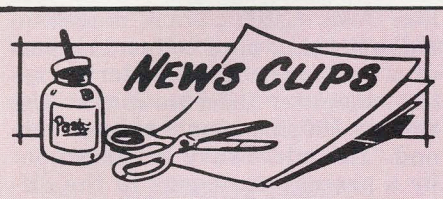
Volume 3 Number 5 May 1962

EE DIGEST

CURRENT DEVELOPMENTS IN ELECTRICAL ENGINEERING AND SCIENCE

Published by AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS for students



Fort Monmouth, N. J. . . . Calculations of the current flow lines in the atmosphere show that the electric current penetrates the ionosphere and reaches far into outer space, according to Dr. H. W. Kasemir, U. S. Army Signal Research and Development Agency. The concept challenges the more widely held theory that pictures the atmospheric current flow as inside a spherical condenser, where the ionosphere is the positive outer sphere, and negatively charged earth is the inner sphere.

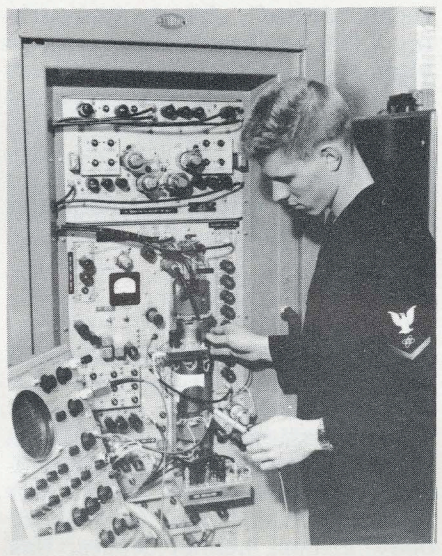
Youngwood, Pa. . . . Molecular functional electronic blocks, tiny parts used in radios and electronic equipment stemming from the concept of integrating into a solid block of material functions ordinarily performed by an assembly of electronic components are available commercially The blocks are smaller and much thinner than a dime, Westinghouse Electric Corp., announced.

New York, N. Y. . . . An oblong UHF (ultra high frequency) antenna located on top of a tower of the George Washington Bridge, is part of a translator system repeating the program of WUHF, Channel 31 in New York. The purpose of the F.C.C. experiment is to discover whether the neglected UHF channels (14 to 83) can provide good TV reception in a large city. The translator was developed by Adler Electronics, Inc., New Rochelle, New York.

Metuchen, N. J. . . . A sensitive microphone, whose working parts look like two tiny mushrooms placed stem to stem, has won a patent. It was supplied for Project Mercury and other space flights. The active element for the microphone is a piezoelectric ceramic. Output of the device is believed substantially free from any effects due to acceleration in space flight. The rights were assigned to Gulton Industries, Inc.

Chicago, Ill. . . . Static electricity has a new enemy in the form of a permanent anti-static chemical. Approximately one part of the new chemical added to vinyl resin compounds, from which records and other products are made, will increase their life by making the products permanently static resistant, it is said. The chemical, a long-chain aliphatic nitrogen derivative, was developed by Armour Industrial Chemical Company.

Recording Storage Tubes Extend System Capabilities



SIGNALS FROM CONVENTIONAL RADAR are fed into this Raytheon scan converter which puts them into a form that can be televised. Here, Electronic Technician Frederick A. Warren, Jr., checks specially-developed storage tube, the heart of the system.

Needs for storing radar and television display, have brought about the development of a versatile Recording Storage Tube. This is accomplished by electron charges on a dielectric surface.

The reported unique capabilities of fast writing and long storage, together with fast erase and immediate read-out, makes the tubes versatile devices for many equipment and system applications.

Scan Conversion

The tubes can perform the function of converting electronic information available in one form, for instance, a radar plot, to another form, such as television-type scanning. A bright display is possible, and the storage characteristics permit the integration of weak targets and the generation of target trails to indicate the past history of moving targets.

Stop Motion

For instant storage and immediate read-out of television pictures, the recording tubes feature the fast writing, reading and erasing characteristics necessary to stop motion.

Integrate Signal Information

Since the storage of information is accomplished by the accumulation of charges on a dielectric material, the repetition of input signals can build up or integrate these charges. Noise is generally random and does not repeat itself as frequently as a desired signal. Therefore it is possible to integrate any signal information that is actually below the noise level until it becomes greater than the noise.

(Continued on page 3, col. 1)

USSR AIMS FOR NINE-FOLD POWER EXPANSION BY 1980

The Soviet Union plans to multiply its electric power capacity nine times in the next twenty years, according to a recent Canadian report.

The ambitious plan would surpass the U.S. electric power making capacity by three times at the end of 1980, if the U.S. stood still. At present the USSR has an electric power capacity only one-third as great as that of the United States.

The major Soviet power expansion would be in the eastern areas, including Siberia. According to one source this would mean a reduction in costs, since Siberian costs are only one-fourth to one-eighth those of the USSR average.

Although a hydro-station network is included in the plans, (and the first units of a planned twenty have gone into service at the Bratsk Station on the Angara River), most of the increase will come from thermal stations fired by low-cost coal and gas.

Plans have also been announced to expedite the exchange of power between eastern and western regions. Because of different time zones, peak periods do not coincide. Ultimately plans call for a single grid covering the entire territory of the Soviet Union.

'OUT OF THIS WORLD' ENERGY SYSTEMS

The April issue of Power magazine reported detailed problems and possible solutions for future space energy systems. The article, entitled "Energy Systems in Space," dealt at length with today's operating space energy systems. EE Digest has digested some of the important highlights. We suggest that those who desire a full account read the complete article. . . .

The engineer will encounter formidable problems in building power systems for future space pioneers. Systems must be relatively small but complex. These energy systems' cores are expected to be delicate, with subsystems similar to many that we have here on earth. They may be considered as miniature industrial plants.

Key Problems

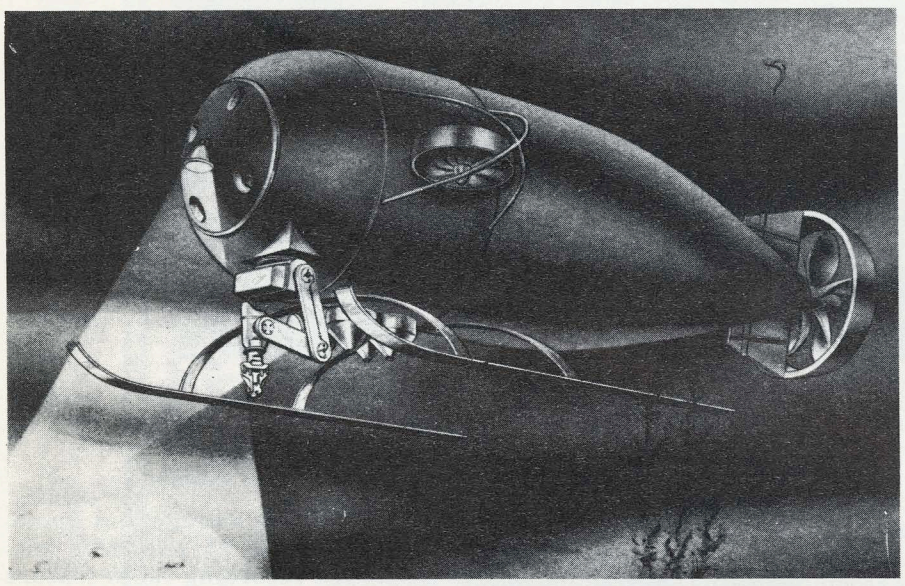
Before designing energy systems for spacecraft the engineer will have to face key problems. In space, he has to assume there is hard vacuum and the component materials of the craft's system have low evaporating rates. Also he has to eliminate shaft seals between working fluids and the space environment. In space waste-heat is rejected by radiation and this poses problems to him. He knows that the vacuum affects some

(Continued on page 4, col. 1)

SAFER FLYING conditions are possible for pilots of civilian aircraft using the new Electrocular TV headset. Pilot can be furnished with a television picture of air traffic information and ground conditions without distracting him from his normal flying duties. Either televised radar data from ground sources or closed-circuit TV picture from camera mounted on airplane may be given to pilot using this unique device. Television with zoomar lens from airplane-mounted camera furnishes pilot with close-up view of vital ground surface areas. The Electrocular display was designed, developed and manufactured at the Hughes Aircraft Co., Fullerton, Calif.

JOIN YOUR AIEE STUDENT BRANCH

NEW UNDER-WATER CRAFT TO EXPLORE OCEAN DEPTHS



SEAPUP AT WORK — The drawn model shows Seapup VI which can hover, land on skis, bank or rotate without disturbing the ocean bottom.

An unconventional underwater research vehicle, the Seapup VI, has been built to carry two men to ocean depths of 6,000 feet. The craft is highly mobile under water and will maneouver like a helicopter and "reach" objects on the ocean bottom with a mechanical arm.

