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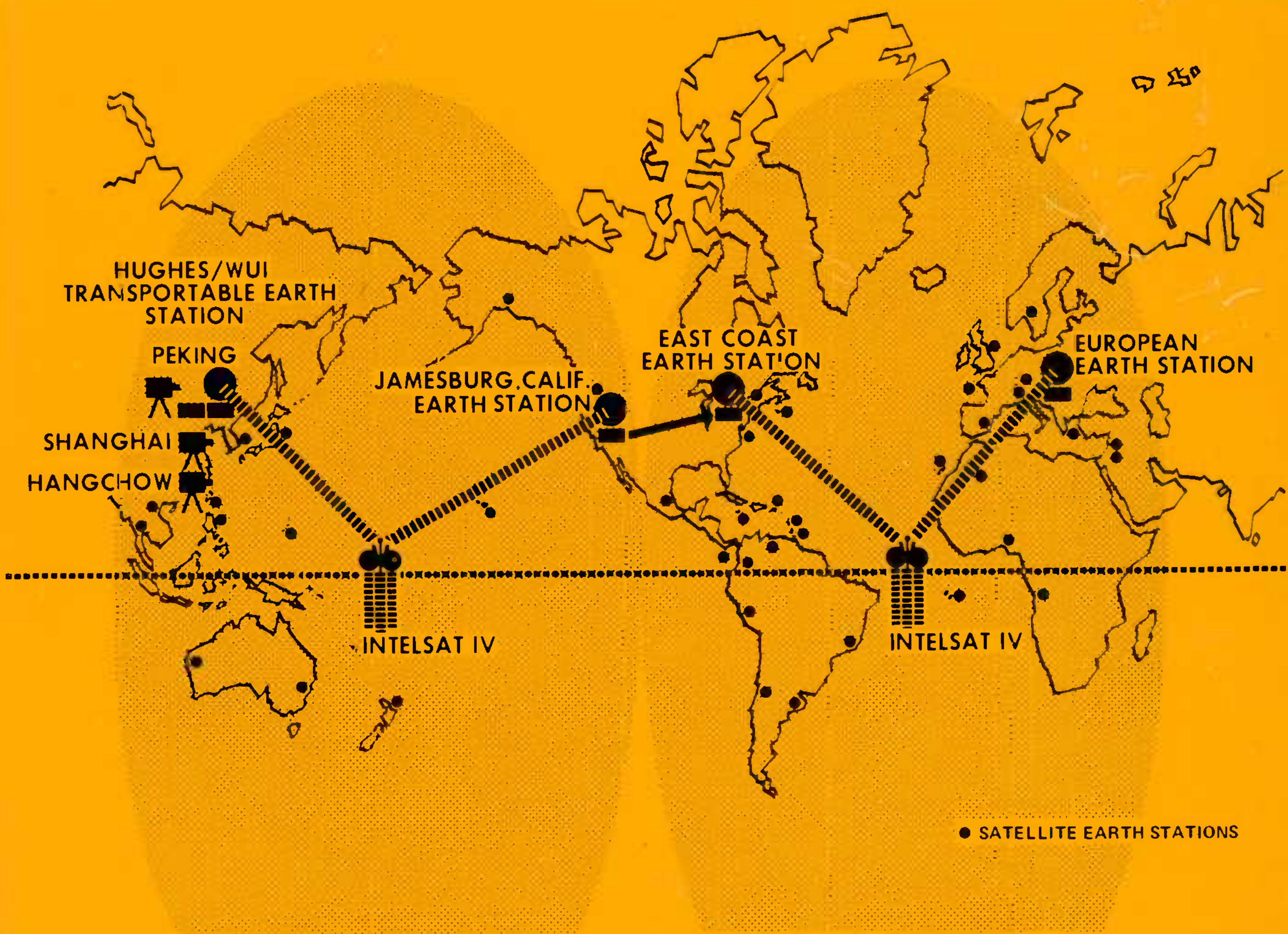
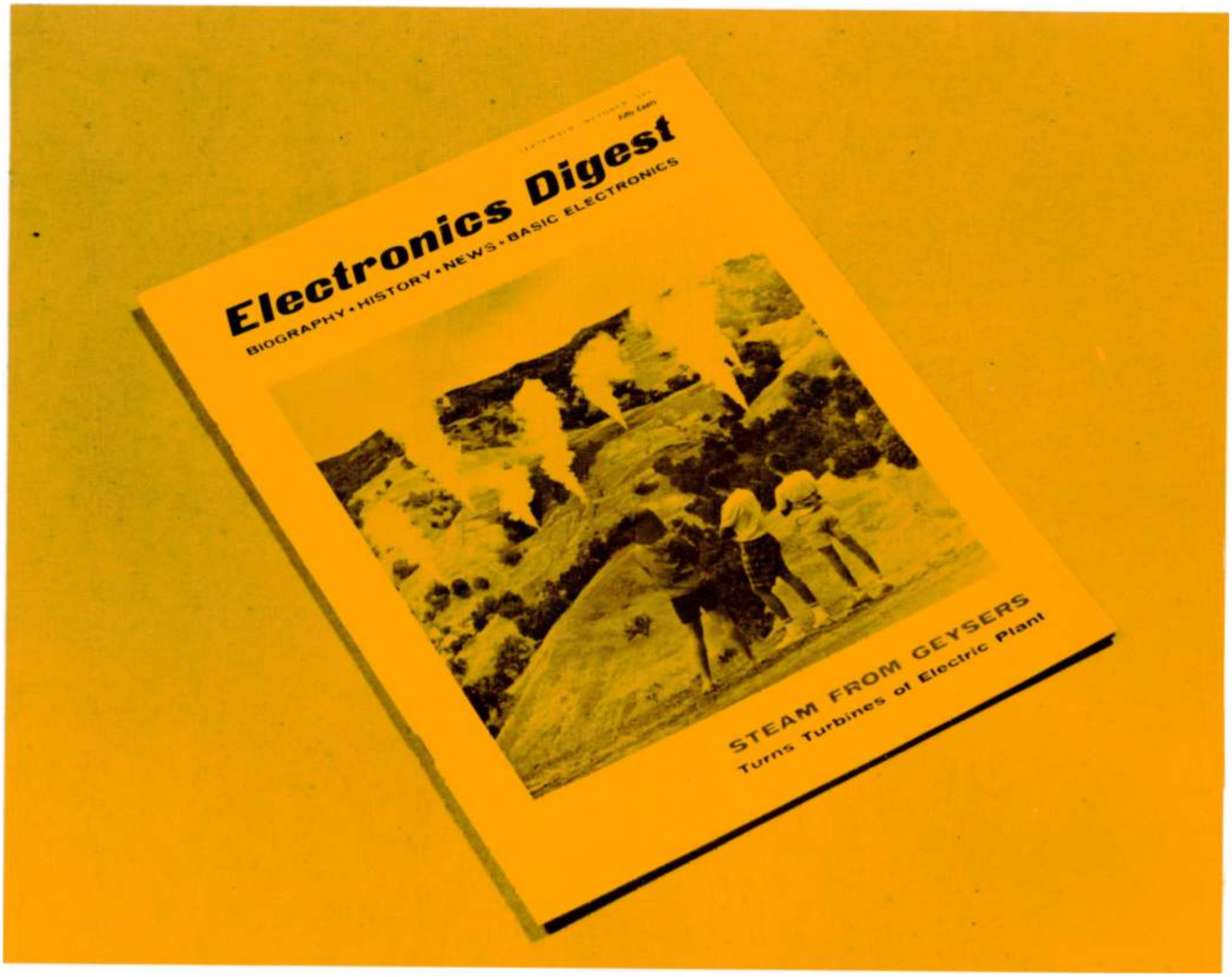


The China Visit . . .

AND ELECTRONICS

(See page 10)



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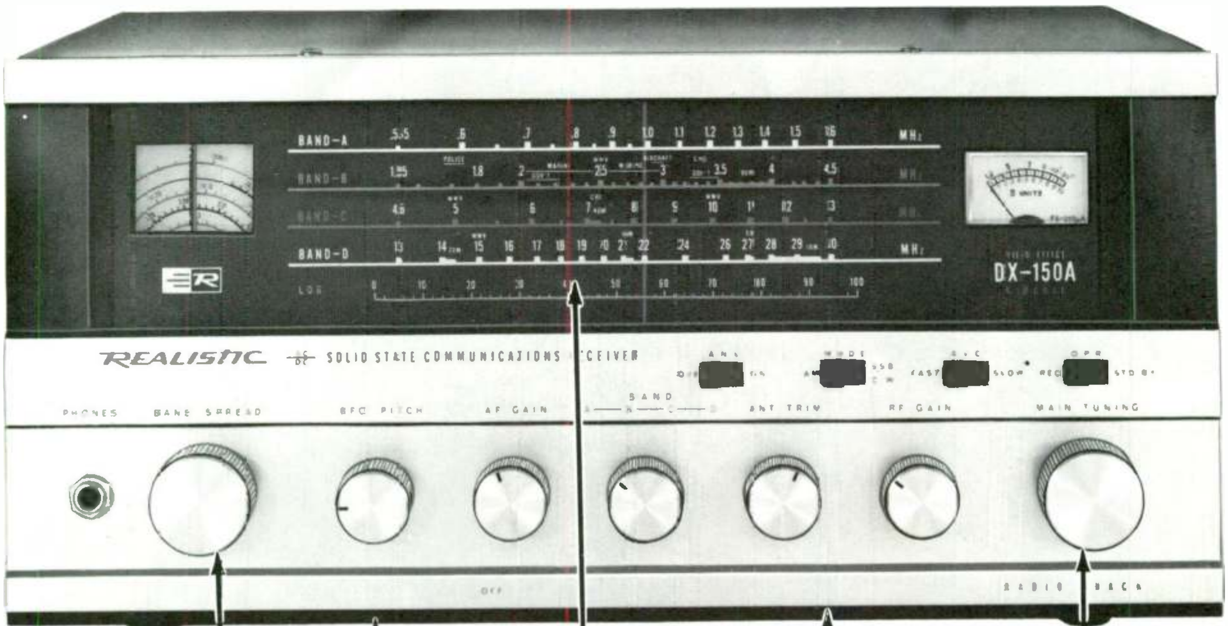

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Volume Five, Number Five March/April 1972

FEATURE ARTICLES

DEPARTMENTS

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New Automatic Cancer Radiotherapy System

A new system called CART (Computer-Assisted Radiation Therapy) is treating patients on a day-to-day basis with up to 30 percent reduction in setup time at the University of Wisconsin Hospitals

Special Medical Report

The first minicomputer-controlled radiotherapy system now is treating patients on a day-to-day basis with a 20-30 percent reduction in setup time at the University of Wisconsin Hospitals. The new system, called CART (Computer-Assisted Radiation Therapy) and introduced earlier this year by Varian Associates, Palo Alto, Calif., consists of a Varian 620/i minicomputer and a Varian Clinac (TM) – 4 Linear Accelerator in a single hardware/soft-ware package.

How CART works

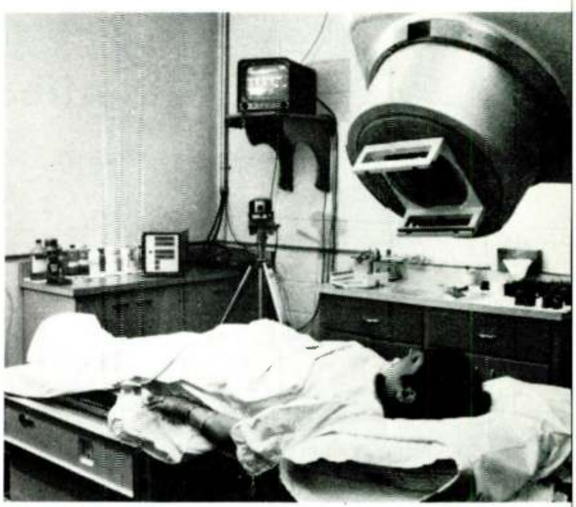
After placing a patient's cassette in CART's cassette reader, the technician, who can be quickly trained to operate CART, enters the patient's identification number on the control room display. If the I. D. number matches that on the tape, the complete patient record is entered into the minicomputer. The minicomputer then proceeds automatically to the next step, which is a visual display of the accumulated monitor dose for each portal, the total accumulated monitor dose, the total number of treatments in the plan, the number given already and the next portal number to be executed.

The computer now compares prescribed treatment parameters with actual settings of the Clinac-4 and its control console and indicates discrepancies on the video monitor. The information which the minicomputer has received from the cassette is now used to control gantry position, beam size, couch position, and size and angulation of the beam. An important safety feature of the system requires insertion of an appropriate key, which only the physician has, in order to give a radiation treatment which meets the proper tolerance criteria. When the computer determines that setup criteria have been met, an appropriate ready light is turned on. This tells the x-ray technician that he may now turn on the beam. When treatment is finished, the teletype automatically prints out the treatment parameters.

Besides the substantial reduction of the possibility of human error, Dr. Tolbert said, one of the chief advantages of the CART system is the ability to gather a good data base for retrospective studies at periodic intervals for the purpose of upgrading treatment modes. "CART gives us unprecedented precision in the administration of radiation therapy treatment, also," Dr. Tolbert emphasized. "There are data which indicate that the difference between cure and complication is very small in terms of the amount of radiation required. The precision provided by the CART system will be of considerable help in minimizing the possibility of cancerous areas receiving more or less than that specified by the physician."

