksonde models employ chaff as a radar-reflector.) When the package is deployed, a small thermistor, subjected to atmospheric temperature, varies in resistance as the temperature varies. This variation is sensed by an electronic circuit in the miniaturized telemetry system; the information is modulated and transmitted to compatible radar tracking equipment on the ground. (Source: Data supplied by The Marquardt Corporation)

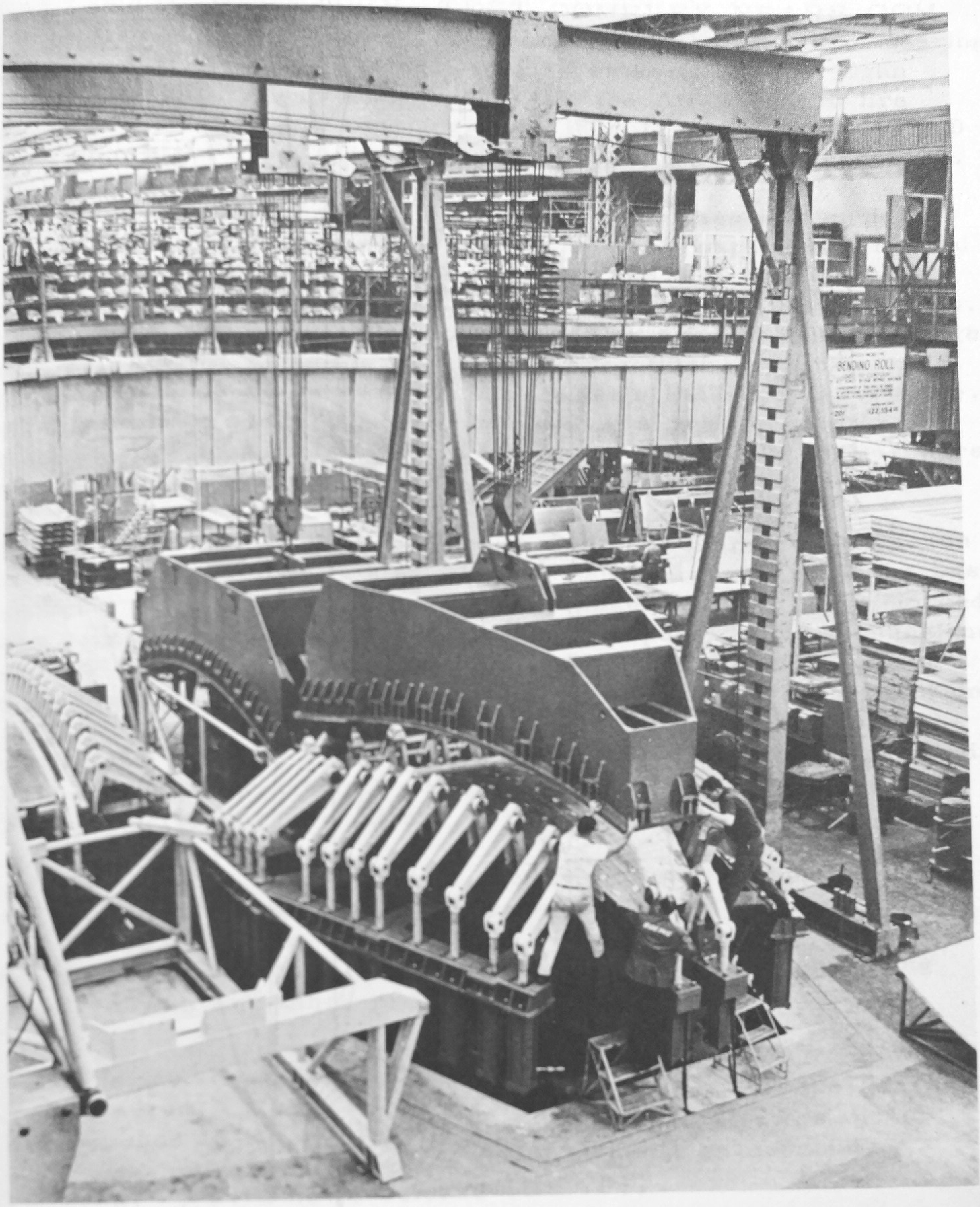