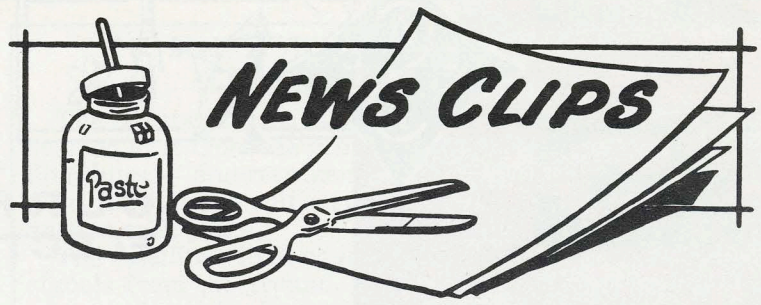
The craft can land on skis, hover, bank, rotate or move forward without disturbing the bottom of the ocean.

The mechanical arm does intricate work on the floor or rocky shelves at the 6,000-foot depth, and the two-man crew can explore these depths for more than eight hours.

Seapup VI is approximately 19 feet long and 8 feet wide. It weighs more than 12,600 pounds.

An emergency safety device releases the magnetically attached manned cabin from the vehicle if the power should fail. The cabin floats automatically to the surface.

The manufacturers of the craft, the General Mills Electronics Group in Minneapolis, has good news for research institutions. According to a company official the cost of the Seapup VI is relatively low.



USSR . . . A Soviet publication says future re-entry methods may include winged vehicles equipped with engines. Aerodynamic heating problems could be solved by controlling speed and direction of re-entry, and the vehicle would be usable for more than one flight. The Russian source says advanced rocket aircraft, already approaching 6,000 km/hr or 25 per cent orbital sped, might be forerunners of these vehicles. This suggests Soviets may have a program similar to U.S. X-15 project, but with the ultimate goal of sending winged craft into space. (Missiles & Rockets, March 12).

●

Stamford, Conn. . . . Light-weight "naked knights" are possible now with the development of a transparent plastic armor, tough enough to stop shrapnel and deflect bullets. It weighs three pounds per square foot and can be used for body armor, helmet lenses, flak suits and canopies for low-flying planes. The U.S. Army is testing this Polycast Corporation material.

San Jose, Calif. . . . A mountain ridge is being used to bend signals of a low power transmitter carrying computer information at the rate of 500,000 numbers each second. The microwave beam is bent by a process analogous to the diffraction of light around a sharp corner. Although over-the-horizon microwave systems are being used for TV and telephone networks, the power needed is ordinarily very high, even several tens of kilowatts, and huge antennas are required. The experiments, conducted by IBM engineers, use power as low as 16 watts and small antennas to send great quantities of information at high speeds.

●

Seattle, Washington . . . Symbolic of electrical developments in the space age is a 1-hp Synduction motor which rotates a 270-seat restaurant near the top of a 600 ft. needle-tower at Seattle's World's Fair "Century 21" Exposition. The motor and the control, which starts and stops the mechanism, was developed by Allis Chalmers Manufacturing Company.

ARMY'S VERTICAL TAKE-OFF, LANDING PLANE NEED'S NO RUNWAYS

The United States Army awarded the vertical take-off and landing plane (VTOL) flight research program to General Electric's Flight Propulsion Laboratory Dept., to design, develop and construct the airframe and the lift fan-in-wing propulsion system.

VTOL planes will need practically no runway to land or take off, an advantage they share with helicopters.

The lift fan propulsion system will make use of two turbojet engines, mounted above and behind the cockpit.

A diverter valve will add the thrust of the engines to that of large lift fans mounted in each wing for vertical take-offs and vertical landings.

Once the plane is off the ground, the diverter valve will channel the thrust of the engines to the rear, just as in normal jet practice, to provide forward propulsion.

A smaller fan near the nose of the aircraft will permit the pilot to control trim and pitch during VTOL operations.

First test flight in the program is scheduled for a year from this May.

Join Your AIEE STUDENT BRANCH

PRESIDENTIAL NOMINEE OF AIEE 1962—1963

Dr. Richard B. Teare, Jr.

Dr. Richard B. Teare Jr., 1962-63 Presidential nominee of the American Institute of Electrical Engineers, is Dean of the College of Engineering and Science, Carnegie Institute of Technology, Pittsburgh, Pennsylvania.

Dr. Teare was born in Menomonie, Wisc., in 1908. He received degrees of Bachelor of Science and Master of Science from the University of Wisconsin in 1927 and 1928 and a Doctorate in Enginering from Yale University in 1937.

From 1929 to 1933, Dr. Teare was in the Engineering Department of General Electric Company. He was on the Yale University staff from 1933 to 1939 and began his teaching career at Carnegie Tech. that year. He is the inventor of a thyraton circuit, voltage regulating device, and holds three patents. He is the author and co-author of many technical and engineering educational papers.

Dr. Teare is a member of the Instrument Society of America, the American Society for Engineering Education, and a Fellow of the AIEE and the Institute of Radio Engineers. He received the 1947 Westinghouse Award in Engineering Education.

Dr. Teare was named to his present post in 1953. He has been active in AIEE for many years. He was a 1957-59 Vice President of the Institute, representing the Middle Eastern District.

The 1962-63 president of AIEE will take office Aug. 1, 1962.

ENGINEERING DEGREES DROP FOR THIRD YEAR

A sobering statistic was revealed by the U.S. Office of Education which showed that the percentage of college freshmen enrolled in engineering has dropped for the third year in a row from 8.2 per cent of the total fall enrollment in 1959 to 7.3 per cent in 1960, and reaching the low point of 6.6 per cent in the fall of 1961. All over enrollment of freshmen in engineering numbered 67,600 last fall.

The only bright spot in the sobering survey was the rise in enrollment among graduate engineers.

A recent National Science Foundation study showed that Soviet-Russians are graduating about three times as many engineers as the United States.

E E DIGEST
Volume 3, May 1962, Number 5
PUBLISHED BY
AMERICAN INSTITUTE
of ELECTRICAL ENGINEERS
345 East 47th Street
New York 17, N. Y.

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Printed In U.S.A.

FEATURETTE

RECORDING STORAGE TUBES

(Continued from page 1, col. 4)

Computers and Storage

The high resolution capabilities and the wide adaptability of the tubes permits storing and processing a vast amount of digital or analog information. Some several thousand pieces of information can be stored, integrated and selectively erased. New information can be added to stored information as desired.

Slow-Down Video

The tubes can be used for bandwidth compression. High frequency electronic signals, requiring wide band-pass amplifiers, can be stored and read-out at slow scanning rates to permit transmission over narrow band-pass transmission lines. In this type of system, storage tubes are used as the intermediate step in transmission and receiving. Information that has been slowly written can be read-out at the receiving end at the original high scanning rate and reproduced on a television monitor. The transmission of high quality pictures, or other data, from location to a remote location, using existing transmission media, is accomplished with this system.

Principles of Operation

When an electron beam strikes any material, secondary electrons are emitted. The quantity of secondary electrons emitted is a function of the primary electron beam.

The secondary electron emitting surface in the recording storage tube is a diaelectric that has been deposited on a metal mesh or screen. Figure 1 illustrates this storage screen mesh. This screen, in the highest resolution types, has more than 2000 cross wires across its diameter.

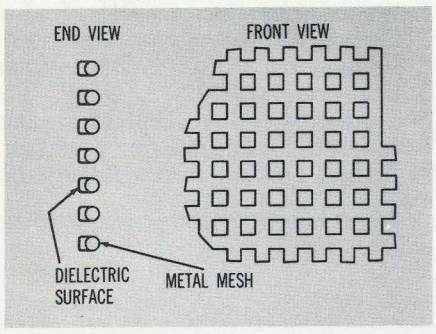


FIG. 1 — Magnified section of storage screen

Figure 2 shows the characteristic curve for secondary to primary emission ratio for the dielectric material used.

Since the velocity of the electron beam will be proportional to the voltage on dielectric material the ordinate of velocity in Figure 2 can be voltage. The crossover, called critical potential, where the secondary to primary ratio is unity occurs at approximately 50 volts.

Using the secondary-emission characteristic shown by Figure 2, the dielectric screen surface can be discreetly charged or discharged as a function of the potential on the metal screen and the position and magnitude of the primary electron beam.

The various modes of operation are described as follows:

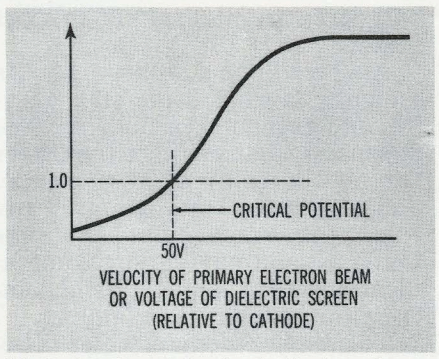


FIG. 2 — Secondary emission characteristic of recording storage tube dielectric

Prime

This is the basic form of erasure and prepares the storage screen for subsequent writing. It is accomplished by scanning the storage screen dielectric with an unmodulated beam. The storage beam mesh is operated at a voltage below critical potential and since the secondary to primary emission ratio is less than unity the dielectric surface can store electrons and become negatively charged to cathode gun potential. A total prime can be used if complete erasure of old patterns is desired or a partial prime can be used if complete erasure of old patterns is desired or a partial prime can be used if it is desired to gradually decrease old signals in amplitude (e.g.: to generate target trails in radar).