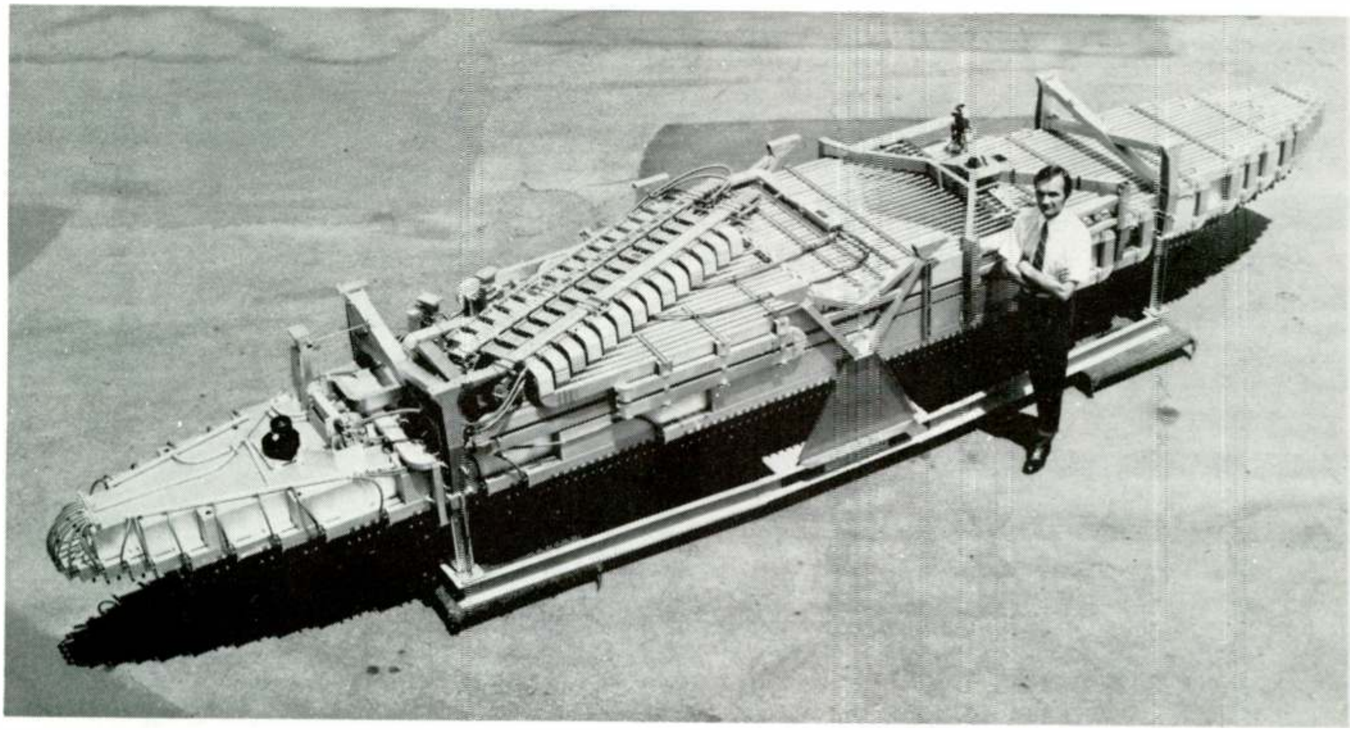
Dr. Tolbert said the hospital, which provided radiation therapy treatments for almost 1100 patients last year, has three radiation units, including two Clinacs and a cobalt unit. The CART system, installed on one of the Clinacs for the past six months, now is processing from four to five patients per day and, when thoroughly operational, will accommodate 40-45 patients per day.

The CART system's hardware package includes, besides the Clinac-4 and the 620/i minicomputer, 16 analog-to-digital channels; 8 digital-to-analog channels (to control four independent treatment couch motions and the four adjustments to the field size and orientation); the Clinac-4 interface unit; a teletype; a cassette read/write unit; a special Technician Interface Panel; and a video/keyboard display through which the technician communicates with the system and with remote displays.



Varian Associates

The first minicomputer-controlled radiotherapy system now is treating patients on a day-to-day basis with a 20-30 percent reduction in setup time at the University of Wisconsin Hospitals. Each patient's history and radiation treatment plan is recorded digitally on a 1/8-inch-wide cassette tape. The radiologic technician (above) merely inserts the cassette in the system, verifies the patient identification and actuates the system. From this point on, a Varian 620/i minicomputer controls the giant Varian Clinac (TM) 4 (lower photo) including the radiation dosage, beam direction, focus, couch position, etc.



Hughes Aircraft Company

ALMOST AIRBORNE — Cradled face down prior to crating for shipment to The Boeing Company, Hughes Aircraft Company's AWACS radar antenna gets last inspection by Hughes radar project engineer, L. A. Burnett. The antenna, first flyable hardware delivered by Hughes under its AWACS radar contract, arrived three weeks ahead of schedule at Boeing, prime contractor for the U. S. Air Force's Airborne Warning and Control System (AWACS). It is now installed in a Boeing radome assembly for further testing prior to delivery of the complete radar system in December of this year. AWACS will provide airborne air surveillance and command, control and communications functions. The surveillance function is provided by a three-dimensional radar capable of detecting and tracking targets operating at high and low altitude over land and water despite ground and sea clutter.

New Airborne Warning and Control System

The U. S. Air Force's Airborne Warning and Control System (AWACS) is designed for the vital roles of providing air defense and tactical command and control

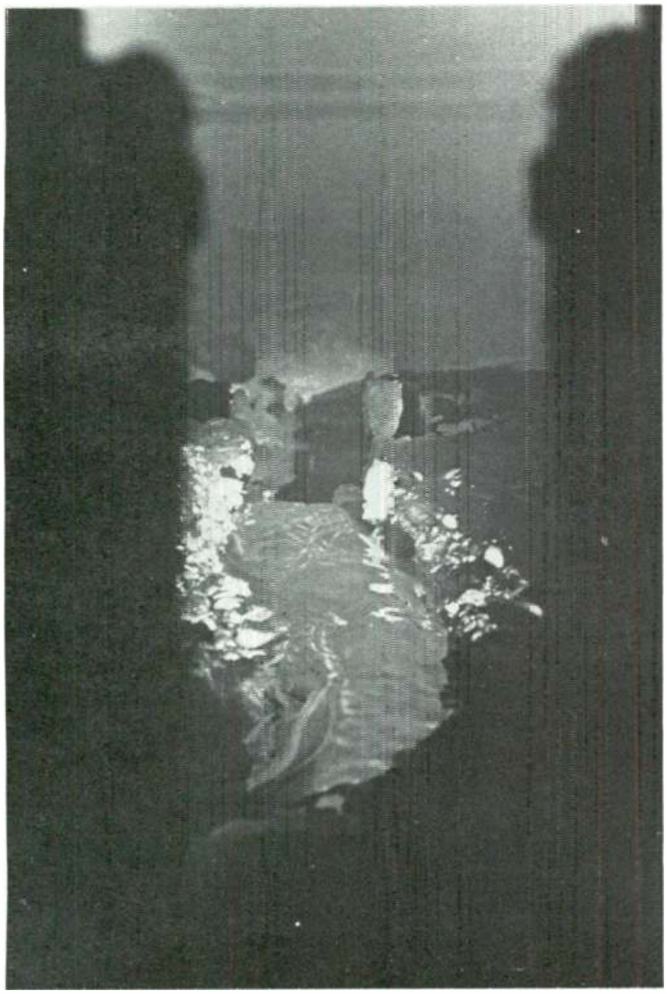
Special Military Report

The first airborne flight test antenna scheduled for the U. S. Air Force's Airborne Warning and Control System (AWACS) program which was delivered to the Boeing Company, Seattle, Washington, is being installed in a Boeing radome assembly for pattern and proof testing. Boeing is prime contractor on the program. The huge assembly was built by Hughes Aircraft Company of Fullerton, California.

AWACS, which was designed for the vital roles of providing air defense and tactical command and control, will employ a three-dimensional radar capable of long-range detection and tracking of enemy aircraft through dense ground-sea "clutter."

The initial phase of the AWACS program calls for the Boeing Company to flight test two different radar systems — one the Hughes system, the other a radar system designed by Westinghouse Electric Corporation. Two modified 707 jet transports, one for each radar system, will be used to carry the new radars during the test period. After careful analysis of actual flight tests, one of the radar systems will be selected for operational use by the U. S. Air Force.

Robert Polkinghorn, Hughes AWACS program manager, said the antenna delivery was the program's first major milestone. He added that the early completion of the radar system matches a similar achievement by Boeing in completion of its radome assembly, which was ready to receive the Hughes antenna on delivery. The 30-foot-wide ellipsoidal-shaped radome assembly housing the antenna will be mounted on top of the fuselage. Delivery of a second Hughes radar system is scheduled for March 1972.



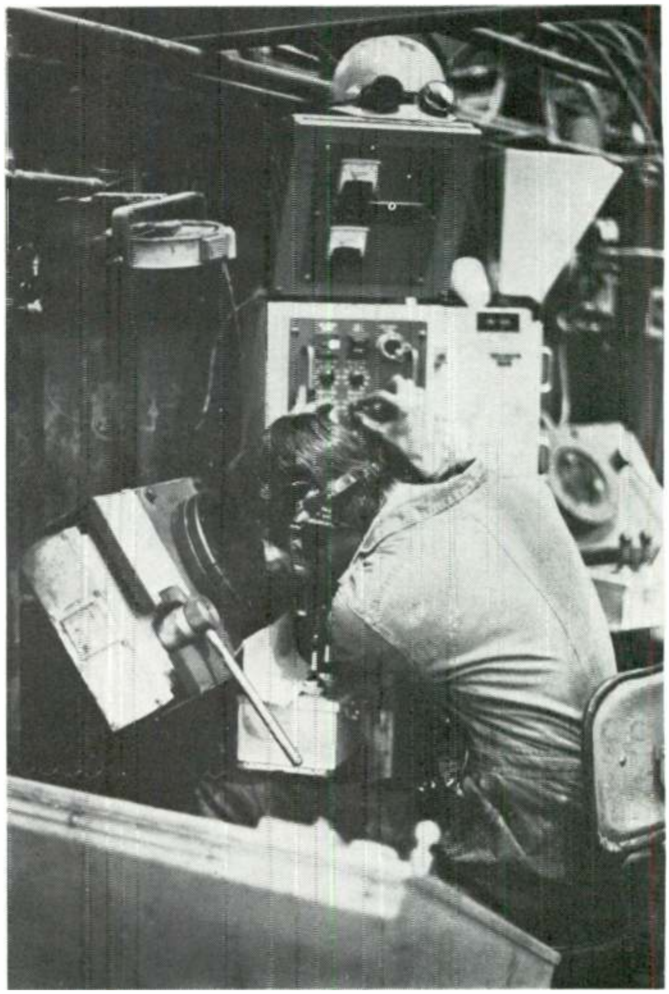


Photo courtesy of Varian Associates

River of molten stainless steel (left photo) is observed through porthole by furnace operator who aims electron beams which literally stir the molten metal and boil away impurities into a vacuum. The same type of high power tubes used by radio stations control the 3.5-million-watt pollution-free furnace – a patented process of the Airco Vacuum Metals Division of Airco, formerly Air Reduction Co.

New Smokeless Steelmaking Plant

A new 30,000-ton-per-year steelmaking plant produces no smoke, no fumes, and no ash. As an ecological bonus, the unusual plant dumps no industrial wastes to pollute San Francisco Bay

Special Ecological Report

A new 30,000-ton-per-year steelmaking plant produces no smoke, no fumes and no ash. As extra ecological and industrial bonuses, the profitable plant dumps no industrial wastes to pollute nearby San Francisco Bay; and its daily waste metallic condensate could be carried out in a lunch pail. However, even the condensate is recycled. The plant's only waste is an occasional wisp of clean steam.

The Airco Vacuum Metals revolutionary plant replaces coal or other polluting fossil fuels with a new process incorporating a battery of Varian super power tetrodes to regulate the power that fires its giant electron beam furnace. This patented process and equipment was developed by a sister division, Airco Temescal, located in Berkeley. Prior to construction of the AVM facility, a pilot furnace was operated at the Temescal plant and the super power tetrodes were used at that time.

The $15 million plant produces 120 tons per day of super-pure stainless

(Continued on next page)

(Continued from preceding page)

steel with the strength and corrosion resistance for such critical applications as chemical process piping, marine hardware, food processing equipment and water-treatment equipment.

At the 75-foot-tall furnace, technicians peer through portholes to direct electron beam guns at the molten metal, literally stirring the white hot river of steel and boiling away impurities into a 0.1 micron vacuum.

Tetrode-limited power supply

Each of the 22 electron beam guns is controlled by super power tetrodes, each rated at 200 kw. Varian/Eimac super power tetrodes are used in Airco Temescal systems as high-speed switches in the high-voltage leads at a point between the power supply and the vacuum system. These devices also act as isolators of radio-frequency waves to minimize their flow back into the power-supply system. This switching action also stops the current flow into the vacuum system wherever there is an incipient arc. Before an arc can become fully developed and self-perpetuating at low voltage, it is starved by the fast shut-off action of the tetrode. Since this fast action occurs within microseconds, the power can be restored to full value after an internal of only about 10 milliseconds.

In contrast to the Airco Temescal high-speed tetrode-regulated systems, older power-supply designs make use of relatively large amounts of inductance in the primary of the system. This inductance serves to limit surges in line current during voltage breakdown conditions, but its stored energy also serves to provide a large pulse of current into the arc which occurs inside the vacuum system during a voltage breakdown.

The stored energy which is then released gives a low-voltage arc an excellent start, and the arc frequently persists until power is physically interrupted. The total time required from the start of the breakdown to the restoration of full power often is one-half second or longer. The resulting inefficiencies in overall power input severely limit the performance of the electron-beam guns in many systems. Inductance-limited power supplies are considered obsolete by present standards of Airco Temescal designs.

Another advantage of the Airco Temescal constant-voltage, tetrode-limited power supply is that the KVA rating of installed power need be only 10 to 15 percent greater than maximum rated power delivered from guns in the form of electron beams. In addition, several guns may be operated in parallel on one tetrode system without significant interaction between guns. Electron-beam guns can be in the same or in separate vacuum chambers. Where guns are located in different chambers, Airco Temescal provides safety disconnects in the high-voltage lines so that operators can work on electron-beam guns in the unit that is down to air while other systems continue to operate.

Maintaining a constant voltage is critical, Airco pointed out, because too little voltage will yield imperfect ingots while too much will burn out the electron guns. The Varian/Eimac tetrodes allow less than one percent voltage deviation.

The application of radio broadcast tubes to steelmaking is part of the continuing effort by Varian to adapt new sources of efficient and pollution-free energy for industrial processing from its scientific research, development and manufacturing. Other Varian products using these new energy sources range from nonradioactive cancer therapy machines to chemical-free metallic plating systems.

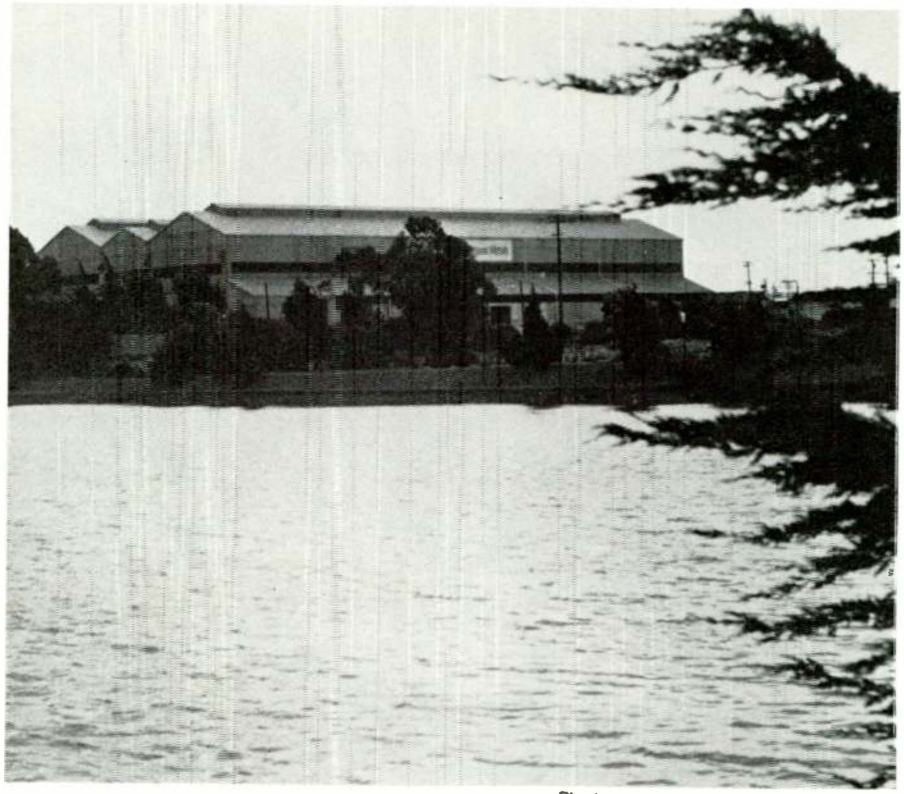


Photo courtesy of Varian Associates

NEW SMOKELESS STEELMAKING PLANT and Berkeley's Aquatic Park recreational area (in foreground) are environmentally compatible. Now in full production of 120 tons per day of high purity stainless, the giant furnace is powered by Varian high power radio broadcast tubes. The revolutionary, pollution-free steelmaking process was developed by Airco Vacuum Metals, a division of Airco (formerly Air Reduction Company).