FIG. 1

INSTRUMENTED ROKSONDE DATA LINK SYSTEM OPERATION

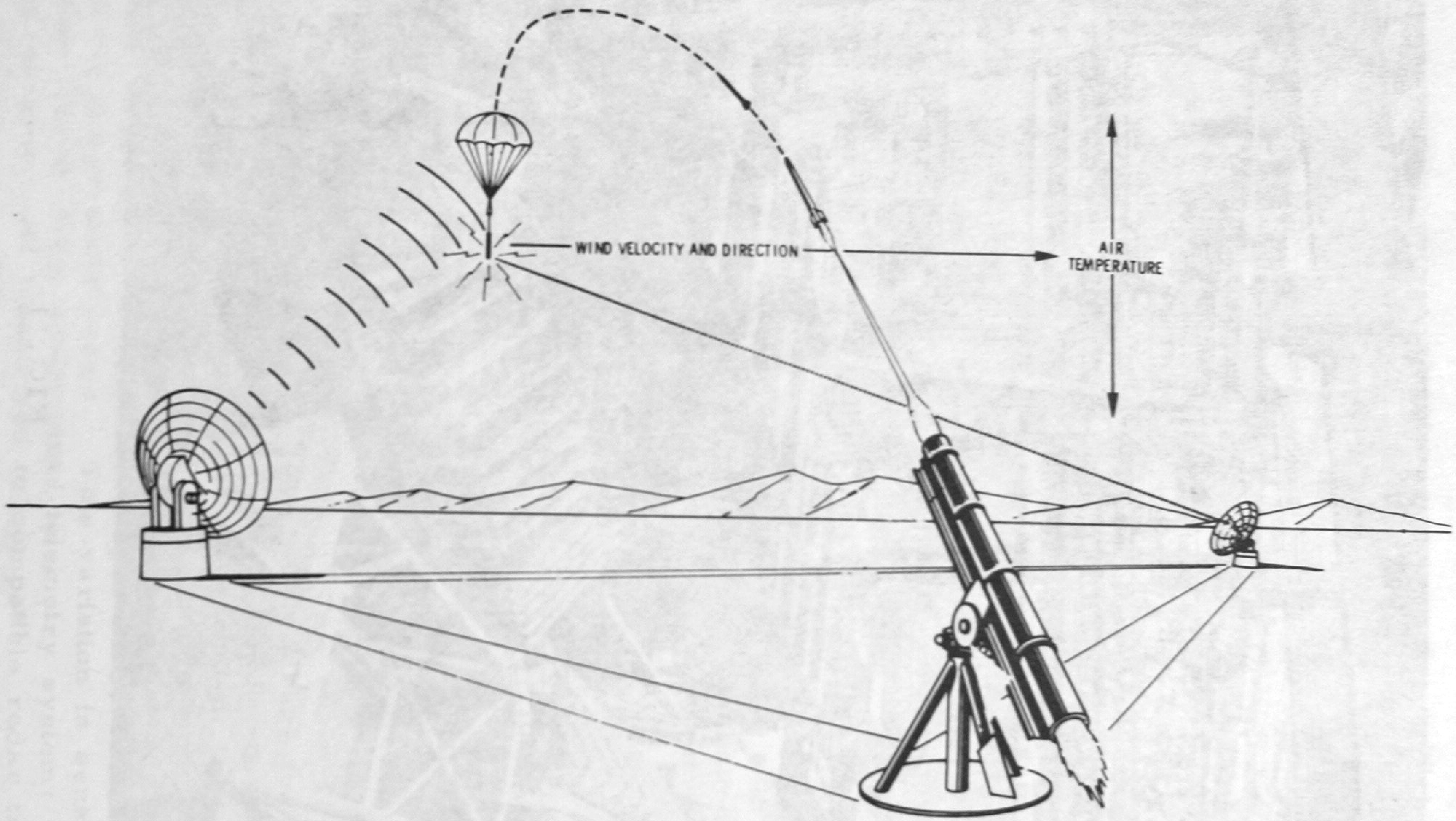

FIG. 2

BALLISTIC RESEARCH, TEST COMPLEX NEARS COMPLETION. A hyperballistic research and test complex is nearing completion at the Air Proving Ground Center (APGC), Eglin AFB, Florida. The facility will enable the Air Force to fire projectiles at velocities reaching more than 12,300 m/sec (40,000 fps), the Air Force Systems Command (AFSC) has announced.