Write

"Writing" of the charge pattern is accomplished by modulation of a scanning electron beam and operation at a storage screen voltage that yields a high secondary to primary emission ratio. This is nay voltage above critical potential and is nominally 300 volts for fastest writing speeds. Since during the prime mode the dielctric surface was negatively charged, the surface is discreetly discharged towards the positive direction by the writing beam. As the modulated beam scans over the surface varying amounts of secondary electrons, depending on the instantaneous beam amplitude, are emitted at the surface and the stored pattern is established.

Read

Once a charge pattern has been written in, it can be read out by scanning the storage screen with an unmodulated beam. The storage screen is operated at 10 to 15 volts. The dielectric surface with its charged pattern is now actually negative with respect to the electron gun cathode. Depending on the charged pattern the electron beam is therefore modulated as it passes through the storage screen to the collector element. See Figure 3.

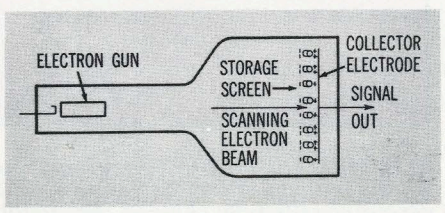


FIG. 3 — Simplified drawing of single gun tube — reading mode

Simultaneous Write and Read modes are possible with the use of two electron guns. This is desirable in most scan-conversion applications. Since two independent potentials can be maintained on the storage screen with respect to the two electron gun cathodes, the tube can be truly writing a charge pattern and reading it at the same time. See Figure 4.

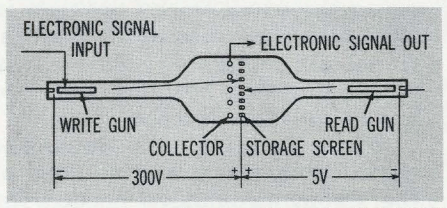


FIG. 4 — Dual gun recording storage tube — simplified drawing

One of the designers and developers of the recording storage tube is Raytheon, Industrial Components Division, Newton, Mass. Raytheon offers three kinds of single gun tubes and a line of two-gun tubes with simultaneous write and read capabilities.

POLARIS SUBMARINE'S GUIDANCE — IMPROVED BY HYDROGEN BEARING

A Gas Spin Gyro uses a cushion of hydrogen in place of the usual ball bearing to support the gyro wheel. It is expected to improve the accuracy of the Polaris sub guidance systems three to four times.

The gyro wheel, spinning on this gas bearing at more than 10,000 rpm, has clearances of only fifty-millionths of an inch between metallic parts.

In spite of almost impossible machining tolerances and immaculate assembly procedures, the new gyro can be produced faster and cheaper than former models, reported the Sperry Gyroscope Company, the designer of the hydrogen bearing. It is possible because bearing tolerances are almost eliminated and "run-in" period is no longer necessary. Life span of the new gyros is estimated at from "thousands of hours" to "indefinite" due to lack of metal-against-metal wear.

The new gyro's greater accuracy will be required for the longer range missile now being developed.

It is in undersea firing that this increased accuracy is critical. Since one degree of error in direction will cause a 41-mile error in the longer range Polaris, the earth must be completely "stopped" to the guidance system.

In the ball bearing gyros, the rotor shifted on the ball bearings, and thus created drift. In the new gyro, the hydrogen gas becomes rigid as the wheel spins. This holds the rotor on dead center to within billionths of an inch. The rotor actually becomes "airborne" within one to two seconds.

NEW INGREDIENTS CREATE METALLIC VAPOR LAMP

A new source of white light, five times as effective as conventional incandescent lamps, and of a comparable whiteness contrasted to standard mercury light sources, has been announced. It is called a metallic-vapor lamp.

GE engineers said the new lamp has up to twice the efficiency and avoids the bluish color that has characterized lamps of this type in the past.

One of the "secrets" of the lamp is the use of small amounts of metallic elements other than mercury, including sodium and thallium. However, details of the lamp's construction and ingredients will not be made public at the present time.

Inventor of the lamp is Dr. Gilbert H. Reiling, who became interested in light sources while performing basic scientific study of gas discharges as a physicist at the General Electric Research Laboratory.

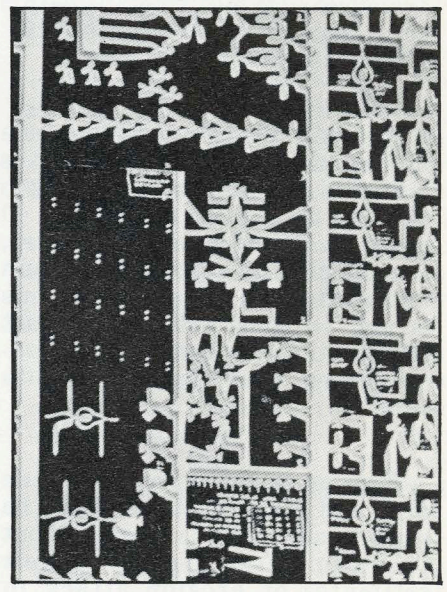
He explained that the new ingredients in the lamp served to produce intense "spectral lines" in that part of the spectrum which can be seen by the human eye, particularly in the orange and red region.

Efficiency is increased, since more of the electric energy is converted into visible light. The lamp has the potential, it is believed, of revolutionizing the lighting of streets, highways, industrial and other large areas.

Demonstration of this lamp showed that light intensities which require 1900 watts for incandescent lighting, or 800 watts for conventional mercury illumination, can be equalled with a single 400 watt bulb incorporating the new discoveries.

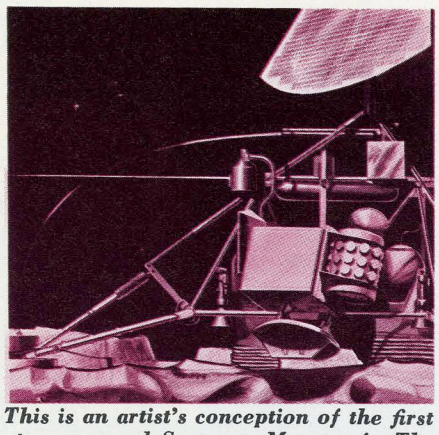
The new metallic vapor lamps are now being studied in a variety of forms and light tests are in progress before introduction of the product can be considered.

WHAT IS IT?



EMBROIDERY?

It is an amplifier subsystem for fluid amplification made of photo-sensitive glass. Picture of desired configurations was developed in glass, then exposed portions were partially or completely etched out, leaving channels, chambers and ports to carry and control fluid flow. The fluid amplification concept foresees increases in reability for logic and control functions now served by electronic circuitry and pneumatic devices. It was developed by Corning Glass Works.



This is an artist's conception of the first atom-powered Surveyor Mooncraft. The power pack is SNAP-11, a 30-pound thermoelectric device which will provide a minimum of 18.6 watts of electrical power continuously for 90-day lunar mission. The output of the generator is expected to rise to 25 watts. Hughes Aircraft Co., will build the spacecraft.

(Continued from page 1, col. 4)
material by evaporating off volatile components, absorbed gases. This results in marked changes in all properties.

The engineer will encounter formidable problems in building power systems for future space pioneers. Systems must be relatively small but complex. These energy systems' cores are expected to be delicate, with subsystems similar to many that we have here on earth. They may be considered as miniature industrial plants.

Space Energy Systems

The future spacecraft must have built-in energy systems for vehicle propulsion and auxiliary electric power for communication, life support, and instrumentation. For deep space, electric propulsion looks promising. It requires power in the megawatt range probably from an on-board nuclear reactor along with a turbine-generator or a magnetohydrodynamic unit which, in turn, may supply all electric needs.

Radiation

The engineer must deal with two sources of radiation, one from the space environment and the other from the craft's own nuclear reactor. Metals and their alloys are relatively resistant to radiation, but the organics are notably susceptible. Some organic materials will show change: glass loses full transparency, electrical insulation may become partly conductive. Ceramics are resistant.

Heat Transfer at Launching

The heat transfer problems are next on the list. After the craft is launched, air temperature drops to about —55 F, rises to 260 F at 40 miles up. Once free of atmosphere, the vehicle side exposed to the sun is heated while the shadowed side is not. In some orbits, the craft plunges through earth's cold shadow, losing solar warmth on both sides.

Erosion in Space

Erosion rates in space by cosmic dust and other particles must be considered. Little is known about the magnitude of this hazard. Best estimates of erosion attack in space vary widely: from 20x 10^{-4} to 10^{-6} cm per year.