First steel mill of its type

Airco's new steelmaking plant, which went on-stream earlier this year, uses a process developed by Airco researchers called electron beam, continuous hearth refining. According to Airco spokesmen, this is the world's first continuous steelmaking process conducted entirely in a vacuum. The combination of electron superheat and high vacuum permits the manufacture of steel of high purity and corrosion resistance. An increasingly important side benefit is that the process permits the manufacture of stainless steel without the addition of nickel – a very costly element of unpredictable supply.

A major new alloy now produced at the Berkeley plant is Airco's E-Brite 26-1 stainless steel in which 26 percent chromium and one percent molybdenum are added to iron. E-Brite 26-1, Airco states, is a lower cost stainless steel with superior strength and corrosion resistant properties. The Airco Vacuum Metal Division of Airco (formerly Air Reduction Company) supplies its E-Brite 26-1 to domestic stainless steel producers who convert it into a variety of mill product forms.

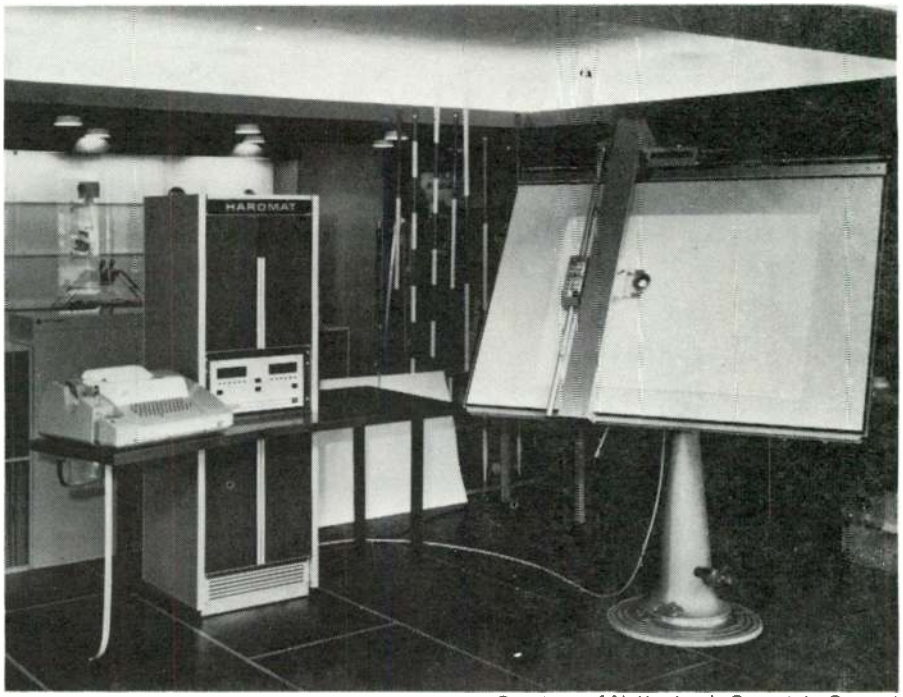
New Electronic Coordinate Reader

A Dutch company has developed an electronic coordinate reader for surface measurements. It can also be used for digitizing traffic graphs, electro-cardiograms, encephalograms and seismograms, and numerical tool control

International Report

To assist in the digitizing of graphical material, a Dutch company has developed an electronic coordinate reader whose most important field of application is in surface measurements. The apparatus is also suitable for digitizing traffic graphs, electrocardiographs, encephalograms and seismograms, and in the preparation of numerical tool control. Manufactured by Hagen Systems of Rotterdam, the Netherlands, the coordinate reader is now available for export to North America and elsewhere.

The measuring unit comprises a plane table which can be moved in all directions. The table can be connected integrally to a desk, and contains the built-in electronic equipment. On the measuring table there is a horizontally movable carriage containing a keyboard and a magnifying lens adjustable in a vertical direction. The position of the measuring mark in the magnifying lens vis-a-vis an arbitrarily chosen set of axes is continuously recorded by electronic counters. The indication on these counters can be passed into an information carrier by pressing a button. All types of extra information needed for further processing can be added to this by means of a keyboard.



Courtesy of Netherlands Consulate General

This photograph shows the measuring unit comprising a plane table which can be moved in all directions. It can be connected integrally to a desk, and contains the built-in electronic equipment. The apparatus is suitable for digitizing traffic graphs, electrocardiographs, encephalograms and seismograms, and in the preparation of numerical tool control.

When following a graph, it is also possible to have automatic recording with pre-set intervals in both the x and y directions. The apparatus can be delivered with a mechanical accuracy of 0.05 millimeters, the digital accuracy being 0.1 or 0.01 millimeters.

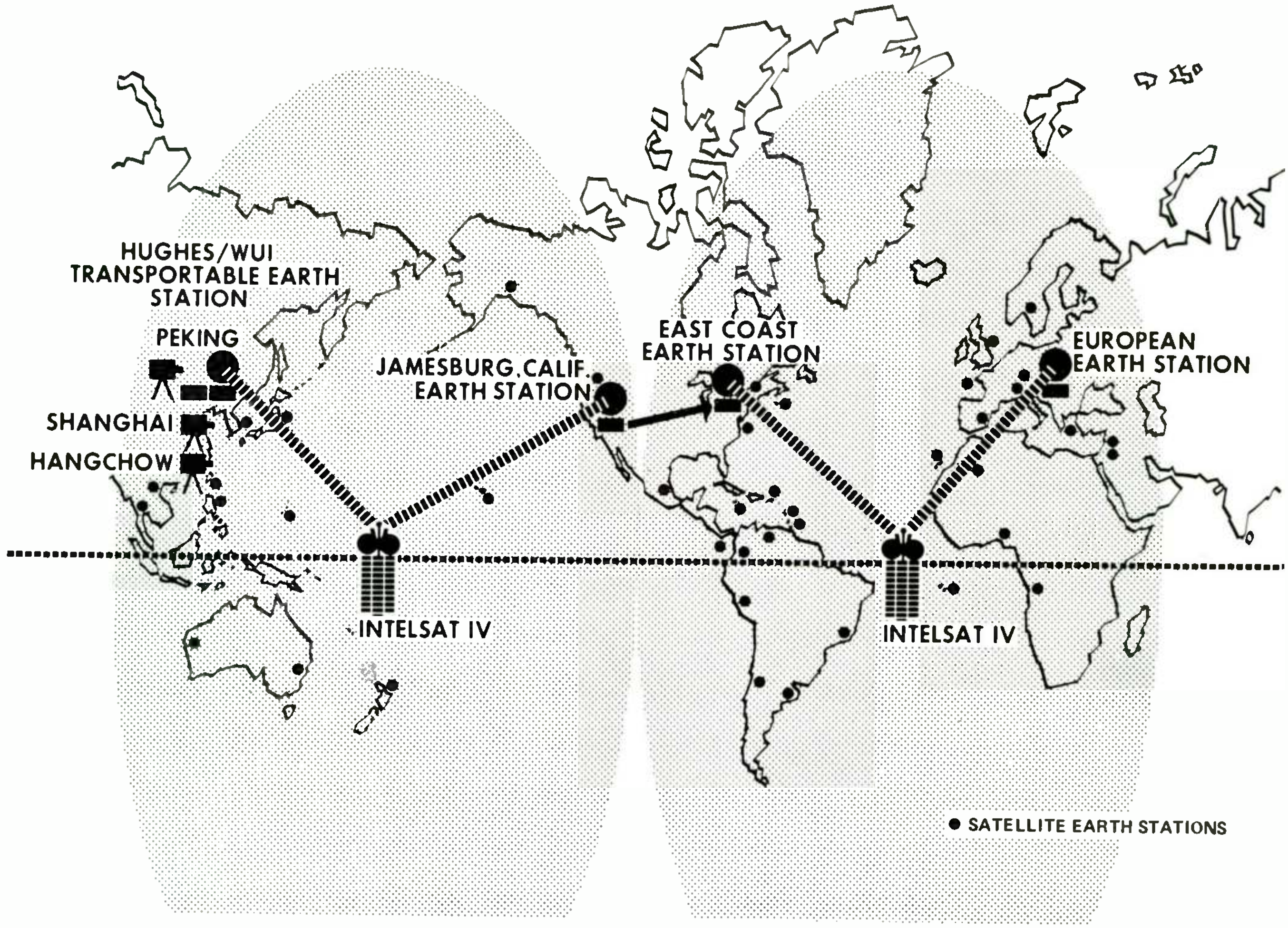
The data may be produced by a teleprinter, fast punched tape, magnetic tape, punched cards, disk memory or on-line to a computer. If a fast punched tape or magnetic tape output is chosen, any desired code can be supplied so that the machine can be used with virtually any computer system.

Besides being suitable for two-dimensional measuring with the aid of a table, the electronic components can also be interconnected to form a recording unit. This features the movement of a spindle or a movement along a ruler for the purpose of positioning. An example to determine the three-dimensional coordinates in aerial photographs. A large number of counters is provided for such an application.

The measuring table is available in three sizes of surface working area: 34.6″ by 48.8″; 34.6″ by 59″, or 44.5″ by 59″. If required, larger sizes are also available for marine engineering.

The magnification factor of the measuring lens and the number of decades can be selected freely in accordance with the object to be measured. The magnification of the lens, which is interchangeable, is a maximum of 10 to 1. The counting frequency is 10 megacycles.

For further information, readers may write to the Netherlands Consulate General, Commercial Division, 10 Rockefeller Plaza, New York, N.Y. 10020.



SMALL WORLD? – Map shows the route traveled by television and press coverage of President Nixon's visit to the People's Republic of China February 21-28. Signals were sent from a mobile satellite ground station provided by Hughes Aircraft Company under contract to Western Union International which was operating from Peking.

Courtesy of Hughes Aircraft Company

Electronics and the Visit to China

The new internationally-built Intelsat IV Communications Satellite, launched at Cape Kennedy in the U.S.A., made possible the viewing of live telecasts from Peking, China, by millions of people throughout the world for the first time

By William M. Palmer

According to an old Chinese proverb, *one picture is worth a thousand words.* It may one day be said of the live telecasts of auspicious events in international relations: a *moving* picture, relayed to the world via communications satellites, *is worth ten thousand words.*

Electronics added an important dimension to the unprecedented visit to Peking, China, by President and Mrs. Richard M. Nixon, of the United States, when it provided for the first time an opportunity for millions of people to observe for themselves an interesting panorama of human behavior in the political and cultural atmosphere of the Peoples Republic of China – a new vantage point not totally dependent upon the interpretations of news analysts or the divergent opinions of politicians.

Thus, space-age electronics has opened new avenues to cultural exchange between the peoples of the earth – a giant step toward better understanding, a logical step toward a peaceful and lasting solution of world problems.

The electronics star of the China visit, Intelsat IV, was launched from Cape Kennedy, Florida, U. S. A., on January 22 of this year *(The New Internationally-Built Intelsat IV,* Electronics Digest for January/February,

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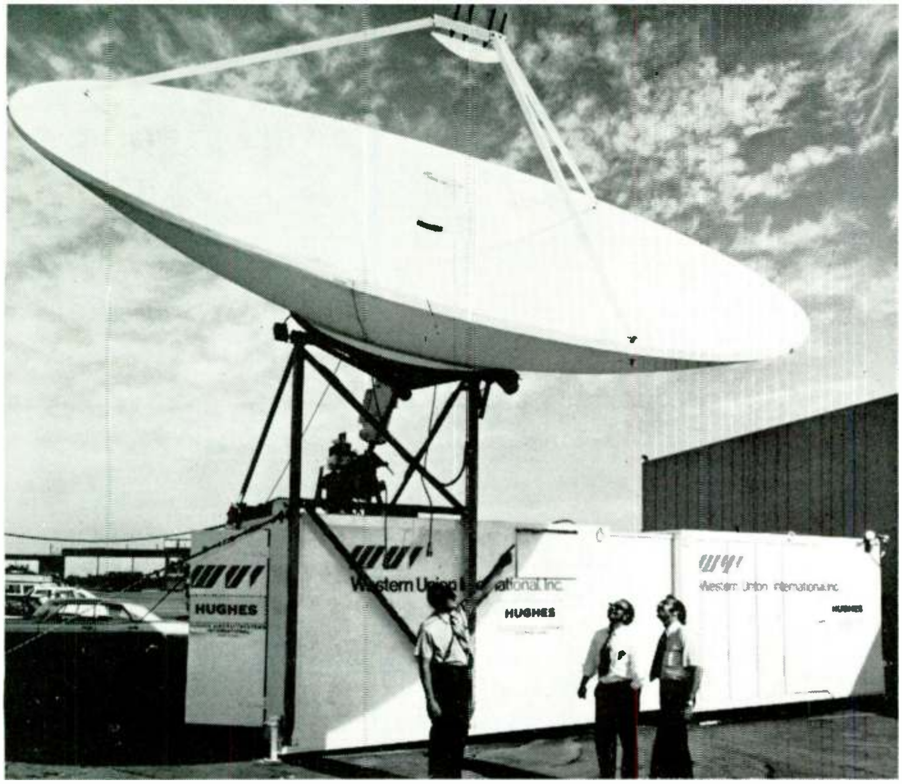

Photo courtesy of Hughes Aircraft Company

ENGINEERS at Hughes Aircraft Company, El Segundo, Calif., examine the highly-mobile satellite ground station that was later air-lifted to Peking to carry live color television and press coverage of President Nixon's China visit.

(Continued from preceding page)
1972), and was maneuvered into synchronous orbit over the Pacific Ocean where it is serving as a new communications link between Asia, Europe, and the United States.

The communications capability of Intelsat IV enables it to provide, for general traffic use, 5,000 to 6,000 two-way telephone circuits plus television capability. The giant space switchboard was built by the Hughes Aircraft Company and an international team of subcontractors.

A mobile satellite ground station, operating from a site about 19 miles from Peking, provided President Nixon and newspaper, magazine, radio and television reporters the only direct means of communication with the rest of the world during the China visit. The $1.5-million satellite ground station, consisting of two 14-foot-long trailers housing sophisticated electronic equipment and a 24-foot-diameter dish antenna, was provided by Hughes Aircraft Company under contract to Western Union International. It sent "live" color television and press coverage out of Peking 24 hours a day.