The facility will make possible the study of damage that could be caused by collision of a space vehicle and tiny particles of natural or man-made space debris. A fragment the size of a pinhead traveling at such velocities can easily penetrate a 1.27-cm(0.5-in.) thickness of aluminum. Development of the terminal ballistic range stemmed from a suggestion by Andrew G. Bilek, an ordnance mechanical engineer working in the Center's Ballistics Directorate. Bilek made an unofficial survey more than a year ago. He studied some blueprints and drawings of an armament stratosphere chamber used in conventional weapons development at APGC.

It was discovered that the chamber could be altered at a fraction of the cost of building a new terminal ballistic range. All the basic elements of a shaped-charge vacuum range existed: a reinforced concrete arena, target chambers, vacuum pumps, and a munitions storage facility. The proposed changes would not affect use of the area for its original purpose--an armament stratosphere chamber.

During the last two years, terminal ballistic data have been acquired from civilian contractors. However, this did not always permit flexibility in testing operations.

Aerojet-General Corporation is modifying the armament facility and has been developing an explosive projection technique for the Air Force. By the end of 1961, APGC was getting valuable terminal ballistics data in a velocity range far above any being acquired with any other projection system.

Some terminal ballistics data has been acquired at APGC with a light-gas gun. However, many experts believe that the gun has been pushed to its operational limits unless an electrostatic or electromagnetic method can be found to boost its capability.
(Source: AFSC news release (USAF))

SHAPING METALS BY THE ELECTROCHEMICAL PROCESS. As the strength and hardness of metals increase, the machining difficulties of these metals increase; in machining today's refractory metals, the workman eventually is confronted with some metals that cannot be handled by conventional methods. Even though the metal may be machined conventionally, the process is often inefficient and damages the material's critical stress properties.

One answer to this problem is electrochemical machining (ECM), as discussed by C. L. Faust in the Battelle Technical Review (Vol. 12, No. 1). Material stock may be removed with ECM, without mechanical tool action, by using electrical energy to produce a chemical reaction that removed metal.

The workpiece, an electrically conductive material that is to be shaped, serves as an anode connected to the positive terminal of a dc power source. The "tool" can be a conductive material shaped to give the desired three-dimensional contour; it serves as a cathode and is connected to the negative terminal. Between the two separate materials is a conducting solution that supports electrolysis by an applied emf flow that drives electrons from the workpiece (anode) and away through the external circuit and power source to the "tool" (cathode). Surface atoms leave the workpiece in accordance with Faraday's Laws:

1. surface metal atom + anion (s) = metal salt + electron (s)

The cathode collects an excess of electrons; for the current to flow, a comparable and counter reaction occurs at the "tool" (cathode) surface:

2. cation + electron (s) = atom

To make ECM practicable, equation 1 (above) requires an ample supply of anions to accept the metal atoms as ions. In a part to be made of pure iron, using an acid chloride electrolyte:

$$Fe + 2\ Cl^- = FeCl_2 + 2\ \text{electrons}$$

For a penetration rate of 0.32 cm/min (0.125 in./min), a controlled, rapid electrolyte passage supporting a current density of at least 150 amp/cm^2 (925 amp/in.^{2}) is required. This condition is recommended for copper, iron, and titanium; for higher penetration rates, the required current density increases as a linear function of the desired time rate. Molybdenum requires about a 200 per cent increase in current density over that given above for copper, etc. However, most high-temperature alloys need only a 50 per cent increase in such current density. (Source: Battelle Technical Review, January 1963)

ACTUATOR ELIMINATES REACTION TORQUE. An inertially balanced actuator, which imparts no reaction torque to a space vehicle while positioning an appendage, has been developed by Garrett-AiResearch, of Los Angeles.