The Mercury Capsule

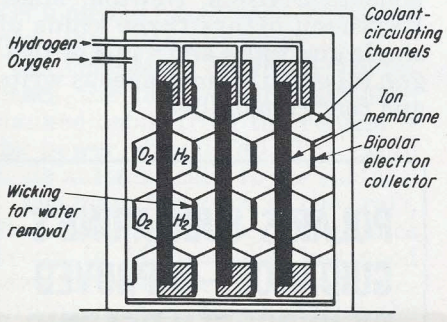
The first U.S. orbital manned flight relied on a packet of six silver-zinc batteries for all the craft's electric needs. Four of these were main batteries, whose 24-v output was designed to handle all mission requirements during the 3-orbit flight, plus a reserve for landing. If voltage had dropped, automatic switching would have turned off non-essential equipment and tied the remaining load into the standby battery, a fifth in the pack. The standby could have handled one orbit plus 12 hours post landing needs.

The sixth battery was a sort of isolated unit, to fire independently the pyrotechnics circuits for emergency exist. Power requirements for the total craft: 30 to 35 amp continuous with surges to 60 amp.

Static Inverters

Three static inverters were used to change dc to ac. One fed the autopilot system, one the environmental system and one stood by. Heat output from the inverters posed the usual tricky problem in the absence of cooling by conventional air currents. Solution: an aluminum-plate heat sink fastened to the capsule structure.

While the flight was confined to earth orbit, there was no need of the strong propulsion needed for interplanetary travel. There was, however, a pack of accelerating and decelerating rockets strapped to the Mercury capsule base.



***ION-EXCHANGE FUEL CELL SLATED FOR GEMINI** — Water, formed as a vapor on oxygen side of each cell, is condensed and filtered, then delivered for crew's drinking needs.*

In the Future

The Mercury project will have several more flights. Late in 1963 the NASA plans to launch a 2-man craft.

The Gemini project, using a 2-man craft, will attempt to master the manned space-flight-rendezvous technique. Here the manned craft will attempt, while in orbit, to approach and dock with an orbiting booster. Once they are joined, the booster would give the needed thrust to push the craft out of orbit and on into space. Thus, lunar flights may become feasible.

Along with project Gemini, engineers will study boosting the strength of spacecraft for direct-flight to the moon.

Nova Booster

Using a multimillion-lb thrust, Nova booster will aim to do the job in one big push. Both plans are being developed to meet the national goal of a manned lunar landing by 1970.

Apollo

The Apollo project will follow Gemini, with the aim of carrying three men to and from the moon. Chemical fuel will propel the craft after it is placed in earth orbit. A larger breathing recycled, purified air will make it possible to reduce the automated complexity of Apollo. In the Mercury capsule the automation is high. In the Apollo Vehicle men will back up many system components.

In the Apollo project NASA will eliminate the space suit as worn by Col. Glenn. The shirt-sleeve environment is expected to provide benefits in increased mobility and effectiveness.

There will be quick-don suits to protect the crew in emergency loss of controlled environment within the command module. Each suit will carry an integral life-support system.

Apollo will be a 3-part craft, its modules labeled command, service, and outbound propulsion. The command module will be the center for all the equipment of control and provisions for regulating living environment. This includes guidance and navigation, communications, life support, and controls for re-entry and landing.

The service module, which is behind the command, will house the fuel-cell power supply and equipments needed on the moon surface. Part of the return-propulsion system will also be there.

Fuel Cells

Men, instruments and life-support equipment aboard Appolo will depend on fuel cells banked alongside silver-zinc batteries for electric supply; the same holds for Gemini.

Why fuel cells for Gemini and Apollo, and why silver-zinc batteries? The battery pack's chief advantage is high capacity: three times that of nickel cadmium. And, of course, silver-zinc batteries worked in the Mercury.

The fuel cells were chosen because of their relatively high output. The cells have no rigid limits of life as long as fuel keeps pouring in.

In brief, a fuel cell is a rather simple electrochemical cell, capable of converting an input fuel directly to low-voltage dc with relatively high efficiency.

Gemini and Apollo will be served by the hydrogen-oxygen team. The cell bank for Gemini will be a General Electric ion-exchange-membrane unit.

The setup will include fuel supply and heat-rejection unit, and offer 60 per cent thermal efficiency at full load. Cells divided into three independent sections will supply about 2 kw of ripplefree dc to the spacecraft's 28-v but. Each section is a pressuretight tank containing five fuel-cell modules and a water accumulator. The fuel-supply and heat-rejection systems will also be divided into three independent sections, cross-manifolded to handle the nees of the complete fuel-cell system, if necessary. A module is formed by 36 ion-exchange-membrane cells, 5/32-in. thick. They are connected in series. Five modules are connected in parallel to form a section that will be paral-

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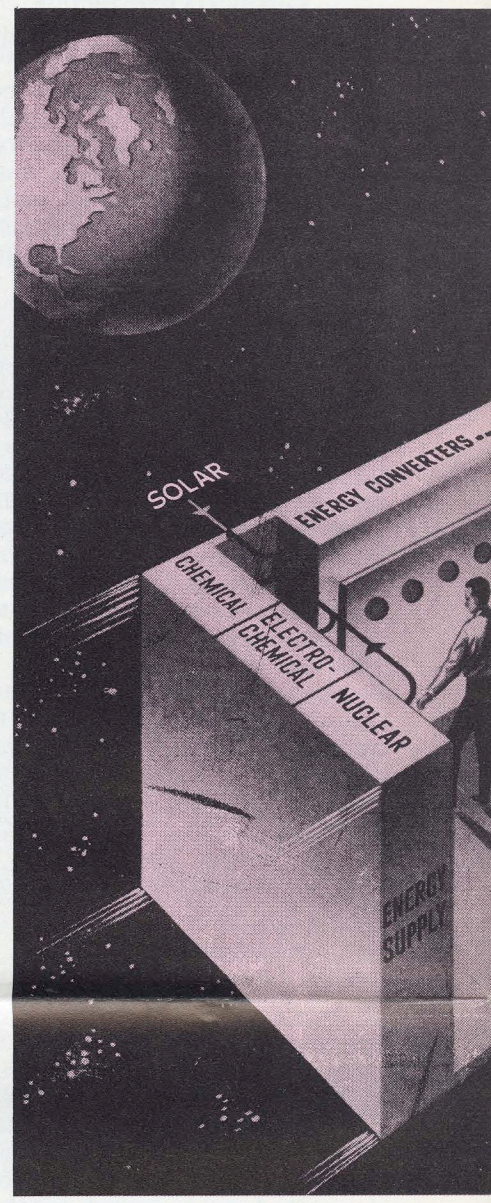
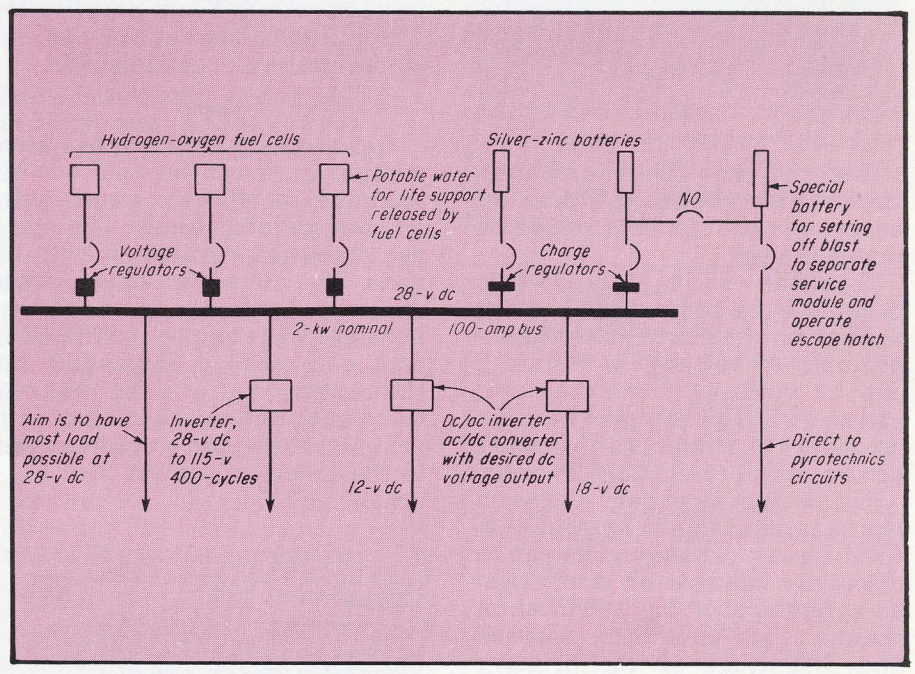
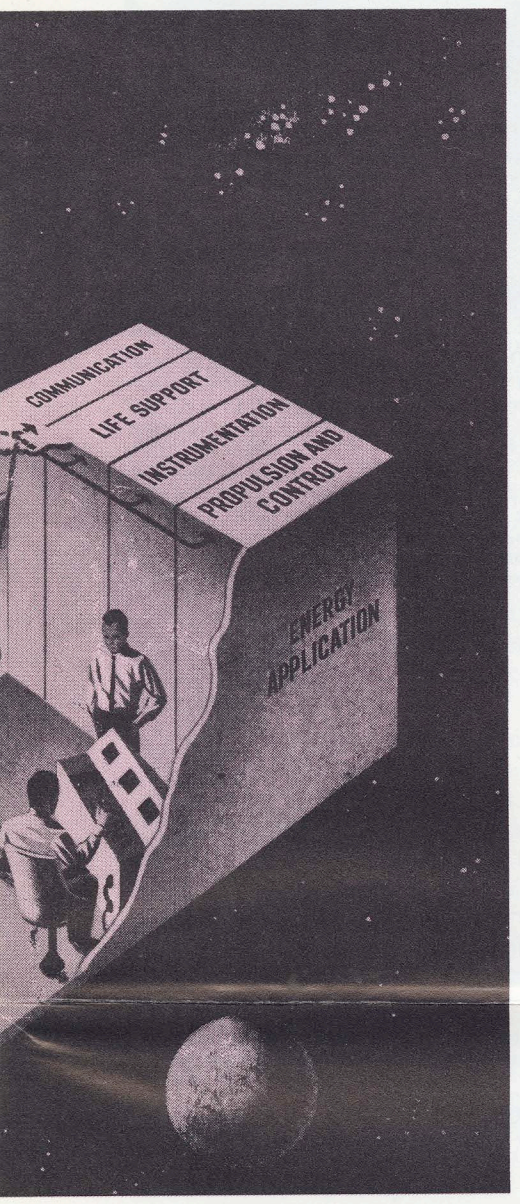