During the period of communications, Intelsat IV sent the signals received from the mobile satellite ground station in Peking down to a Comsat ground station at Jamesburg, California, U. S. A., through an AT&T switchboard at Oakland, California, then via microwave to a Comsat station on the East Coast of the United States. These transmissions were then relayed to Europe via an Intelsat satellite in orbit over the Atlantic Ocean – a relay route of nearly 100,000 miles for signals carrying the "live" television coverage of President Nixon's visit for European viewers. Yet, the signals reached them almost instantaneously.

The first version of the mobile satellite ground station was developed by Hughes Aircraft Company in 1968; and it provided "live" color-television coverage of Pope Paul's visit to Columbia, South America. Later that same year, it relayed television pictures of the Mexico City Olympics to the Far East.

In October 1971, the mobile ground station was used in Iran as a Western Union International communications link during the Shah's celebration of the 2,500-year-anniversary of the founding of the Persian Empire.

Intelsat is owned by an 83-nation International Telecommunications Satellite Consortium, and is managed by Communications Satellite Corporation (COMSAT).

The China visit is now history . . . and electronics was there. It will be remembered by countless people of this generation who viewed "live" telecasts of the historic events which took place. Future generations may call it a significant milepost in man's use of electronic communications in his quest for friendly relations with all peoples of the earth.

FOR THE HANDICAPPED

Spoken command dials telephone for handicapped

Engineers at Bell Laboratories in Holmdel, New Jersey, are investigating an experimental device that can dial a telephone number when given spoken commands.

Voice control of the device is achieved through a simple form of integrated circuitry that converts sound waves into electrical pulses to open and close the electromechanical switches necessary for obtaining a dial tone, executing dialing, and terminating a call.

A similar voice control device may one day provide "hands-free" telephone service for motion handicapped persons. Also in the future, the device could possibly be used to operate more sophisticated electrical equipment or machinery.

A small circular display of ten lamps labeled with the numerals zero through nine is used along with the voice control device. The lamps light in numerical sequence. Any voice utterance spoken in coincidence with a lighted numeral will activate that number.

Speaking the numbers "one "three," and "five" as the corresponding numerals light up in this order will enable the device to store in its memory all of the digits in a typical telephone number. As the numbers are spoken, the corresponding lamps remain lighted in the display for a slightly longer interval to indicate registration in the device's memory.

The memory in the voice control device will transmit stored digits as a series of electrical pulses to telephone dialing circuitry when a special command is given.

A telephone number remains in the memory even after it is dialed and can be reused any time the dialing command is given. Storing a new number will automatically erase the old one from the memory.

ELECTRONICS AND ECOLOGY

Earth's resources to be monitored by U. S. built ERTS-A satellite

A new scanning device, designed to diagnose whether the nation's resources are well or ailing, has been developed by Hughes Aircraft Company, and has been delivered for tests with NASA's Earth Resources Technology Satellite (ERTS-A), scheduled for launch this year.

An engineering model of the instrument, called a Multi-spectral Scanner (MSS), is now undergoing tests at General Electric Company's space division, Valley Forge, Pa., where the ERTS satellite is being built under direction of NASA's Goddard Space Flight Center.

The scanner is designed to detect and record the light "signature" of solar energy emitted by agricultural crops, forests and rivers to indicate their environmental health, and to pinpoint underground deposits of minerals and oil, said Tom Mattis, Hughes MSS program manager.

For example, he said, by monitoring wheat fields early in the growing season, the MSS could provide information on the health and potential yield of the crop, or it could detect crop disease so that it can be treated before serious losses occur.

Or, the device could determine where range conditions are best for cattle to graze, where a farmer should drill for water, or where pollution is occurring in lakes and streams.

The 100-pound MSS, an optical-mechanical device, will scan a swath of the earth 100 nautical miles wide during each orbit of the ERTS satellite over the U.S. It will record signal data in four separate bands of the electromagnetic spectrum, including the near infrared, and convert the light emissions into photo-like images to show the condition of various natural resources, Mattis said. The recorded data will provide information not obtainable if photographed by conventional optical lenses or television cameras, he added.

"All objects reflect, radiate or absorb heat or light energy," he explained. "Each object radiates its own individual 'signature' which can be detected as infrared or ultraviolet radiation, or as other electromagnetic radiation, including the visible color spectrum."

The ground resolution from orbit will be about 250 feet — equivalent to looking at a one-quarter-inch square from 100 yards away, he said.

The 2,000-pound ERTS-A satellite, which will be launched by NASA from the Western Test Range near Lompoc, Calif., will be boosted by a Thor-Delta rocket into a 492-nautical-mile orbit. The satellite will circle the earth every 103 minutes and photograph the entire earth's sphere every 18 days during its one-year mission life.

NASA scientists, in support of various government agencies including the Departments of Agriculture and Interior, believe the experimental program will provide a base for an operational system that could enable strict management and conservation of the nation's critical natural resources, Mattis said.

Reaction of fish to insecticides

Behavior of fish exposed to insecticides will be studied by a Texas A&M University biology professor under a $58,000 grant from the National Institute of Environmental Health Sciences.

Dr. Herman Kleerekoper was awarded the one-year grant on the basis of results obtained from a $7,400 pilot experiment grant from the Department of Health, Education and Welfare agency.

Title of the grant is "Behavioral

Toxicology Induced by Insecticides."

Concept of the study will be to expose fish to sub-lethal doses of insecticides and then place them in a monitoring tank to observe locomotor behavior.

The monitoring tank includes a series of photoelectric cells built into the floor. Lights placed above the tank cast the fish's shadow on the cells which form part of an electric circuit connected to a computer.

Dr. Kleerekoper, who joined the Texas A&M faculty in 1968 after teaching 20 years at McMaster University in Canada, uses the monitoring tank in conjunction with several other projects, including studies of fish navigation.

SPACE RESEARCH

Hughes to build test ion engine for outer space

Hughes Aircraft Company has been awarded a $750,000 contract by the National Aeronautics and Space Administration to build an ion engine for space propulsion and to conduct an endurance test simulating the time of its prospective missions.

The contract, awarded by NASA's Lewis Research Center, Cleveland, to the Hughes Research Laboratories here, calls for the fabrication of a 30-centimeter-diameter mercury-fueled electron bombardment ion thruster. The thruster is the size and configuration that may be used as a standard thruster module to serve as the prime propulsion system for spacecraft.

Ion engines originally were developed to provide low thrust and high efficiency in terms of fuel utilization for long-term space applications. They operate by bombarding the fuel with electrons to obtain ionized particles, and accelerating the ions by an electric field to produce thrust.

The ion engine in the new Hughes development program can have several applications in space exploration, said Cyril R. Collett, program manager. It can be used to raise synchronous satellites to their proper orbits, he said, in addition to providing the propulsion for unmanned interplanetary spacecraft.

Celestial mapper aboard satellite

An electro-optical system aboard a U. S. Air Force satellite mapped 80 per cent of the sky during three revolutions of the earth Oct. 20-21.

The system, called CMP (for Celestial Mapping Program), is a highly sensitive instrument that will collect radiometric data on the natural celestial background, said William A. Craven, Jr., manager of the Hughes Aircraft Company's electro-optical division, where the system was built.

Several innovations in the design of the CMP are expected to allow a six-month or longer in-orbit operating life of the instrument.

Use of a self-cooling sunshade to prevent aperture loading, and a liquid rotary joint to carry cooling fluid across the gimbal interface are two of the unique features of the CMP system, Craven said. A one-axis gimbal that will provide a total of 205 degrees of motion for scanning also is employed.

The CMP, developed for the Air Force's Space and Missile Systems Organization, was launched on the same space vehicle that carries the Flexible Rolled Up Solar Array (FRUSA), developed by the Hughes space and communications group.

MILITARY DEVELOPMENTS

Laser rangefinders will give U.S. tanks deadly aim

An $8.3 million contract for production of laser rangefinders for the U. S. Army's Sheridan armored reconnaissance vehicle has been awarded by Frankford Arsenal, Philadelphia, to Hughes Aircraft Company.

The rangefinder consists of a ruby laser, telescope-like optics and associated panels and electronics.

In operation, the rangefinder is aimed at the target, utilizing self-contained pointing optics, and the laser is fired. The light beam, traveling at 186,000 miles a second, reflects off the target and back into a receiver telescope. The system automatically registers the elapsed time for the laser beam's round-trip, computes the distance in meters and displays the range on a readout.

Hughes Aircraft Company

With this exact range information, tank crewmen can fire conventional armament with a greatly improved probability of scoring a direct hit on the first try, Mathews said.

EDUCATIONAL ACHIEVEMENT

A woman? Yes! Electrical engineer

ARLINGTON, TEXAS — Charlotte Ann Wright became accustomed to "the reaction" in her electrical engineering classes at the University of Texas at Arlington.

At the first class meeting each semester, a man would walk in, do a double-take and say, "I must be in the wrong class — there's a girl in here."

It was understandable. Charlotte says there were no other women in any of her EE courses.

"Then, after they found out I was supposed to be there, they'd always offer to help me out, but it usually worked out the other way around," recalls Miss Wright, who scored a rare academic "double" at UTA this fall.

She finished two B.S. degrees, graduating with highest honors in electrical engineering and high honors in math. And she did that in just four and a half years, going straight through — summers, too — while posting a 2.81 grade point average on a 3.0 scale.

NEW PRODUCTS

Mini-Twenty Three CB transceiver

A 23-channel Citizens Band transceiver that is small enough to fit in most glove compartments, yet sells for under $100 has been announced by Radio Shack.

Designed to provide effective, inexpensive full-capability communications for any car, truck or boat, the Realistic® Model TRC-50 Mini-Twenty Three is being hailed by Radio Shack as a breakthrough in both size and price for 23-channel CB transceivers.

The transceiver, which is only 1½x5¼x7⅞", is rated at a full 5-watts input and has a frequency-synthesis circuit for 23-channel operation with no additional crystals needed.

Realistic products are available exclusively through more than 1250 Radio Shack and Allied Radio Stores in 49 states and Canada, or by mail. Radio Shack is a Tandy Corporation Company (NYSE).

MEMBERSHIPS

Brookner elected to IEEE

Dr. Eli Brookner, a Raytheon Company engineer, has been elected a Fellow of the Institute of Electrical and Electronics Engineers by that organization's board of directors.

The membership grade of fellow is the highest attainable in the institute and is conferred only on persons of outstanding qualifications and achievements in their field of interest. Dr. Brookner was cited for his contributions to radar signal processing and wave propagation in random media.

With Raytheon since 1962, Dr. Brookner is a consulting scientist in the company's Equipment Division.

MEETS/SEMINARS

OST electronics alumni to meet

Electronics alumni of Oklahoma State Tech, Okmulgee, have been invited to join with other OST graduates returning to their alma mater April 29-30 to help celebrate Tech's 25th anniversary.

An innovative and exciting program has been planned for the scheduled OST Alumni Association's Homecoming Saturday, April 29, according to John Cathey, association president. Registration begins at 9 a.m. in Covelle Hall, and will be followed by a day-long slate of fun activities.

Sunday afternoon, April 30, the campus once again will be busy as visitors converge at the Okmulgee school for a special Open House. Alumni unable to attend the Homecoming on Saturday are encouraged to participate in the Open House on Sunday.

Ferrite devices seminar in France

The Centre D'Etudes et de Recherches de Toulouse in France has announced that their Microwave Research Department will hold the First International Seminar on Ferrite Devices from the 27th through 30th March 1972.

During the seminar, new concepts associated with optimization and miniaturization of ferrite devices will be pointed out.

Information is available through: Monsieur le Professeur THOUREL, O.N.E.R.A. — C.E.R.T., B.P., No. 4025, 31 — Toulouse FRANCE.

BOOKS/BROCHURES

Traveling-wave tube story

A 22-page brochure describing the history, technology and applications of the traveling-wave tube has been made available by Hughes Aircraft Company's electron dynamics division.

The new brochure discusses how the TWT works, electrical and mechanical constructions, different types of tubes, and possible future developments and trends. It may be obtained by contacting Hughes Electron Dynamics Division, 3100 West Lomita Blvd., Torrance, Calif. 90509.

Science Notebook study-guide

As a part of the new Science Notebook series of study-guides for teachers, students, hobbyists, a programmed self-teaching lesson on *Scientific Notation* is off the press. The lesson, or study-guide, covers the "mathematical shorthand" used in electronics and other scientific areas to simplify calculations involving small decimal numbers or large whole numbers. It is an excellent "short course" for students, teachers in presenting a review of the subject, or for hobbyists.

The new publication from the Book / Educational Division, Electronics Digest, P. O. Box 9108, Fort Worth, TX 76107. The cost is only $1.00 per copy with special classroom rates available on request from science teachers.

Helium-neon laser products

A six-page brochure describing Hughes Aircraft Company's one-, three-, and ten-milliwatt helium-neon laser products has been made available by the company's electron dynamics division.

The new brochure gives the features, specifications and applications of the new lasers, which are designed for use in construction, industrial and general laboratory work. It may be obtained by contacting Hughes Electron Dynamics Division, 3100 West Lomita Blvd., Torrance, Calif. 90509.

New WWV format

Effective July 1, 1971, Radio Stations WWV and WWVH, operated by the National Bureau of Standards, changed their transmission format for their Standard Time and Frequency Broadcasts. SPECIFIC PRODUCTS has a new brochure detailing the new format for WWV and WWVH, available free of charge.

Address your request to: Specific Products, a Division of The Dr. Henry L. Richter Corporation, 1237 South Shamrock, Monrovia, California 91016.

Royal Earl House

Inventor of the Printing Telegraph

September 9, 1814 • February 25, 1395

by William M. Palmer

More than a century ago, during the Civil War years, an odd-looking machine called the telegraph printer took its place as a means of rapid communications. Many messages of the nation were handled with this remarkable invention which was once hailed as "the highest product of which human skill is capable." It ended Morse's exclusive patent control of the telegraph field in this country.

Invented by Royal E. House and patented in April, 1846, it was the first telegraph machine to print Roman letters, numerals, and punctuation marks instead of the Morse code. It helped Western Union's parent company, New York & Mississippi Valley Printing Telegraph Company, get its start in telecommunications. The original company was organized in Rochester, on April 1, 1851.

Today, few would deny Royal House the title of genius. Few would deny his great courage and tenacity. House, who was born on a farm, is said to have been so poor that he slept under the lathe for lack of a bed; and that he worked out the elaborate mechanical details of his invention without the aid of drawings, written plans, or models of any kind. An extraordinary achievement!

In order to protect his invention against piracy, House divided the machine into several sections. Then he sent the sections to different machine shops for the manufacture of parts. He assembled the first telegraph printer with his own hands, and placed it on exhibition in the basement of New York's City Hall in the fall of 1844 – only a short time after Morse had sent his historic first telegram, "What hath God wrought," from Washington, D. C. to Baltimore, Maryland.

The original House telegraph printer looked more like a small piano with a "coffee-grinder" handle than a communication device. It was operated by means of manual power, compressed air and a variety of springs and friction. Two men were required at each end of the wire for operation. One, a "grinder," provided printing motion by turning a crank, while the other man operated the keyboard.