Called a "Zeract Drive" (Zero Reaction), the new actuator inherently balances all inertial and frictional forces, internally in the actuator as well as externally to the actuator. Frictional forces are neutralized by counterbalancing and arranging internal components, such as gears, and effectively trapping internal forces within the power circuit.

The actuator has applications where reaction torque from moving a mass is undesirable. This reaction torque often affects the attitude or orientation of a space vehicle, requiring compensating forces to maintain proper orientation. The new actuator eliminates this problem.

Some applications for the actuator include orientation of spacecraft antennas, solar array panels, cameras, and telescopes. Size, weight, and power of the device depend, as in normal electromechanical requirements, largely on the mass moved, acceleration and friction forces. (Source: Data supplied by the Garrett Corporation)

GLASS FIBER USED TO BUILD ROCKET CASING. The largest segmented and jointed glass fiber rocket engine casing in the world, 400 cm (156 in.) in diameter, has been successfully fabricated by United Technology Center, UTC division president B. R. Adelman announced on February 12.

The case (Fig. 3) is designed to be used either by itself, with end closures, or as a segmented part of a longer solid-propellant

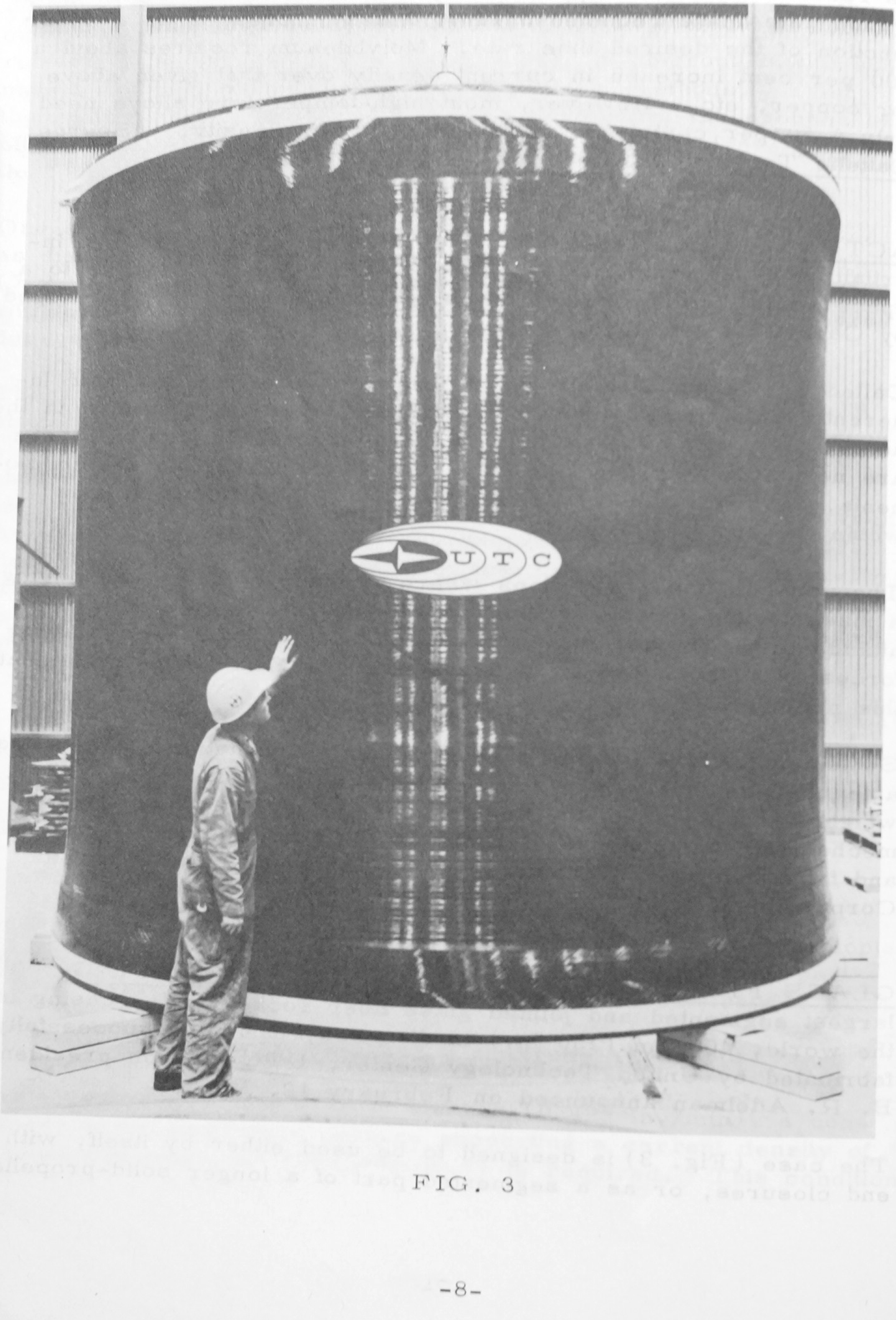

FIG. 3

rocket engine. The filament employed in its fabrication is long enough to reach from the Earth to the Sun and back twice--over 600 million km (372 million mi).