***ELECTRIC DISTRIBUTION** aboard manned lunar spacecraft may well approach scheme outlined above. During nonpeaking parts of the flight, fuel cells should keep silver-zinc cells fully charged. Air circuit breakers with manual toggles will probably be used.*

IIS WORLD SYSTEMS



leled again with adjacent sections through the 28-v bus.

Performance of the individual modules, sections and the complete system is monitored electrically and thermally.

Forms Water

Water is formed as a vapor on "oxygen side" of each hydrogen-oxygen fuel cell. A temperature difference makes it condense on the current collector where it is absorbed by flat wicks. Water is transferred by capillary transport to a drain wick located under each module. It is then forced by gas pressure through a capillary liquid gas separator, and on into a reservoir. Potable water is thereby secured for the space crew.

Operating heat from the fuel-cell is picked up and rejected through radiators. A small pump for fluid circulation is the only moving part in the system.

Up to date only one recorded test has been announced for the fuel cell in a space vehicle. It was a 30-minute flight and the test cell telemetered back no voltage or current fluctuation.

On the schedule, however, are more refined tests for fuel cells. High speed cameras along with instruments for checking gas pressure, temperature, voltage and current will measure fuel-cell performance.

Solar Scheme

What other means have been considered? Solar was probably first. This system would carry a 2-kw load, if the sun was available close to 100 per cent of flight time. Since that wouldn't be possible the plan should design means to store the sun's energy during dark periods.

There are two ways to utilize the sun for electric supply. Simplest: feed the sun's output directly to a photo-voltaic or photoelectric cell, a thermoelectric or thermionic unit, and arrive at a dc output. The other approach is to interject a thermal cycle powering a turbine or Sterling (reciprocating hot-cold air) engine.

Of the possible direct solar means, the silicon photo-voltaic cell would be high on the list. With careful selective grading the efficiency of this cell would be near 14 per cent.

Costs for a silicon-cell power system, one source estimates, might run as high as $400,000 per kw.

Since solar flux in the Earth's vicinity runs about 125 watts per sq. ft., an array of 10 per cent cells might tally up to 80 sq. ft. per kw, but the cost might still be about $300,000 per kw.

Photoelectric Method

The photoelectric method uses photon energy from the sun to liberate electrons from photoemissive surfaces, such as cesium antimonide. Although the cost is lower, only 1 per cent efficiency is now available. There are doubts that these cells will be used for the tight scheduled Gemini and Apollo projects.

The thermionic converter was probably another likely candidate. In this system a cathode emitter is heated by concentrated solar energy, releasing electrons from the hot cesium-coated surface. Efficiencies of 8 and 14 per cent have been recorded. This system was estimated to weigh about 60 lb. per kw in the 2-kw range. This promising system was ruled out for immediate use by NASA because of incompleted development work.

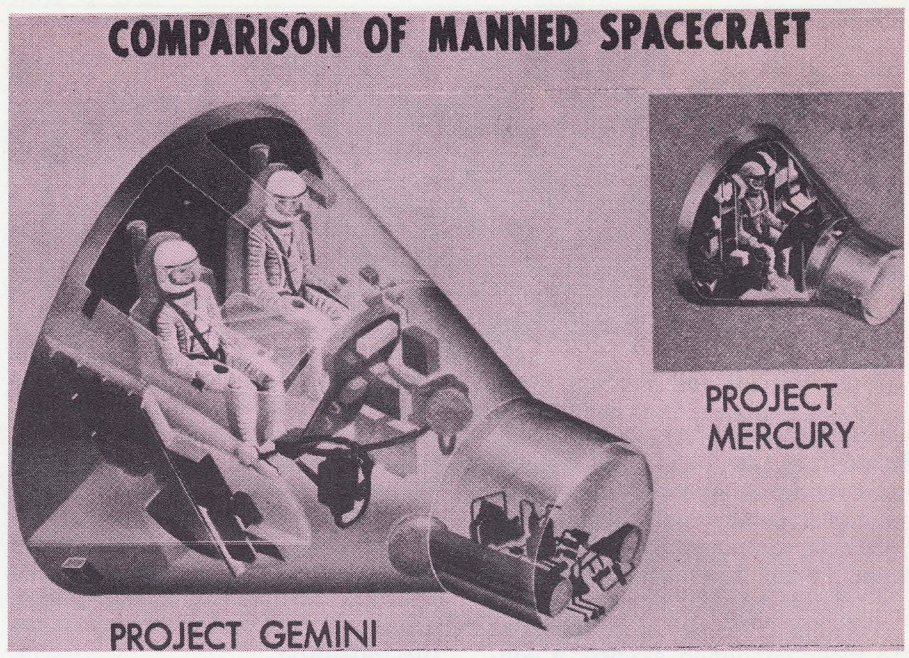
Thermoelectric Conversion

Thermoelectric conversion promises a thermal efficiency of about 7 per cent. The system is based on the old principle of maintaining a temperature differential on opposite ends of two dissimilar semi-conductor materials. The last two systems might share a major role in future space flight, especially if nuclear reactors are used for manned spacecraft.

Indirect Conversion

The turbine and engine come into plans with the system of indirect conversion of the sun's energy. If turbines are used, one operating principle calls for transferring sun's heat to the boiler of a closed mercury-vapor cycle. Large solar collectors and heat-dumping radiators are required to get a usable turbine output. Weight could run 750 lb. for a 3-kw unit. This system's problems are providing means of lubrication and combating corrosion in liquid-metal systems.

The Sterling engine, utilizing either hydrogen or helium in a closed cycle, was another possibility, with the solar heat input being transferred to the closed cycle by a liquid medium.



RENDEZVOUS CAPSULE—The two-man spacecraft Gemini, named for the twin stars Castor and Pollux, will be used to develop rendezvous techniques for joining parts of spacecraft sent aloft separately and for extended earth orbit missions lasting a week or more.

Looking at the whole picture, solar energy is not a strong candidate for use. Facing the solar arrays toward the sun at all times would be difficult. However, both turbine and Sterling engine might use a non-board gas supply rather than solar energy. Typical: the open-cycle hydrogen-oxygen turbine. The package might well weigh 50 lb. for a 2-kw unit, including engine, generator, regenerator.

A Nuclear Powerplant, a tiny auxiliary power generator, is fastened to the base of the latest Transit satellite before vibration tests. Fueled with plutonium-238, it is designed to provide continuous electrical energy to satellite transmitters, independent of the sun's rays. It was built by The Martin Company, Baltimore, Md.

Nuclear Energy

Beyond projects Gemini and Apollo, most experts agree that nuclear energy is essential in any long-range look at space exploration. Under study are many techniques using nuclear sources for propulsion. Two receiving a large amount of attention are the nuclear rocket and electric propulsion.

A nuclear propulsion rocket is made up of a reactor for heating the propellant (hydrogen), a turbopump, a jet nozzle and a control system. Fission heat energy is transferred to a hydrogen propellant flowing through the reactor. After it's heated, hydrogen gas is ejected through the jet nozzle to produce thrust.

Electric propulsion is far beyond the mere planning stage. Simplest electric rocket is the so-called arc jet. An electric arc, struck between two electrodes, provides initial energy input. A propellant, helium for example, is fed into the arc chamber, heated, then exhausted out the nozzle to produce thrust.

Such arc engines are being developed in the 30-kw range. Teamed with a suitable power supply, these engines could propel a "mother" spacecraft around the earth. Perhaps this craft could drop off small satellites for a communication-satellite system.