Despite its complex mechanism, the House printer could handle over 2,000 words an hour, depending upon the operator's skill. It was twice as fast as Morse telegraph recorder systems, and was considered to be more accurate.

When New York & Mississippi Valley Printing Telegraph Company changed its name to Western Union in 1856, it continued to use the House printer. However, it found the telegraph printer expensive to operate and maintain. Consequently, completion of the first transcontinental telegraph line in October, 1861, brought about a gradual reduction in use of telegraph printers. The Morse system, greatly simplified with keys and sounders, was found to be more efficient and less costly to operate. Thus obscurity finally overtook the invention of Royal House.

Now the situation is again reversed. Morse telegraphy is virtually obsolete, while printing telegraphy along with its latest communications ally, facsimile, moves over 95% of the nation's telegrams.

"It's quite puzzling,' says a Western Union spokesman. "There were many hundreds of House printers operated by our original company and by ourselves. Now, over the years, it seems that they have disappeared and none have been preserved."

Royal House was born in Rockland, Vermont, on September 9, 1814. A few months later, his parents, James N. and

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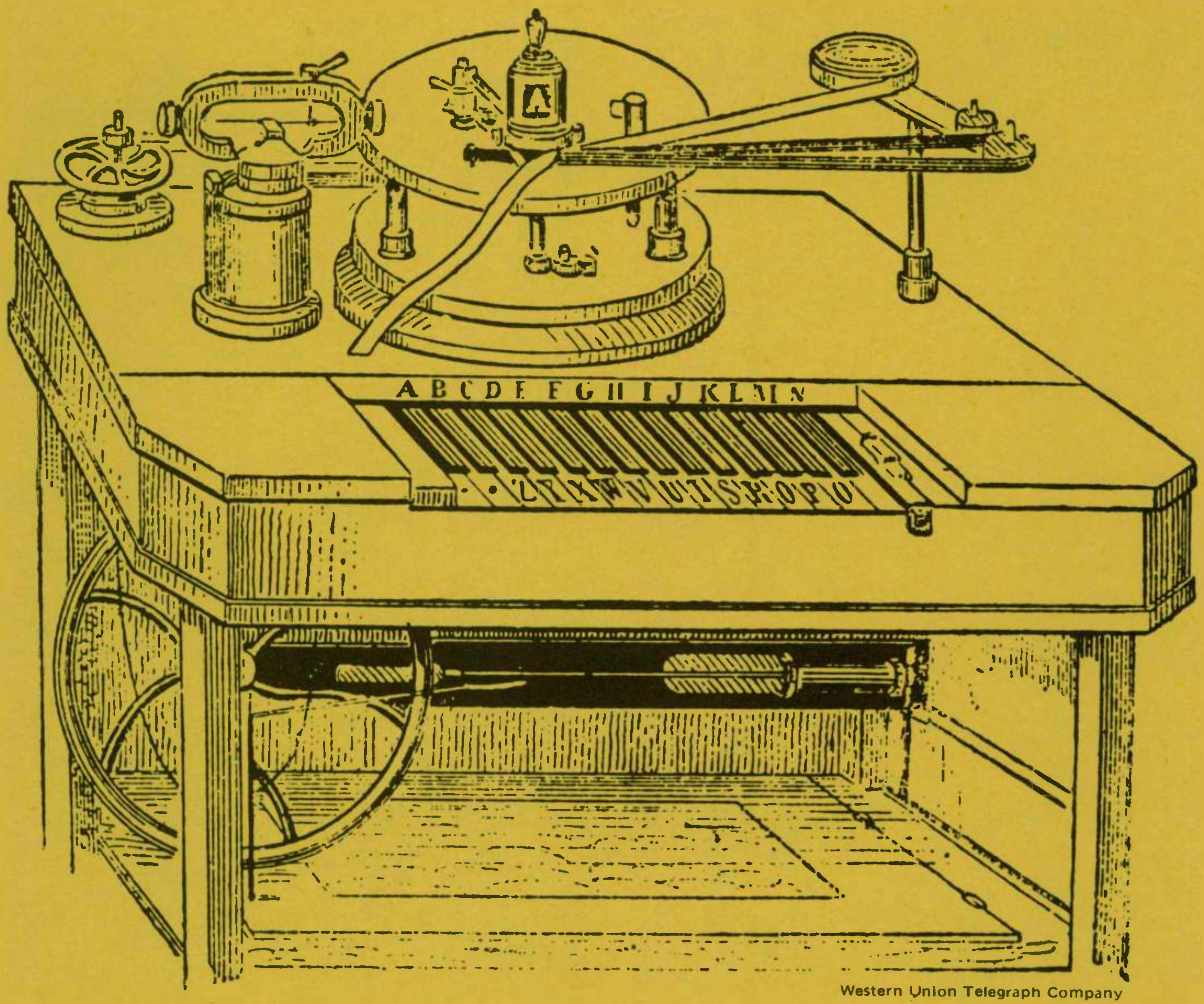

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(Continued from preceding page)

Hepsibah (Newton) House moved to a small town called Little Meadows in Susquehanna County, Pennsylvania. It was rather isolated country in those days – schools were few and far between, as people of that era might have expressed it. Consequently, young Royal received most of his elementary education from his mother.

At an early age, House developed a keen interest in mechanics and science. One of his first inventions, designed at age 26, was a water-wheel which embodied principles of the modern turbine. Notwithstanding this, he expressed a desire to study law, and with that goal in mind he moved to Buffalo, New York, in 1840, where he lived with one of his relatives. After a short time there, he chanced to read a scientific work dealing with electricity. It captured his interest so thoroughly that he gave up the idea of studying law and returned home to undertake electrical experiments. This, of course, led to his invention of the printing telegraph, as well as several other instruments used in telegraphy.

Royal House died on Monday, February 25, 1895, in Bridgeport, Conn., where he had lived the remaining years of his life. His death came only a few months before his eighty-first birthday. The fame that he had once enjoyed had diminished and so had his great invention, the printing telegraph (although the instrument was destined in the years ahead to again replace the Morse telegraph). *The New York Times* carried a brief obituary notice on page 3, upper right-hand column, on February 27, 1895.

Royal Earl House exemplified the pioneering spirit that built America, and gave it a coveted place among the nations of the world – the America where freedom of the individual, combined with opportunity, has flourished for almost 200 years.

IN REMEMBRANCE...

By William M. Palmer

Let us honor our men of science
Who once walked upon the planet Earth
Along the uncharted trails of electricity
In search of a better way of life
For all mankind

THE CENTENNIAL MEMORIAM OF THE INVENTOR OF THE TELEGRAPH

Samuel F. B. Morse
April 27, 1791 — April 2, 1872

Many of our great inventors of electrical and electronics devices were originally educated or trained for other fields of endeavor, and Samuel F. B. Morse was a member of that fraternity.

Morse was born in Charlestown, Mass., April 27, 1791. He possessed a natural aptitude for art that was evident from his early youth, and by the time he had reached his mid-teens he was considered to be an accomplished artist. During the early part of his life this strong interest and ability in painting brought him many honors. His great loye for art eventually took him to Europe where he studied and painted for a period of time.

It was while studying at Yale University that Morse first became interested in electrical studies – thus planting a seed of thought that finally led to his inventing the electromagnetic telegraph.

At the age of 41 the scientific phase of Morse's life began in earnest. The year was 1832, and he was returning home from Europe. It was during this voyage that the telegraph took shape in the mind of the inventor, and he thereupon sketched, in rough drawings, the necessary devices which were required for operation of the instrument. He completed his first workable apparatus in 1837, and it was exhibited in New York City.

Many other small companies were licensed by Morse to use his invention. One of those companies was formed to build a line in the Midwest . . . it was a name destined to become famous, Western Union. It was in 1861 that this company built the first continental telegraph line.

Morse received many honors during his lifetime and was also honored with memorials in later years. One of the most singular honors is a statue of the inventor which is located on the second floor "Hall de Extranjeros" (Foreigners Hall) of the magnificent "Palacio de Correos y Telecommunicaciones" (Post Office and Telecommunications Palace) in Buenos Aires, Argentina, South America.

Courtesy of Western Union Telegraph Co.

This old photograph shows Samuel F. B. Morse as he looked in the sunset-years of his eventful life. He sent the famous message, "What hath God wrought," from Washington to Baltimore on May 24, 1844. It marked the beginning of a new day in rapid communications over great distances – a most significant key to America's economic progress.

The inventor's father was clergyman, author, and publisher. His mother's grandfather was one of the presidents of Yale University. It is said that Morse, throughout his lifetime, was an humble man. He received praise and honors in genuine humility.

Morse died in New York City on April 2, 1872, several weeks short of his birthday.

He will long be remembered as a great American and his achievements stand out as a tribute to the American way of life.

Courtesy of Zenith Radio Corporation

Yesterday and Today . . .

MORE THAN STYLES HAVE CHANGED – This old Zenith radio at left (model 7D-127 for you antique radio buffs) sold for $49.95 in 1937 and was 19 inches high. Its big black round dial was a major feature those days to tune in radio greats such as Fred Allen and Fibber McGee and Molly. Zenith's new Royal B21 battery-operated transistor radio is quite a change. It tunes FM and AM, fits in your pocket, and plays with the protective grill-door closed on battery power. Its manufacturer's suggested retail price is much less – $19.95. It features today's latest development in radio – a hidden printed circuit antenna which eliminates the need for the telescoping FM whip antenna.

Illustrated History of the Vacuum Tube

Battery-operated tubes were progressively miniaturized in the 1920s. Although called "peanut" tubes, the first types in the series were comparatively large

PART TWO

by Robert G. Middleton

Battery-operated tubes were progressively miniaturized in the 1920 s. Although called "peanut" tubes, the first types in the series were comparatively large. For example, the WD-11 illustrated in Fig. 1 was 4 ¼ inches long and 1 ¼ inches in diameter. On the other hand, its filament-supply requirements were quite modest, and could be met by a No. 6 dry cell, or even a Size D flashlight cell. The filament drew 0.25 ampere at 1.1 volts. By way of comparison, a UV-200 tube drew 1 ampere at 5 volts, and required a storage battery for its filament supply. The UV-200A tube drew 0.25 ampere at 5 volts, and could be operated from four No. 6 dry cells.

Fig. 1 The WD-11 "peanut" tube was 4-¼ inches in length.

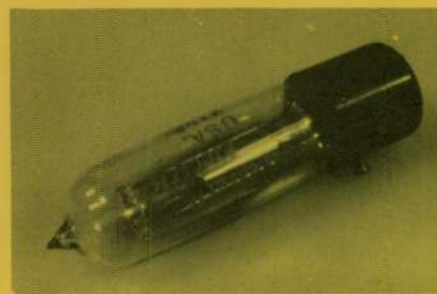

Fig. 2 Western Electric 215-A "peanut" tube.

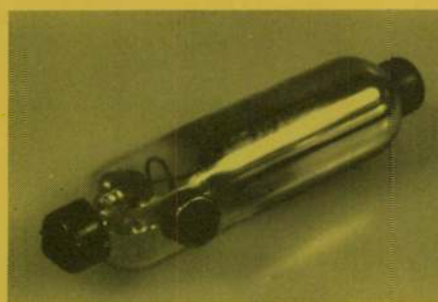

Fig. 3 The Marconi V24 valve.

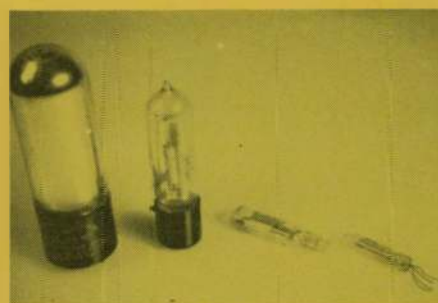

Fig. 4 Trend of miniaturization. Left to right: UV-199, 215-A, pentode subminiature tube, triode subminiature tube.

Although considerably larger than a peanut, the Western Electric 215-A tube shown in Fig. 2 was only half the size of the WD-11, approximately. The 215-A was 2 ½ inches long and 5/8 inch in diameter. Its filament rating was the same as for the WD-11. On the other side of the Atlantic, the British developed the V24 valve seen in Fig. 3. This tube employed a pure tungsten filament, whereas the WD-11 and 215-A utilized filaments treated with rare-earth elements. In turn, the filament-current demand of the V24 was several times as great, and the tube was operated from a storage battery.

Next, let us observe the comparative sizes of the tubes illustrated in Fig. 4. The UV-199 is smaller than a WD-11, but larger than the 215-A. In turn, the 215-A is much larger than the subminiature tubes, which are properly termed "peanut" tubes. The subminiature triode is the smallest, and is 1 inch in length by 3/16 inch in diameter. This is one of the smallest tubes that has ever been produced. Its filament is operated at 0.625 volt, and draws 50 milliamperes. The pentode subminiature tube has a filament that requires 1.25 volts at 50 milliamperes. It provides up to 25 milliwatts of output power. Both types of subminiature tubes employ a 45-volt B battery.

TABLE 1
Landmarks in Vacuum and Gas Tube History

1883: The Edison Effect	1920: UV-200 and UV-201 Tubes
1905: Fleming Valve	1921: Peanut Tubes and ¼-kw Power Tubes
1906: DeForest Audion	1922: Thoriated Filaments
1912: The Tungsten Filament	1923: Cathode-Type Tubes
1913: X-Ray Tube	1925: Cold-Cathode Gas Rectifier Tubes
1914: Oxide Coated Filaments	1927: AC Operated Tubes
1916: Cathode Ray Tube	1928: Screen-Grid Tubes and Thyratrons
1917: DeForest Audiotron	1929: Power Pentodes
1918: Tungar Mercury Vapor Rectifier	

Early Screen-Grid Tubes

Development of the screen-grid tube opened up a new era in design and performance of tuned radio-frequency (TRF) receivers. A tuned radio-frequency amplifier stage has the configuration of a tuned-plate tuned-grid oscillator circuit. To operate satisfactorily as an RF amplifier, a triode TRF receiver required some form of neutralization. This requirement was technically difficult, since adequate neutralization at the high-frequency end of the tuning range resulted in over-neutralization and loss of amplification at the low-frequency end of the tuning range. Although elaborate neutralization methods were developed, some other method of controlling RF amplifier oscillation was sought by design engineers.

A triode tube oscillates in the basic TPTG configuration because of the small amount of capacitance between the plate and grid electrodes. A 201-A tube had about 10 pf of plate-grid capacitance, which represented a practical minimum value in triode construction. In the latter 20's, the tetrode tube made its appearance, and stable high-gain tuned RF amplifiers could then be used in receivers. The first tetrode was the type UX-22, illustrated in Fig. 5. It employed a screen grid around the plate electrode, as depicted in Fig. 6. Thereby, an

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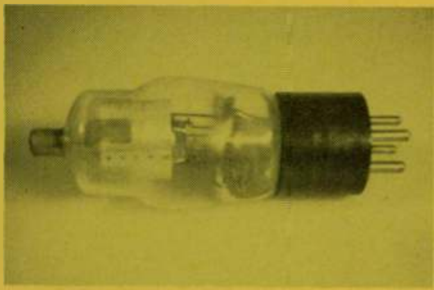

Fig. 5 The UX-22 screen-grid tube.