The company performed the winding of the case at its new filament winding facility at Coyote, California. A number of smaller segmented glass engines have been fired there by the firm in the past year. The filament winding facility is capable of producing glass fiber rocket engine casings of more than 6.1 m (20 ft) in diameter. It was built to support a two-year effort to apply the advantages of glass filament-wound casings: light weight, low cost, and short leadtime. Glass fiber filament-wound cases cost considerably less to build than steel cases, both because the materials involved are less expensive and because a facility for making filament-wound cases costs considerably less.

Glass fiber cases weigh about 30 per cent less than steel cases. As a result, it is possible to develop engines in which the usable propellant accounts for as much as 94 per cent of the rocket's total weight.

The basic process for winding glass fiber cases is relatively simple. High-strength glass rovings, each containing some 250,000 glass fibers one-tenth the thickness of a human hair, pass through a resin bath and are wound onto a rotating mandrel. A shuttle guides the resin-impregnated glass fiber over the mandrel in high-strength patterns that are continued until the desired wall thickness for the casing has been built up (Fig. 4). After it is wound, the casing is hardened and cured in an oven. (Source: Data supplied by United Technology Center)

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

NOTE: Those reports with an AD number may be on file in the local ASTIA branch in Bldg. 4484. Readers can save time by calling 876-6088 and inquiring if such reports are available before ordering them through NASA.

1. DEVELOPMENT PROGRAM FOR MICROWAVE RADIATING POWER SOURCE FOR SPACE VEHICLE TELEMETRY TRANSMITTER, L. A. Roberts. AD 278 713