Ion Engine

And another approach is the ion engine. Here a propellant (cesium) is heated, then ionized (stripping an electron off the cesium atom) so that the propellant becomes positively charged. This charged cloud of ions is accelerated by high-voltage fields and exhausted through a nozzle to produce thrust. Since the beam is positively charged, it must be electrically neutralized. Otherwise an opposite electric charge would build up on the spacecraft, drawing the beam back into the engine and reducing thrust to zero.

The magnetohydrodynamic engine is next in the line. Here a small arc is used. The electric arc not only heats gas but ionizes and disassociates it as well. Gas in that condition is tagged plasma. Plasma behaves as an electric conductor. This is important since after the plasma accelerates through the nozzle, it passes between two parallel plates. These plates fit between magnetic poles so a magnetic field is established.

The electric-motor principle then comes into play: when a conductor (plasma) is acted upon by mutually perpendicular electric and magnetic fields, it moves. Thus the gas is further accelerated.

The next problem is where will the electric supply come from in any of these propulsion schemes? Attention centers about the nuclear reactor.

Of the many forms of nuclear electric plants one, for example, operates by applying the nuclear heat of fission directly to a thermoelectric or thermionic converter giving an immediate dc output. It may serve as input for a variety of rotating systems. One, typical, being the 300-1000 kw unit now under development for the U.S. Air Force — AEC project SPUD. Here power will be delivered by thermally linking nuclear-fission energy and a potassium-vapor turbine.

And with the development of superconducting-magnets, the teaming of a nuclear heat source with a MHD generator looks most promising.

NUCLEAR ENERGY WHAT IT IS AND HOW IT ACTS

By ANDREW W. KRAMER,
Editor of ATOMICS

The following digest is taken from ATOMICS, October issue. It discusses atomic theory in relation to practical experience and demonstrates the smallness of atoms by means of the Crookes spinthariscope.

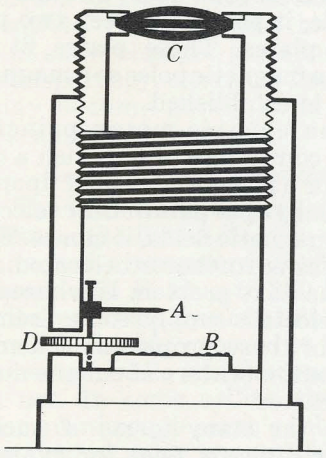
It is difficult for most of us to try to visualize things we cannot see or which are not directly evident through one of our five senses. It is completely meaningless to most of us to say that the tip of the needle is composed of 10^{12} or 10^{15} atoms, even when the exponents are translated into zeros.

Yet there is a way of giving even the most hardened skeptic a conception of the number of atoms that can be placed on the point of a needle. It involves an aspect of radioactivity.

The Crookes Spinthariscope

Many years ago when radioactivity and radium were a mystery in physics, Sir William Crookes invented a little instrument — a gadget — which he called the spinthariscope. Sir William found that when a surface coated with zinc sulphide and exposed to radiation, was observed under a low-power microscope, it appeared luminous.

This phenomenon is the basis of the spinthariscope. The spinthariscope, incidentally, is the only genuine instrument worked by radium that can be bought, radium and all, for approximately five dollars. The reason for this apparent paradox is to be found in the fact that it is in the essence of the result to be obtained — to reduce the amount of radium involved to the smallest possible quantity. This unusual condition allows a practically unlimited number of spinthariscopes to be made out of an almost invisible quantity of radium bromide. The amount of radium in each instrument is absolutely unweighable and invisible.



The Crookes spinthariscope.

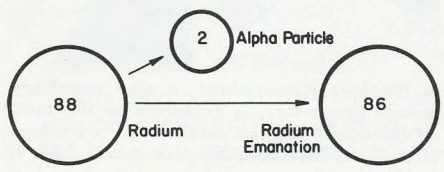
A vertical section of such an instrument is shown in the illustration. The point of a needle, A, is made to touch the inside of a tiny phial *which once contained radium*. After this brief contact with the inside surface of the phial the needle is mounted centrally in a small brass tube at the bottom of which is a phosphorescent screen, B, coated with zinc sulphide. At the upper end of the tube is a lens, C, for magnifying the screen, and by means of a little thumb screw, D, outside, the needle point may be moved nearer to or farther away from the zinc sulphide screen.

If now, in a dark room, the screen is observed through the lens, it will be seen to be luminous. This luminosity can be concentrated or spread out by adjusting the needle point so that it is nearer to or farther from the screen. After the eye has become accustomed to the darkness, it will be seen that the luminosity is not just a quiet continuous glow but shows discontinuity.

It resembles most nearly a shower of shooting stars. Bright, momentary flashes of light or scintillations, too numerous at any instant to count, are appearing and disappearing in the field of vision. The minute, insignificant trace of radium on the point of the needle is belching forth *alpha* particles, that is, nuclei of helium atoms. When radium disintegrates spontaneously it emits helium nuclei.

Each flash, the result of the impact of a single alpha particle with the atoms of the screen, lasts but one forty-thousandth of a second, so its momentary brilliance is exceedingly great.

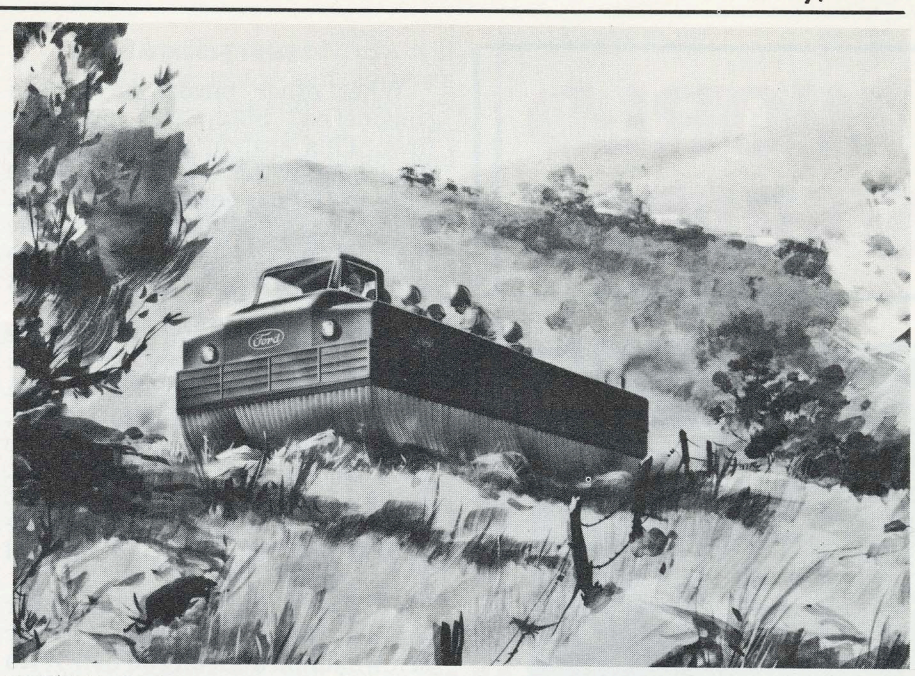
When radium disintegrates it emits an alpha particle, that is, the nucleus of a helium atom. The atomic number (number of electrons, hence also the value of the positive charge on the nucleus) of radium is 88. Similarly, the atomic number of helium is 2. Thus, when radium emits an alpha particle, what is left after the alpha particle has been ejected, is radium emanation (a gas at room temperature) with atomic number 86.



It seems incredible that the incessant bombardment of the zinc sulphide screens can be caused by such an infinitesimal quantity of radium, yet it is so. In a month's time, if the instrument is reexamined, the scintillations are as numerous and brilliant as before. After a time, perhaps a year, the phosphorescent screen itself will be worn out by the continual bombardment of the alpha particles and will become insensitive. If, however, it is replaced by a new one, the radium will be found as active as ever and in another year's time the new screen will be worn out.

Replace the screen, year after year, until the owner of the instrument passes away, hand it to his heirs and successors — even his race will have been forgotten before the radium shows any perceptible sign of exhaustion.

When we stop to consider this action — when we contemplate the mighty swarm of particles streaming out from this minute quantity of radium through the centuries, we get some idea of how small an atom of matter really is. A single grain of radium bromide expels, each second, about ten thousand million alpha particles.

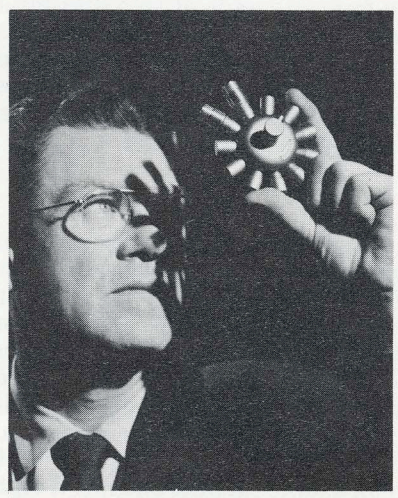


FUTURE GROUND TRANSPORTATION — Drawing shows experimental air cushion vehicle (FMC/ACV-1) moving with ease on a cushion of air over rocky and rough terrain. The vehicle, being built by Ford's Aeronutronic Division, Newport Beach, Calif., will have a two-to-three foot ground clearance and will glide over rocks, bushes, swamps, ice, ocean or lake waves, and other similar obstacles at speeds up to 40 miles an hour. Ford is building the experimental vehicle to prove out design concepts, such as the skirt around the vehicle's outer edge which minimizes air loss and reduces engine power requirements. The skirt is made of separate three-foot-long flexible plastic strips, that "retract" as they hit obstacles, then snap back into place. The vehicle, measuring 21 x 8 feet, will be completed and ready for off-the-ground and over-water tests by mid-year.