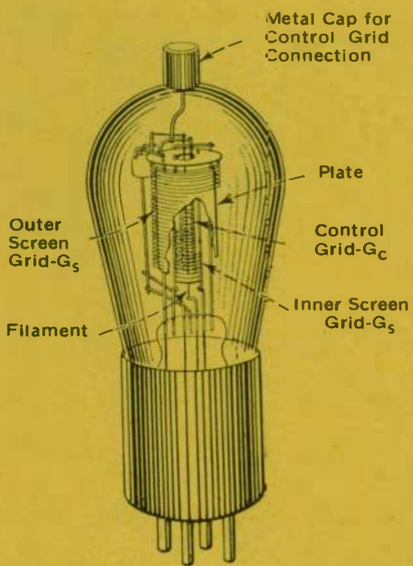

Fig. 6 Construction of an early tetrode tube.

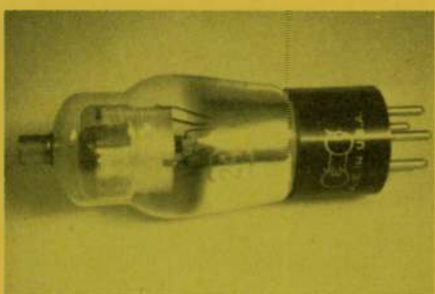

Fig. 7 The type 24 screen-grid tetrode.

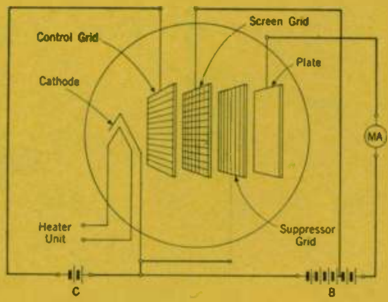

Fig. 8 Plan of a pentode tube.

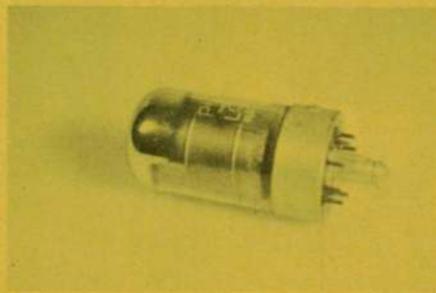

Fig. 9 A pentode tube with a Loktal base.

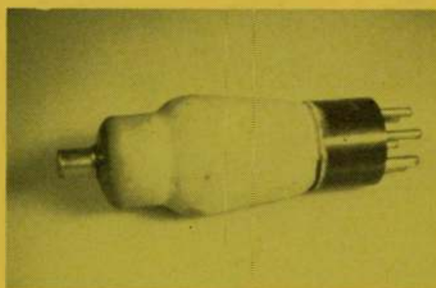

Fig. 10 A pentode tube with a spray-coated glass envelope.

Fig. 11 A metal-type pentode tube.

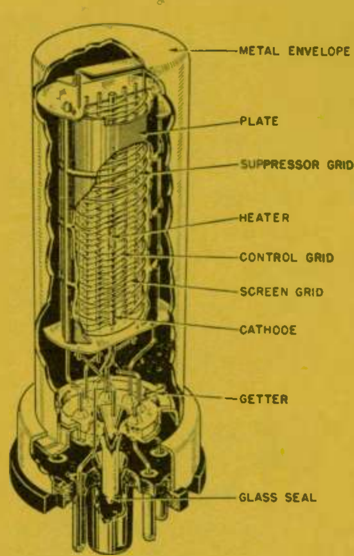

Fig. 12 Physical construction of a metal-type pentode.

Fig. 13 Control-grid construction for sharp-cutoff (left) and remote-cutoff (right) tubes.

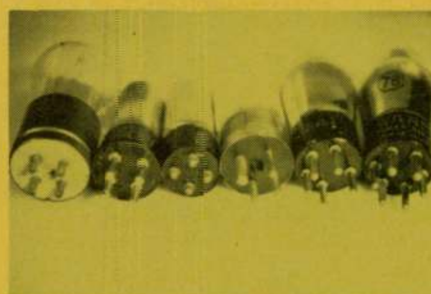

Fig. 14 Some basings used on historical tube types.

HISTORY OF THE VACUUM TUBE

(Continued from preceding page)

electrostatic shield was interposed between the plate and control grid. In turn, the plate-grid interelectrode capacitance was practically eliminated.

The UX-22 tetrode was a filament type tube, operated at 3.3 volts and 0.132 ampere. Thus, it was in the category of battery-type tubes. It was used as a high-gain detector, as well as an RF amplifier tube. The UX-22 had an amplification factor of 300 times, whereas the 201-A had an amplification factor of only 20 times. The next screen-grid tetrode to be developed was the type 24; seen in Fig. 7. This was a heater-cathode type of tube, operated on 2.5 volts AC with a current drain of 1.75 amperes. It employed a 5-pin base with a top cap. In a properly designed RF stage, a gain up to 100 times was obtainable.

Although the type 24 tetrode represented an important breakthrough in tube technology, it had a limitation to the amount of output signal voltage that could be handled. That is, electrons arriving at the plate "splashed out" secondary electrons from the plate. These secondary electrons returned to the plate, provided that the instantaneous plate voltage was greater than the screen-grid voltage. However, if the plate swung below the screen-grid voltage, the secondary electrons were captured by the screen grid, and lost to the plate circuit. In turn, the output signal voltage was limited by this operating condition. It was not practical to use a very low value of screen-grid voltage, because the average plate current was thereby reduced objectionably.

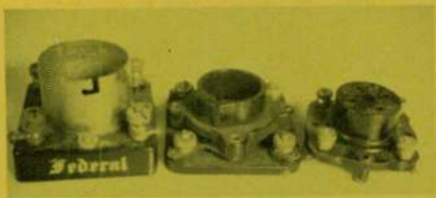

Fig. 15 Some antique tube sockets.

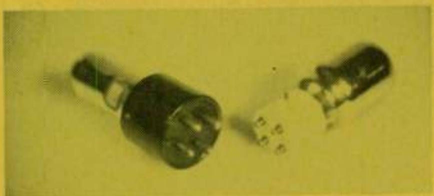

Fig. 16 Larger tube on smaller base, and smaller tube on larger base.

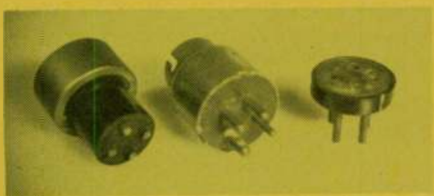

Fig. 17 Typical tube adapters.

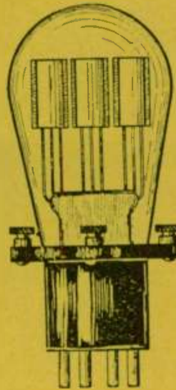

Fig. 19 An early triple triode.

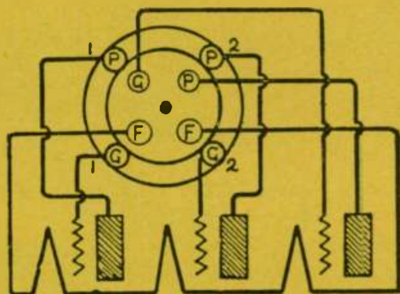

Fig. 20 Terminal arrangement of the triple triode.

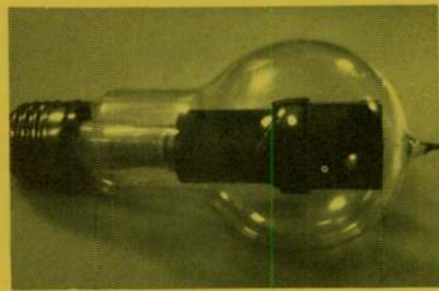

Fig. 22 The Amrad S tube was a cold-cathode gas diode.

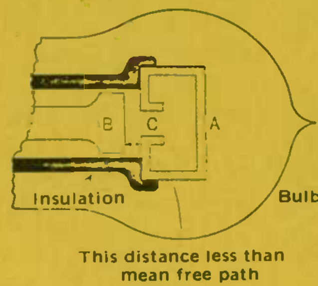

Fig. 23 Internal construction of the S tube.

Fig. 24 Another version of the S tube.

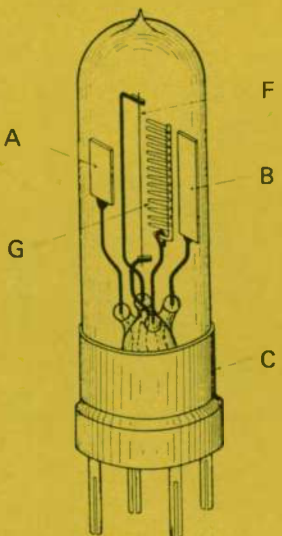

Fig. 18 Plan of the negatron tube.

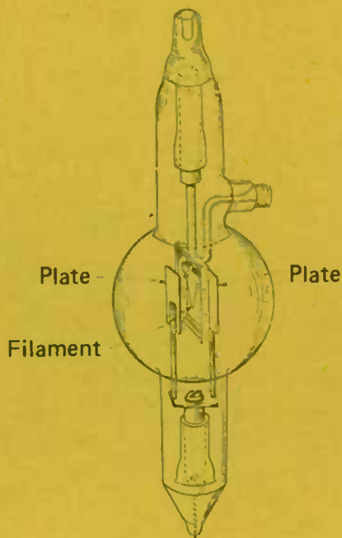

Fig. 21 A high-vacuum Kenotron rectifier diode.

Fig. 25 The full-wave cold-cathode BH rectifier tube.

The first improvement on the type 24 tube was made by treating the plate with substances that reduced secondary emission. This version of the tetrode was called the 24-A. It had the same supply-voltage and current requirements as the type 24. Because an output signal-voltage limitation was still present, however, tube engineers continued their efforts to find a completely satisfactory answer. This was a particularly important problem in high-power tetrode tubes, because limitation of available power output represents substantailly increased operating costs.

Early Pentode Tubes

With the development of the pentode tube depicted in Fig. 8, the limitation on signal-output voltage imposed by tetrode design was eliminated. A pentode tube employs an additional grid between the plate and screen grid to repel secondary electrons back to the plate regardless of the instantaneous plate potential. This additional element is called a suppressor grid. It is usually connected to the cathode (or filament) so that it is always negative with respect to the plate. Fig. 9 shows the appearance of an early pentode tube. This version illustrates the Loktal type of base.

Pentodes provided such high gain that extensive shielding was required to avoid feedback among receiver components. For example, the tube shown in Fig. 9 had a transconductance of more than 2,000 micromhos. Metal "cans" were commonly placed over tubes to provide external shielding. In another design, the glass envelope of the pentode was sprayed with a metallic paint, as illustrated in Fig. 10. This spray coating was grounded to the receiver chassis and provided external shielding for the tube.

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Another of the old-type designs employed a metal-type envelope, as seen in Fig. 11. Thus, the envelope served as an external shield for the tube. Fig. 12 shows the physical construction of a metal-type pentode. Pentodes were produced in sharp-cutoff and remote-cutoff types. As the name indicated, sharp-cutoff action caused the plate current to stop abruptly when the control grid was negatively biased to a certain critical point. On the other hand, remote-cutoff (variable-mu) action caused the plate current to cut off gradually as the control grid was biased more negatively. Fig. 13 depicts the control-grid designs for the two types of tubes. Although a variable-mu tube was a very poor detector, it was a superior amplifier in automatic volume-control circuits, because it minimized crosstalk at any value of control-grid bias.

Tube Bases and Adapters

Various tube basings were used for early tubes, as exemplified in Fig. 14. Some bases were large, and others were small. Some had short pins and others had long pins. Pin diameters and spacings also varied. In turn, different types of sockets were required for various tubes. Typical sockets are shown in Fig. 15. To convert a storage-battery receiver into a dry-cell receiver, it was not sufficient to change tubes and batteries. That is, dry-cell tubes in general would not fit into storage-battery tube sockets.

Conversion to another tube type originally entailed changing the tube sockets. However, the problem was then eased by alternate basings of tubes. For example, a large type tube might become available either with its original type of base. Similarly, a small type tube might become available either with its original type of base, or with a large type of base, as seen in Fig. 16. Various kinds of tube adapters were also developed, as shown in Fig. 17. Thus, a 199 could be used in a WD-11 socket, a WD-11 could be used in a UX-201A socket, a UV-201 could be used in a 199 socket, and so on. Table 1 lists some landmarks in tube history.

The Negatron Valve

Negative resistance can be obtained by special tube design, as well as by positive-feedback circuits. A British tetrode called the negatron was used in the 20's for this purpose. Fig. 18 shows the plan of a negatron. A is the anode, and B is the diversion anode; G is the grid, and F is the filament. Operating voltages are adjusted so that electrons emitted by the filament divide about equally between the anode and the diversion anode. This division is adjustable by the bias on the grid. Then, if the anode is made more positive, the anode current decreases. Or, if the anode is made less positive, the anode current increases. This is the definition of negative resistance.

Note in passing that conventional triodes and tetrodes also exhibit negative resistance when operated under suitable conditions. Secondary emission is exploited in this application. That is, the anode is operated at a lower positive potential than the adjacent grid. In turn, secondary electrons from the anode are collected by the grid. Each original or primary electron may dislodge 10 or 20 secondary electrons, depending on the operating voltages. Thus, when the anode is made more positive, less anode current flows. Conversely, when the anode is made less positive, more anode current flows. This is called the dynatron operating mode of a triode or tetrode.

Multiple Element Tubes

Various types of multiple element (multiple section) tubes have made an ephemeral appearance in the electronics field. An early triple-triode was designed as depicted in Fig. 19. A standard four-pin base was used, supplemented by a flange around the upper part of the base, with four binding posts. These binding posts were terminals for two of the grids and two of the plates, as shown in Fig. 20. This tube employed a common filament for all three triode sections. In Europe, additional terminals were provided for this type of tube by means of flat copper strips emerging from between the base and the glass envelope. Each strip was terminated with a binding post.

Early Rectifier Tubes

When the change was made from battery to house-current operation of receivers, various types of rectifier tubes were developed for use in power supplies. The first rectifiers were merely large versions of the Fleming valve, as depicted in Fig. 21. They were "hard" tubes; that is, they operated at a high vacuum. The General Electric Co. led in their manufacture, and termed the power rectifier tube a Kenotron. Although satisfactory for small-current demands, the large tube drop in a high-vacuum rectifier made it inefficient for high-current demands. Therefore, research was directed to development of rectifier tubes with low anode resistance.

Ionized gases were found to provide adequately low anode resistance, and several kinds of "soft" rectifier tubes were introduced. One of the first was the S tube, illustrated in Fig. 22. This was a half-wave rectifier evacuated to a specified critical pressure. Its internal construction is depicted in Fig. 23. Note that this is a cold-cathode type of tube. The anode A is a hollow cylinder with a hole C opposite cathode B, which is a flat disk. The spacing between A and B is so small that it is less than the mean free path of an electron. However, an electron starting from the center of B can shoot into the hollow enclosure A, and travels far enough to produce ionization.