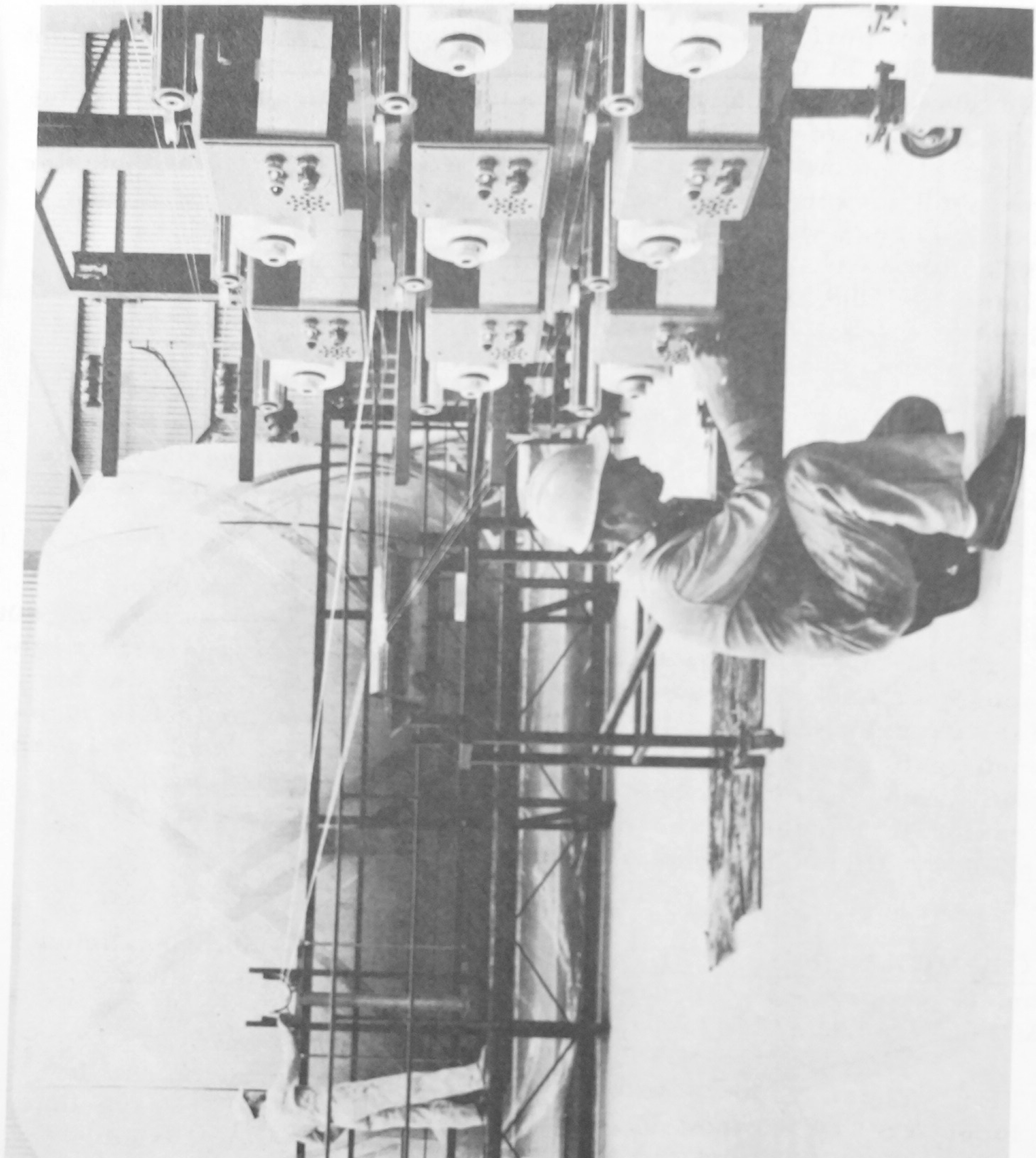

FIG. 4

2. CW FUZE SIMULATOR SYSTEM DESIGN, H. F. Shaw. AD 278 382
3. STUDY AND EXPERIMENTAL INVESTIGATION ON SAMPLING RATE AND ALIASING IN TIME DIVISION TELEMETRY SYSTEMS, J. W. Capps and others. AD 278 515
4. SPEECH DURING WEIGHTLESSNESS, C. W. Nixon. AD 284 688
5. PSYCHOMOTOR PERFORMANCE UNDER CONDITIONS OF WEIGHTLESSNESS, J. E. Wade. AD 285 549
6. MACHINING OF REFRACTORY MATERIALS, N. Zlatin and others. AD 282 282
7. EQUIVALENT CIRCUITS AND EFFICIENCIES OF FUEL CELLS, J. I. Slaughter. AD 282 283
8. COMPACT POWER FUEL CELL, J. O. Smith and others. AD 282 862
9. EVALUATION OF NEW CATHODE-ANODE COUPLES FOR SECONDARY BATTERIES, E. F. Uhler and G. S. Lozier. AD 277 197
10. NEW CATHODE-ANODE COUPLES USING NONAQUEOUS ELECTROLYTES, J. E. Chilton, Jr. AD 277 171