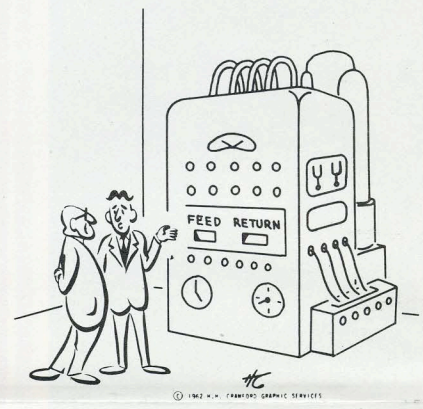
Universal Tungsten Welding Electrode

Tungsten inert-gas welding has become one of the most valuable precision welding methods, especially in the aircraft, missile, and atomic-power industries. The arc is drawn with a nonconsumable tungsten-alloy electrode, and the work area is shielded by an inert gas to prevent contamination from the air. Four different electrode alloys have been needed in the past, each performing better than the others for specific application.

Now, a universal electrode developed by Westinghouse Lamp Division engineers serves for all situations and is better than the earlier compositions in some respects. For example, it is superior where arc "fluttering" cannot be tolerated, as is often the case in complex shapes. It also minimizes contamination of the weld with tungsten, an especially important factor in fabricating uranium fuel elements. The new electrode eliminates the risk of selecting an improper electrode for a job and also simplifies ordering and stocking of electrodes, the Westinghouse Engineer reported.



NEW SPACE AMPLITRON delivers more power per pound. Radical design permits use of single small magnet for the tube which delivers 25 watts, yet weighs only 16 ounces. Efficiency of 60 percent, combined with light weight and compact design, make the new Amplitron ideal for space communications systems. It was introduced by Raytheon Company's Microwave & Power Tube Division.



"Actually, it's an oversized pencil-sharpener but we like it because it looks impressive."

Pure Metals May Act As Superconductors

A new superconducting element, in which an electrical current seemingly flows forever without resistance, has been reported to be present in very pure molybdenum.

The finding suggests that many other metallic elements may also be superconductors if they are just made pure enough.

Bell Laboratories engineers Drs. T. H. Geballe and B. T. Matthias, with E. Corenzwit and G. W. Hull, Jr. discovered the new superconductor, the 24th known and the first since 1953. Previous investigators had failed to find molybdenum's superconducting properties because of traces of impurities. Bell engineers used samples much more pure than those previously studied.

They found that molybdenum becomes a superconductor at about one degree Kelvin.

The pure molybdenum samples were prepared by heating molten pellets of the metal for a long time in an arc furnace until the impurities were "boiled off," and by growing a single crystal, then purifying it by electron-beam melting and floating-zone refining.

The discovery of the importance of purity on superconductivity will have an influence on theories about the nature and occurrence of superconductivity. It suggests that metals previously believed not to be superconductors should be examined again in a very pure state.

COMMUNICATIONS SWITCHING SYSTEMS

By A. E. JOEL, JR.
Bell Telephone Laboratories
New York, N. Y.

There are two fundamental parts to a communication system. First, there is the means which enables one to transmit and receive intelligence. Second, there is the ability to connect these receivers and transmitters in different combinations. The techniques, devices and circuits which are combined to make this flexibility possible are known as a "switching system."

Switching systems are employed in all forms of electrical communication: telegraph, data, telephone, radio and television. Switching systems have been employed since the early days of the electric telegraph. The first, crude switches activated by operators and later plugs and jacks, have matured and expanded until today our nationwide telephone switching system is probably the largest and most complex machine in existence.

The over-all complex of successive switching stages in an exchange or central office and the paths between offices has become known as the "switching network." The quantity of devices (or switches) and the particular pattern for their wiring is determined by considerations of "traffic." Many theoretical probability and statistical approaches are used in dealing with the design and engineering of switching networks. This phase of communications switching systems is of considerable interest in itself.

"Signaling" is an important phase of the switching problem. Such signals are usually divided into two categories, one "supervisory" to indicate origination, answer and dismissal of a connection, and the other is "pulsing" which provides the discrete or digital information which specifies the output to which the connection or path is desired.

Many signaling languages using direct and/or alternating currents have been devised. In interpreting such signals and in the control of the switches themselves "logic" circuits are employed. Techniques employing two-valued or Boolean algebra have become known as "switching algebra" and are used as tools in designing such circuits. Information theory and operations research techniques are also employed in the over-all planning of a switching system.

Electronic devices are being used as switching elements. Their use in switching networks allows both "space division," where a physical path is available for each connection, and "time division," where each desired connection shares a common transmission medium to provide a sampling of the transmitted intelligence at a rate high enough for accurate reconstruction. Combinations of space and time division networks are also feasible.

Large scale digital memories and time shared control make it possible to introduce "programming" techniques, to eliminate some of the complexity and lack of generality in the type of logic circuits employed in the control. In this sense the control portion of a switching system may be looked upon as a special purpose digital computer.

Application of electronic networks and controls, switching algebra and information theory design techniques and the ability to program systems to offer more flexibility in the services rendered by switching systems open many new frontiers in this field which claims the oldest and largest automata.

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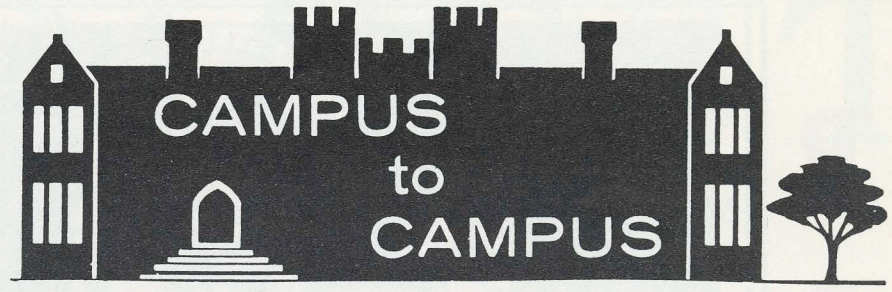


A *Harvard University* report showed that 81 per cent of students entering with "sophomore standing," who take the freshman college year in high school, are graduated with honors, as contrasted with 39 per cent winning honors after a full four year program.

The *University of Southern California* dedicated its Computer Sciences Laboratory, equipped by two manufacturers of electronic data processing equipment. A UNIVAC Solid State 80 and a Honeywell 800 will hum away in the laboratory. The Honeywell 800 with the Magnetic Tape System used with it could, for instance, "read" or "write" all of the information in the Central Los Angeles telephone directory in about six minutes.

Birds are tracked by radar by ornithologoists on the campus of the *University of Michigan* to solve the mysteries of bird migration.

Government contracts for research directly relating to the nation's space defense programs have been awarded to the *Ohio State University* Research Foundation. The grants will support research in the departments of electrical engineering, geodetic science, aeronautical and astronautical engineering, physics and astronomy and chemistry.

Important space research for the U.S. Air Force is being carried out through experimentation with "rotating chairs" designed and built at the *Georgia Institute of Technology,* Atlanta. A primary aim is to determine the causes of illness resulting from disturbances of the vestibular system. An attempt is being made to establish the connection between sea and air sickness.

Four new graduate research laboratories in electrical engineering were dedicated at the *University of Minnesota,* as part of the university's observance of Minnesota Electronics Recognition Week. The new facilities will help meet a need for research space in the E.E. Dept.

A new computing system with a "memory" consisting of rows of metal dots on thin glass plates and with calculating speed measured in billionths of a second will be installed in *Case Institute of Technology's* Computing Center early in 1963.

MOE SAPIEN
THE MECHANICAL MAN

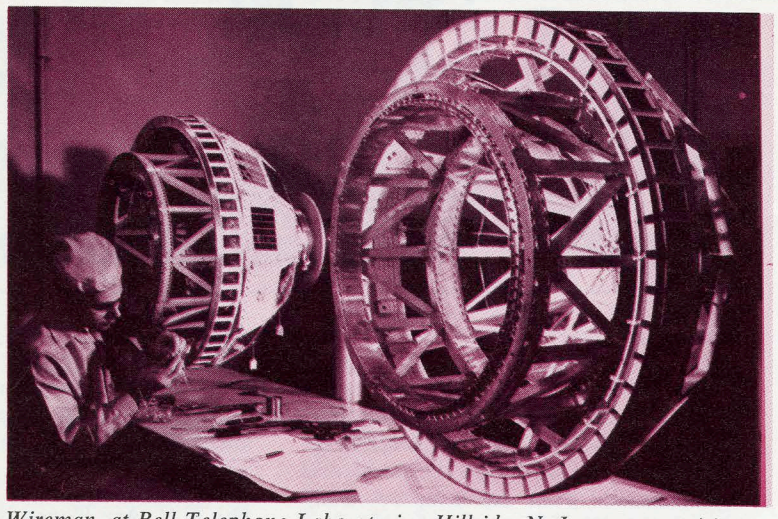
A five-foot tall robot who talks, shakes hands, turns his head, and flashes his gorgeous green eyes at anyone who stands near him, was admired in The Stevens Alumni Letter.