When the S tube is ionized, conduction occurs. On the other hand, when it is not ionized, conduction does not occur. We observe from Fig. 23 that ionization can occur only when electrons travel from B into A. Therefore, the tube operates as a rectifier. The gas pressure is quite critical, and the tube usually ended its useful life when a drift in pressure eventually occurred. Another version of the S tube is illustrated in Fig. 24.

Full-wave cold-cathode rectifier tubes were also developed, as ex-emplified in Fig. 25. This was called the BH rectifier tube. Its design was basically the same as that of the S tube. However, two anodes were employed so that the ripple frequency was doubled. A higher ripple frequency facilitates filtering, since capacitive reactance decreases with an increase in frequency. Mercury-vapor rectifier tubes were also utilized to some extent in receivers, and were almost universally employed in transmitters. A mercury-vapor tube is essentially a diode into which a small amount of mercury has been introduced. In operation, the mercury is partially vaporized, so that a "soft" tube results which has a very low tube drop.

The New Direction

In this era, attention was turning to short-wave operation, and the high-frequency limitations of conventional tubes were becoming very prominent. The groundwork had been laid previously for development of the more sophisticated designs that were to come. Completely new concepts of electronic technology were imminent, and were to lead to modern high-frequency tubes such as the magnetron, klystron, and traveling-wave types.

The Nuclear Industry '71: Never a Dull Moment

By any index of progress it was a very good year. The peaceful atom rode the crest of a great paradox: heavy new commitments to atomic power and other uses of nuclear energy in the face of problems of public/political acceptance and economic uncertainty

No matter whether the U.S. electric power consumption nearly doubles every 10 years, as now seems likely, or expands at some lessor rate, it is evident that electric energy will increasingly be called upon to combat the growing environmental pollution affecting many areas of the country.

Special Report

With a bow to Charles Dickens, a sometimes dazzled, sometimes frazzled nuclear industry would agree that 1971 was the best of all times and the worst of all times. For the second year, at least, the peaceful atom rode the crest of a great paradox: heavy new commitments to atomic power and other uses of nuclear energy in the face of substantial problems of public (and political) acceptance and mounting economic uncertainties.

By any index of progress it was a very good year indeed: Cumulative orders for nuclear power capacity topped 100-million kilowatts; the over-all industry growth was pegged at 15 per cent, and some non-power sectors, notably radioisotope and nuclear instrument applications in medicine, continued at an even higher rate – 20-25 per cent; the on-line performance of the 22 operable nuclear power reactors was astonishingly good; the public and private sectors, with an assist from President Nixon, appeared close to agreement on the timing and financing of the first large-scale fast-breeder demonstration plant; and all across the land, people were discovering that a nuclear neighbor is much like any other industrial neighbor, only a lot cleaner and quieter.

As of December 22, the Atomic Industrial Forum counted 26 domestic nuclear power plant order for 1971. These represented a combined capacity of 26,000 megawatts electrical (Mwe), eclipsing the 1967 record. In all of 1970, according to the Forum, sales totaled 15 nuclear units in the continental U. S. and one in Puerto Rico, for a total capacity of 16,378 Mwe. In prior years, orders ran as follows: 1969 – seven units (7,200 Mwe); 1968 – 14 units (13,000 Mwe); 1967 – 30 units (25,000 Mwe); and 1966 – 24 units (19,500 Mwe).

A closer look at the nuclear power picture in 1971 brings out the paradoxical mixture of good news and bad. On the positive side can be counted the entry into the commercial nuclear power field of Gulf General Atomic, manufacturer of a reactor system that is altogether different from those sold by the four other U. S. vendors – the High Temperature Gas-cooled Reactor (HTGR). Gulf scored impressively, selling two 1,115-Mwe units to Philadelphia Electric and two 770-Mwe units to Delmarva Power & Light Co. (The latter order came too late to be included in the attached reactor listing.)

On the pessimistic side, the year saw several hard-pressed utilities unexpectedly turn to intermediate fossil-fired generators as their nuclear schedules were battered out of shape by siting and construction delays and new licensing requirements. One 1971 order – Florida Power & Light Co.'s Hutchinson Island No. 2 – was postponed indefinitely and several utilities were wavering on optional reactor commitments. Setbacks of this sort were still a rare exception and were offset to an extent by indications that a nuclear project shelved some years ago – N. Y. State Electric & Gas's Bell Station – may soon be resurrected in modified form. Increasingly, utilities in areas normally dominated by fossil fuels, especially the Southwest natural-gas country, veered toward nuclear power because of fuel shortages.

All told, the lead time for construction and licensing of large nuclear stations, once 4-6 years, is now closer to 8-9 years. It is not uncommon for just the construction-permit phase of the licensing cycle to take two years. So fierce have siting problems become for some utilities, that several have seized enthusiastically on an interesting new concept: huge barge-mounted nuclear reactors anchored several miles offshore in ocean waters. Both General Electric and Westinghouse are developing such systems, and a group of utilities, spearheaded by Public Service Electric & Gas Co. of New Jersey, may solicit formal proposals in 1972. A third manufacturer, Combustion Engineering, has announced plans for nuclear reactors built on artificial islands.

The New Environment

In a year of considerable turmoil for the atom, three developments stand out: the Atomic Energy Commission's proposed reduction of power-reactor radiation emissions to "as low as practicable" levels; the renewed debate over reactor safety, sparked by some inconclusive mockup tests of emergency core cooling system characteristics; and the landmark decision of the Circuit Court of Appeals for the District of Columbia, declaring that AEC had made a "mockery" of the National Environmental Policy Act (NEPA) of 1969.

The expected clampdown on routine reactor emissions – final numbers will be determined after public rule-making proceedings early in 1972 – will probably limit plants to about 10 per cent of the current permissible population exposure level of 170 millirem per year. This could impose costly retrofitting of equipment, although reactors already on line have, with very few exceptions, demonstrated that they can operate at even lower emission levels. AEC has no intention of scrapping fence-post release limits for individual nuclear plants. By specifying more stringent release limits, the Commission may help tone down the emotional debate over-low-level radiation effects.

The nuclear power controversy seems to abhor a vacuum, and as the low-level

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radiation issue fades, reactor safety has once more come to the fore. Concern in this area was heightened in 1971 by some much-publicized semi-scale tests at the AEC's National Reactor Testing Station in Idaho that tended to raise questions about the predicted behavior of reactor emergency core cooling systems. While some experts scoffed at the validity of the Idaho tests, the AEC immediately specified, as an interim measure, new maximum temperature and power-density levels and scheduled rule-making proceedings early in 1972 to settle on long-term emergency-cooling requrements.

On the three milestone events of 1971, by far the most stunning impact was made by the court decision in Calvert Cliffs Coordinating Committee v. AEC. The ruling held that AEC had taken too narrow an approach to its obligations under NEPA in not considering non-radiological environmental implications of nuclear installations. The Commission bowed to the Court decision and in September instituted a sweeping new environmental-impact review that directly affected 66 license applications involving 97 nuclear power reactors. In addition to these, the regulations applied to five power reactors that received their operating licenses after January 1, 1970 (the effective date of NEPA), 10 plants whose provisional operating licenses were issued before 1970, three reprocessing facilities and several material-license applications. First indications were that the new environmental-impact review, including a full-dress cost/benefit analysis for every nuclear facility, would bring the nuclear power program to a prolonged and costly halt. But toward year-end it appeared that the AEC would move very selectively in suspending those projects already under way (eight reactors held up out of 48 reviewed). Ironically, the Calvert Cliffs plant, near Baltimore, Md., which sparked the epic lawsuit, sailed through its initial review unscathed. For license applicants still on the threshold of a nuclear commitment, the new NEPA review may be more painful – possibly another 10 months tacked on to the licensing ordeal.

A Healthy Growth Rate – New Ventures

Against this rather somber backdrop, what happened to nuclear energy's competitive position in 1971? The cost of building nuclear plants, after eight years of almost unbroken escalation, appeared finally to have settled down at around $285 per kilowatt of installed capacity (thus, a million-kilowatt plant would cost $285-million). Foreseeable price increases in 1972, according to some industry economists, will revolve largely around additional equipment that might be required to satisfy new safety or thermal-effects criteria. The sums involved are not inconsequential – running, for example, up to $15-million for a natural-draft cooling tower – but environmental retrofitting is not unique to nuclear power plants.

Capital costs of fossil-burning generators have risen hand in hand with those of nuclear, but the conventional station maintains a $60-80 per kilowatt capital-cost advantage; the story is quite different, however, on the operating side of the ledger. There, nuclear fuel continues to show remarkable price stability – less than 20 cents/million Btu – while fuel costs for fossil-fired units have shot up to more than 50 cents/million Btu for low-sulfur coal and oil. The breakeven fuel cost between nuclear and coal now is around 26 cents/million Btu.

In a year of generally fitful economic expansion, most sectors of the nuclear industry chalked up enviable results in 1971. Although composite figures are tricky, it is estimated that U. S. utilities, as of mid-1971, had already spent $18-billion for nuclear power equipment and $3.5-billion for uranium fuel. Through 1980, the investment in nuclear power is expected to total $65-billion for plant and equipment and $17-billion for fuel lease. In 1971, after years of probing and negotiating, three fuel leases, for more than $80-million worth of material, were consummated and a half dozen others were being explored.

The huge projected sales of uranium have not yet begun to bring any feeling of joy or comfort to domestic uranium producers. The strongly competitive U.S. raw-materials industry expects several more lean years before the tide turns. Its problem is multi-fold: stretched out deliveries as plants run into delays; an AEC proposal to begin selling off the government's 50,000-ton stockpile, beginning in 1974; tightened federal mine radiation-control standards, whose implementation will entail hefty research and development expenditures; the pent-up competitive pressures of foreign uranium producers, who are still barred from selling their ore for use in American reactors, but who hope to beat down the embargo doors by the late 1970's: and, as always, the expense of exploration and development of new reserves.

The continued decline in exploratory drilling – estimates for 1971 are for 15-million feet, compared with the record 1969 level of 29.8-million feet – is causing real concern in the industry. One key factor appears to be price. Uranium concentrate in 1971 was selling well below the $8.00/pound level used to define the upper range of "low-cost uranium." The going price, not much more than $6.00/lb, was so low that it stifled exploration activity. The implication is ominous when looked at from the standpoint of domestic reserves. A recent AEC estimate is that, at $8.00/lb, the U. S. has known recoverable reserves of 246,000 tons of uranium, enough to meet anticipated demand for the next 10-11 years. At $6.00/lb, the reserve figure shrinks to only 150,000 tons. The true reserve picture is, of course, somewhat brighter; AEC estimates that potential additional reserves, recoverable at $8.00/lb, should total 490,000 tons, and if one were to pay as much as $15.00/lb, 900,000 tons more could be reclaimed. These added reserves would see the nation through several decades, even without help from the fast breeder.

As mentioned, 1971's big industrial news in commercial nuclear power was Gulf General Atomic's breakthrough sale of two large HTGRs. Gulf also moved to establish itself in other areas of the fuel cycle. It formed a joint venture with United Nuclear Corp. for the fabrication of Light Water Reactor fuel (Gulf already makes its own HTGR fuel); it linked up with Allied Chemical in construction and operation of a large fuel reprocessing facility in South Carolina; and it acquired substantial uranium-mining properties in New Mexico.

Fuel reprocessing is a rapidly expanding industry of its own. Currently limited to one privately owned plant (the Getty-Skelly Oil Subsidiary, Nuclear Fuel Services), capacity will be augmented in 1972 by a second supplier, General Electric's plant at Morris, Ill. Allied Gulf Nuclear's plant is expected on line in 1974, and Jersey Nuclear Co., an affiliate of Standard Oil of New Jersey, may announce building plans before long. On the debit side, a potential reprocessor, Atlantic Richfield, retrenched its nuclear activities, dropping plans for a reprocessing plant in South Carolina and selling most of its NUMEC fuels facility to Babcock & Wilcox.

The Breeder: More Than a Gleam

Surveying the Alphonse and Gaston

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type of jockeying among the diverse supporters of the fast-breeder reactor, particularly on financing, an elder statesman of the nuclear community commented last April: "As Billy Graham says, it's time to come up front now." Lead by President Nixon, that's precisely what the parties to this new venture did in 1971, although the parade never threatened to turn into a stampede. The Federal Government's kitty for the first large breeder demonstration plant, a roughly 300-Megawatt facility estimated to cost $500-million plus, was raised from $80-million to $130-million. More than 70 investor-owned utility companies have pledged close to $250-million; the publicly owned utilities are trying to line up $50-million more.

Choice of prime contractor for the initial project has been repeatedly delayed, but is now expected to be announced early in 1972. Atomics International (a division of North American Rockwell), General Electric and Westinghouse are the only contenders. The reactor will be operated at close to commercial conditions and will test out fuel reliability, sodium characteristics and – most important – the system's ability to breed more fuel than it consumes. Site and utility participation in the first plant have not yet been determined.

President Nixon has virtually committed the U. S. to having the first plant in operation by 1980. He has also signalled the start of a second demonstration breeder without so far specifying how it is to be financed. Introduction of a truly commercial breeder in this country is expected about 1986.

The prospects of generating electricity by even more exotic means than the breeder became much more realistic to utilities in 1971, as both the U. S. and Soviet Union edged toward the crucial proof that fusion energy can be controlled in a plasma long enough to generate heat, hence power. Significant was AEC's decision, late in 1971, to elevate controlled fusion work to full division status. Several utilities are now supporting private fusion research.

For '72, New Challenges and Hurdles

Not unexpectedly, the volatile nuclear controversy keeps shifting from the much-debated or demonstrably safe aspects of the technology to the more technical, forbidding areas of contention. In 1971, there was a perceptible shift from low-level radiation and routine reactor operation to the threat of major accidents and the ultimate disposal of radioactive wastes. Before long, as the nuclear power plants extend their exemplary safety record, the accident issue, too, may fade, and the debate over emergency core cooling may turn out to have been a tempest in an Idaho steam pot. But waste disposal, although technologically well under control, has become bogged down in prolonged evaluation of techniques.

The waste predicament is, essentially a government problem, since AEC policy specifies that all high-level industrial waste must eventually wind up in a federal repository. The physical quantities involved are not spectacular (about a cubic foot per year per 1,000-Mwe reactor, after solidification), but the precautions that must be taken with this residue, for thousands of years to come, are extraordinary. The AEC's preferred means of permanent storage is in deep salt beds. The problem is to find a site that combines physical security with political acceptability.

Hard decisions also face government and industry in areas less visible to the public: How long before expansion of the U. S. uranium-enrichment capacity becomes imperative? Who will step forward to build the new billion-dollar plants, and should they be based on the same technology as currently operating facilities (gaseous diffusion) or an alternate technique, much fancied by European scientists (ultracentrifugation)? Can the promising Plowshare program of using nuclear explosives to unlock inaccessible natural resources be unlimbered in time to help stave off a potential domestic energy crisis? And can industry and government arrive at an effective and compatible approach to safeguarding nuclear materials?