The Letter said Moe was built from old metal parts. The inside of the manufactured person was cluttered with complicated electronic circuitry designed by Larry Carter, a 20-year-old junior at Stevens Institute of Technology in Hoboken, N. J.

Moe, a labor of love, was put in service in a fraternity house where, during the early spring "rush," he welcomed potential brothers. He shook their hands and said: "How do you do, I'm Moe Sapien and I want to welcome you to Phi Sigma Kappa fraternity. You're our kind of guy."

The pledges' reactions were unrecorded.

PROJECT TELSTAR



Wireman, at Bell Telephone Laboratories, Hillside, N. J., connects wiring in the lower hemisphere of two models of the Telstar experimental communications satellite. The slotted equatorial ring is one of the satellite's broadband communications antennas. Most of the electronic components will be contained in a canister that fits into the center of the satellite frame.

THE BELL SYSTEM'S TELSTAR EXPERIMENTAL COMMUNICATION SATELLITE:

The Telstar's first function is to receive a radio signal beamed at it from the ground, amplify this signal — ten billion times — and retransmit the signal on another frequency. Also, the satellite will carry equipment to record its performance at each stage.

The satellite will be equipped to receive special "command" signals from the ground, which will turn circuits off so that power will not be drained away needlessly while the satellite is on the opposite side of the earth.

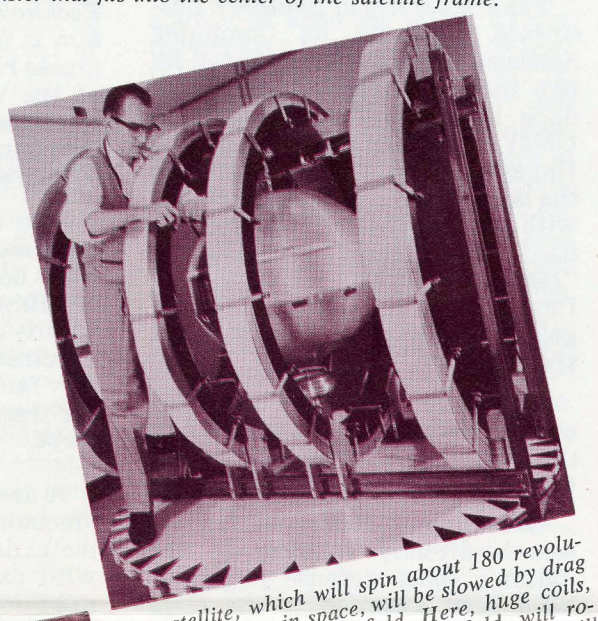
The satellite is roughly spherical in shape, but with 72 flat faces, or facets. It is 34½ inches in diameter and weighs about 170 pounds. The metal framework is made of magnesium, the shell of aluminum, coated with aluminum oxide sprayed on by a plasma jet process.

Two antennas, equator-like, girdle the satellite. These are receiving and transmitting antennas for the basic communications function of the satellite; they also transmit a precision tracking beacon signal.

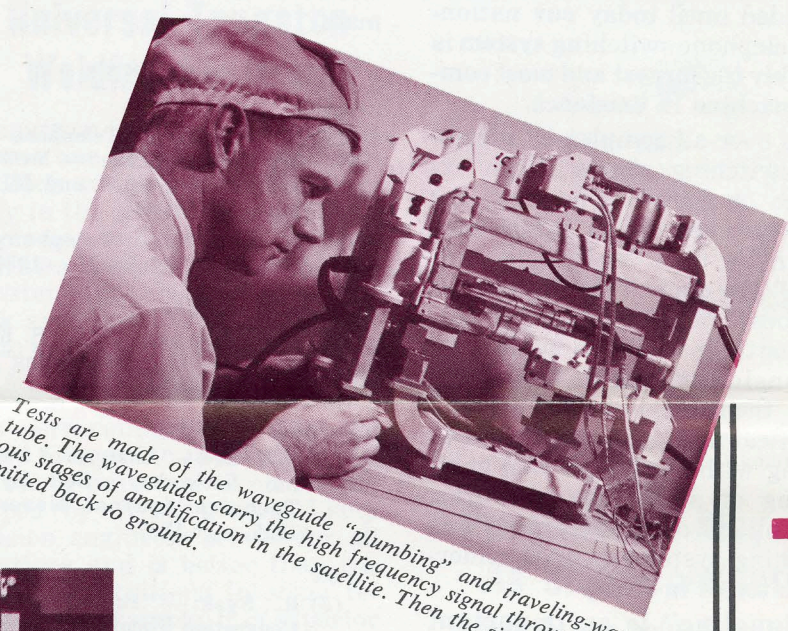
Another antenna atop the satellite will be extended from the inside after a protective launching nose fairing has been cast off. This antenna will serve telemetry, command and beacon circuits.

The satellite will contain one electron tube and 2528 semiconductor devices — 1064 transistors and 1464 diodes.

Late this spring the satellite will be launched by a Delta rocket.

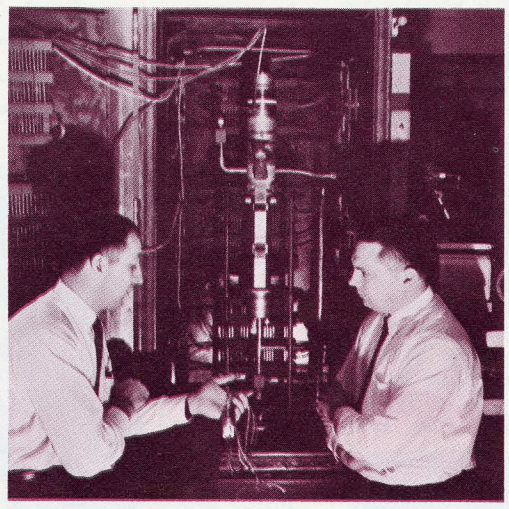


The satellite, which will spin about 180 revolutions per minute in space, will be slowed by drag of the earth's magnetic field. Here, huge coils, which produce a large magnetic field, will rotate around the model. The dragging effect will be measured. From this, engineers can predict the amount of dragging effect on the satellite in orbit.

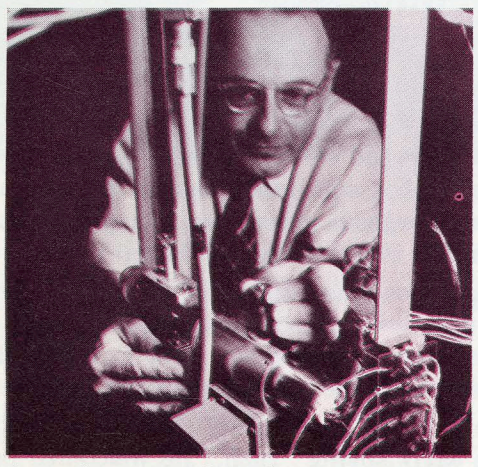


Tests are made of the waveguide "plumbing" and traveling-wave tube. The waveguides carry the high frequency signal through various stages of amplification in the satellite. Then the signal is transmitted back to ground.

Don't do this to your TV set: Pink, liquid plastic is poured into a mold around an electronic sub-assembly of the Telstar satellite. The foam plastic will form a rigid mass so that electrical connections will be more immune to shock and vibration. But should one component fail, replacement would be difficult without damage to the others. Later, the satellite's electronic parts are assembled in a canister and locked in solid with the plastic.



Comparing two of the traveling wave tubes to be used: left a small traveling wave tube that will operate inside the active satellite itself. The large tube, shown mounted in a vacuum station was later installed in the Bell System's ground station at Andover, Me. On the vacuum station the residual gas pressure is reduced to a negligible level by pumping and baking.



A traveling wave tube is the only electron tube to be carried in the satellite, which otherwise is comprised of "solid state" components — transistors and the like. The traveling wave tube must be designed for the highest efficiency because of the limited electric power available in the satellite. The aim is to develop satellites that will last many years in space.

In orbit, the satellite will spin about 180 revolutions per minute, which will make it tend to remain pointed toward the same direction in space. But it must be well balanced so that it does not wobble or tumble. Dynamic spin balance test is shown.

In a room lined with pyramids of foam plastic that absorb radio energy, engineer inspects a model of the Telstar experimental communications satellite. The chamber simulates the radio environment of space for antenna tests. Broadband transmitting and receiving antennas girdle the satellite while a beacon antenna is on top. Patches of solar cells on the shell of the satellite convert sunlight into electricity to provide power.