Where, then, does such a tumultuous year leave the nuclear industry? Perhaps it was summed up best by the new AEC chairman, James R. Schlesinger, who prefaced a stern lecture to the industry about its new responsibilities vis-a-vis a more neutral AEC with these words:

" . . . think for a moment about the truly remarkable achievements of the industry in a brief span of time. It is just 18 years since construction started at Shippingport (the first central station nuclear power plant). It is under 17 years since President Eisenhower's Atoms for Peace Message. It is but 15 years since the Commission inaugurated its Power Reactor Demonstration Program. It is but eight years since Oyster Creek (considered the first competitive power reactor). It is just five years since the first order was placed for a 1,000-Mwe power reactor. In a four-year period, 1963-67, capacity on order from the industry increased fifteen fold. These are spectacular developments. To draw an analogy, it is similar to the entire history of commercial aviation from Kitty Hawk to the Boeing 747 being compressed into less than a score of years. And in the commercial breeder and the fusion reactor we look forward to, as it were, the vertiable space age of nuclear energy."

This list includes only commercial nuclear generating units with capacities larger than 100 megawatts (100,000 kw) net. Thus a number of relatively small experimental or developmental plants are excluded. Also not shown is the large (776 Mwe net) N-Reactor at Hanford, Wash., originally built primarily for plutonium production but now operated as a dual-purpose plant supplying power to the Washington Public Power Supply System.

Reactors in operation or licensed by AEC to start up as of December 1971 are indicated in bold face type. The reactor types listed are: Pressurized Water Reactor – PWR; Boiling Water Reactor – BWR; High Temperature Gas-cooled Reactor – HTGR. The reactor manufacturers are: Babcock & Wilcox – B&W; Combustion Engineering – C-E; General Electric – GE; Gulf General Atomic – GGA; Westinghouse – W.

State and Location	Plant	Net Mwe	Type/Mfr.	Utility	Operable
Alabama					
Decatur	Browns Ferry 1	1,118	BWR/GE	Tennessee Valley Authority	1972
Decatur	Browns Ferry 2	1,118	BWR/GE	Tennessee Valley Authority	1972
Decatur	Browns Ferry 3	1,118	BWR/GE	Tennessee Valley Authority	1972
Houston County	Joseph M. Farley 1	829	PWR/W	Alabama Power Company	1975

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State and Location	Plant	Net Mwe	Type/Mfr.	Utility	Operable
Alabama *(Continued)*					
Houston County	Joseph M. Farley 2	829	PWR/W	Alabama Power Company	1977
Arkansas					
London	Arkansas Nuclear One	850	PWR/B&W	Arkansas Power and Light Company	1973
London	Arkansas Nuclear Two	950	PWR/C-E	Arkansas Power and Light Company	1975
California					
Humboldt Bay	**Humboldt Bay**	**68**	**BWR/GE**	**Pacific Gas and Electric Company**	**1963**
San Clemente	**San Onofre 1**	**429**	**PWR/W**	**Southern California Edison Co. & San Diego Gas and Electric Co.**	**1967**
San Clemente	San Onofre 2	1,100	PWR/C-E	Southern California Edison Co. & San Diego Gas and Electric Co.	1976
San Clemente	San Onofre 3	1,100	PWR/C-E	Southern California Edison Co. San Diego Gas and Electric Co.	1977
Diablo Canyon	Diablo Canyon 1	1,060	PWR/W	Pacific Gas and Electric Company	1973
Diablo Canyon	Diablo Canyon 2	1,156	PWR/W	Pacific Gas and Electric Company	1974
Clay Station	Rancho Seco	800	PWR/B&W	Sacramento Municipal Utility District	1973
Mendocino County	Mendocino 1	1,100	BWR/GE	Pacific Gas and Electric Company	1977
Mendocino County	Mendocino 2	1,100	BWR/GE	Pacific Gas and Electric Company	1979
Colorado					
Platteville	Fort St. Vrain	330	HTGR/GGA	Public Service Co. of Colorado	1972
Connecticut					
Haddam Neck	**Connecticut Yankee**	**562**	**PWR/W**	**Connecticut Yankee Atomic Power Co.**	**1967**
Waterford	**Millstone Point 1**	**650**	**BWR/GE**	**Northeast Utilities**	**1970**
Waterford	Millstone Point 2	830	PWR/C-E	Northeast Utilities	1974
Florida					
Turkey Point	Turkey Point 3	721	PWR/W	Florida Power and Light Company	1972
Turkey Point	Turkey Point 4	721	PWR/W	Florida Power and Light Company	1972
Red Level	Crystal River	850	PWR/B&W	Florida Power Corporation	1972
Ft. Pierce	Hutchinson Island 1	850	PWR/C-E	Florida Power and Light Company	1973
Ft. Pierce	Hutchinson Island 2	850	PWR/C-E	Florida Power and Light Company	indefinite
Georgia					
Baxley	Edwin I. Hatch 1	786	BWR/GE	Georgia Power Company	1973
Baxley	Edwin I. Hatch 2	817	BWR/GE	Georgia Power Company	1976
Hancock Landing	unnamed	1,100	PWR/W	Georgia Power Company	1978
Hancock Landing	unnamed	1,100	PWR/W	Georgia Power Company	1979
Illinois					
Morris	**Dresden 1**	**200**	**BWR/GE**	**Commonwealth Edison Company**	**1959**
Morris	**Dresden 2**	**809**	**BWR/GE**	**Commonwealth Edison Company**	**1970**
Morris	**Dresden 3**	**809**	**BWR/GE**	**Commonwealth Edison Company**	**1971**
Cordova	Quad Cities 1	809	BWR/GE	Commonwealth Edison Company & Iowa Illinois Gas and Electric Co.	1972
Cordova	Quad Cities 2	809	BWR/GE	Commonwealth Edison Company & Iowa Illinois Gas and Electric Co.	1972
Zion	Zion 1	1,100	PWR/W	Commonwealth Edison Company	1972
Zion	Zion 2	1,100	PWR/W	Commonwealth Edison Company	1973
Seneca	LaSalle 1	1,100	BWR/GE	Commonwealth Edison Company	1975
Seneca	LaSalle 2	1,100	BWR/GE	Commonwealth Edison Company	1976
not announced	unnamed	1,100	PWR/W	Commonwealth Edison Company	1978
not announced	unnamed	1,100	PWR/W	Commonwealth Edison Company	1979
Indiana					
Dunes Acres	Bailly	660	BWR/GE	Northern Indiana Public Service Co.	1976

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State and Location	Plant	Net Mwe	Type/Mfr.	Utility	Operable
(Continued)					
Iowa					
Cedar Rapids	Duane Arnold	550	BWR/GE	Iowa Electric Light and Power Co.	1973
Louisiana					
Taft	Waterford 3	1,165	PWR/C-E	Louisiana Power and Light Company	1977
Maine					
Wiscasset	Maine Yankee	823	PWR/C-E	Maine Yankee Atomic Power Co.	1972
Maryland					
Lusby	Calvert Cliffs 1	800	PWR/C-E	Baltimore Gas and Electric Company	1973
Lusby	Calvert Cliffs 2	800	PWR/C-E	Baltimore Gas and Electric Company	1974
Massachusetts					
Rowe	**Yankee**	**175**	**PWR/W**	**Yankee Atomic Electric Company**	**1960**
Plymouth	Pilgrim	687	BWR/GE	Boston Edison Company	1971
Michigan					
Big Rock Point	**Big Rock Point**	**72**	**BWR/GE**	**Consumers Power Company**	**1962**
South Haven	**Palisades**	**821**	**PWR/C-E**	**Consumers Power Company**	**1971**
Lagoona Beach	Enrico Fermi 2	1,127	BWR/GE	Detroit Edison Company	1974
Bridgman	Donald C. Cook 1	1,100	PWR/W	Indiana and Michigan Electric Co.	1972
Bridgman	Donald C. Cook 2	1,100	PWR/W	Indiana and Michigan Electric Co.	1973
Midland	Midland 1	527	PWR/B&W	Consumers Power Company	1976
Midland	Midland 2	855	PWR/B&W	Consumers Power Company	1977
Minnesota					
Monticello	**Monticello**	**545**	**BWR/GE**	**Northern States Power Company**	**1971**
Red Wing	Prairie Island 1	550	PWR/W	Northern States Power Company	1972
Red Wing	Prairie Island 2	550	PWR/W	Northern States Power Company	1974
Nebraska					
Fort Calhoun	Fort Calhoun	475	PWR/C-E	Omaha Public Power District	1972
Brownville	Cooper	800	BWR/GE	Consumers Public Power District	1972
New Jersey					
Toms River	**Oyster Creek**	**640**	**BWR/GE**	**Jersey Central Power and Light Co.**	**1969**
Lacey Township	Forked River	1,100	PWR/C-E	Jersey Central Power and Light Co.	1977
Salem	Salem 1	1,090	PWR/W	Public Service Electric and Gas Co. (Philadelphia Electric Co., Delmarva Power and Light Co., Atlantic City Electric Company)	1973
Salem	Salem 2	1,112	PWR/W	Public Service Electric and Gas Co. (Delaware Valley Group)	1974
Newbold Island	Unit 1	1,115	BWR/GE	Public Service Electric and Gas Co.	1975
Newbold Island	Unit 2	1,115	BWR/GE	Public Service Electric and Gas Co.	1977
New York					
Buchanan	**Indian Point 1**	**270**	**PWR/B&W**	**Consolidated Edison Co. of N.Y., Inc.**	**1962**
Buchanan	Indian Point 2	1,033	PWR/W	Consolidated Edison Co. of N.Y., Inc.	1972
Buchanan	Indian Point 3	1,033	PWR/W	Consolidated Edison Co. of N.Y., Inc.	1973
Oswego	**Nine Mile Point 1**	**600**	**BWR/GE**	**Niagara Mohawk Power Corporation**	**1969**
Oswego	Nine Mile Point 2	1,100	BWR/GE	Niagara Mohawk Power Corporation	1977
Rochester	**Robert E. Ginna**	**470**	**PWR/W**	**Rochester Gas and Electric Corporation**	**1969**
Shoreham	Shoreham	820	BWR/GE	Long Island Lighting Company	1975
Lansing	Bell	800	BWR/GE	New York State Electric and Gas Co.	1978
Scriba	James A. Fitzpatrick	825	BWR/GE	New York State Power Authority & Niagara Mohawk Power Corporation	1973

(Continued on next page)

State and Location	Plant	Net Mwe	Type/Mfr.	Utility	Operable
(Continued)					
North Carolina					
Southport	Brunswick 1	821	BWR/GE	Carolina Power and Light Company	1975
Southport	Brunswick 2	821	BWR/GE	Carolina Power and Light Company	1976
Bonsal	Shearon Harris 1	915	PWR/W	Carolina Power and Light Company	1977
Bonsal	Shearon Harris 2	915	PWR/W	Carolina Power and Light Company	1978
Bonsal	Shearon Harris 3	915	PWR/W	Carolina Power and Light Company	1979
Bonsal	Shearon Harris 4	915	PWR/W	Carolina Power and Light Company	1980
Cowans Ford Dam	William McGuire 1	1,150	PWR/W	Duke Power Company	1976
Cowans Ford Dam	William McGuire 2	1,150	PWR/W	Duke Power Company	1977
Ohio					
Oak Harbor	Davis-Besse	872	PWR/B&W	Toledo Edison Company & Cleveland Electric Illuminating Company	1974
Moscow	William H. Zimmer	840	BWR/GE	Cincinnati Gas and Electric Company	1975
Oregon					
Rainier	Trojan	1,106	PWR/W	Portland General Electric Company	1974
Pennsylvania					
Shippingport	Beaver Valley 1	847	PWR/W	Duquesne Light Company & Ohio Edison Company	1973
Shippingport	Beaver Valley 2	847	PWR/W	Duquesne Light Company & Ohio Edison Company	1977
Peach Bottom	Peach Bottom 2	1,065	BWR/GE	Philadelphia Electric Company (Public Service Electric and Gas Co., Delmarva Power and Light Company, Atlantic City Electric Company)	1973
Peach Bottom	Peach Bottom 3	1,065	BWR/GE	Philadelphia Electric Company (Delaware Valley Group)	1974
Goldsborough	Three Mile Island 1	830	PWR/B&W	Metropolitan Edison Company	1972
Goldsborough	Three Mile Island 2	900	PWR/B&W	Metropolitan Edison Company & Jersey Central Power and Light Co.	1973
Limerick Township	Unit 1	1,100	BWR/GE	Philadelphia Electric Company	1975
Limerick Township	Unit 2	1,100	BWR/GE	Philadelphia Electric Company	1977
not announced	unnamed	1,160	HTGR/GGA	Philadelphia Electric Company	1979
not announced	unnamed	1,160	HTGR/GGA	Philadelphia Electric Company	1981
not announced	Susquehana 1	1,100	BWR/GE	Pennsylvania Power and Light Co.	1977
not announced	Susquehana 2	1,100	BWR/GE	Pennsylvania Power and Light Co.	1978
Rhode Island					
Rome Point	Rome Point 1	900	PWR/W	New England Electric System	1979
Rome Point	Rome Point 2	900	PWR/W	New England Electric System	1981
South Carolina					
Hartsville	**H.B. Robinson 2**	**700**	**PWR/W**	**Carolina Power and Light Company**	**1970**
Lake Keowee	Oconee 1	874	PWR/B&W	Duke Power Company	1972
Lake Keowee	Oconee 2	874	PWR/B&W	Duke Power Company	1972
Lake Keowee	Oconee 3	874	PWR/B&W	Duke Power Company	1973
Parr	Virgil C. Summer	915	PWR/W	South Carolina Electric & Gas Co.	1977
Tennessee					
Daisy	Sequoyah 1	1,175	PWR/W	Tennessee Valley Authority	1973
Daisy	Sequoyah 2	1,175	PWR/W	Tennessee Valley Authority	1974
Rhea County	Watts Bear Dam 1	1,150	PWR/W	Tennessee Valley Authority	1976
Rhea County	Watts Bear Dam 2	1,150	PWR/W	Tennessee Valley Authority	1977
Vermont					
Vernon	Vermont Yankee	540	BWR/GE	Vermont Yankee Nuclear Power Corp.	1972

(Continued on next page)

State and Location	Plant	Net Mwe	Type/Mfr.	Utility	Operable
(Continued)					
Virginia					
Gravel Neck	Surry 1	800	PWR/W	Virginia Electric and Power Company	1972
Gravel Neck	Surry 2	800	PWR/W	Virginia Electric and Power Company	1972
Mineral	North Anna 1	927	PWR/W	Virginia Electric and Power Company	1974
Mineral	North Anna 2	927	PWR/W	Virginia Electric and Power Company	1976
Mineral	North Anna 3	940	PWR/W	Virginia Electric and Power Company	1977
Mineral	North Anna 4	940	PWR/W	Virginia Electric and Power Company	1978
Washington					
Richland	Hanford 2	1,103	BWR/GE	Washington Public Power Supply System	1977
Wisconsin					
Two Creeks	**Point Beach 1**	**497**	**PWR/W**	**Wisconsin Michigan Power Company**	**1970**
Two Creeks	Point Beach 2	497	PWR/W	Wisconsin Michigan Power Company	1972
Carlton	Kewaunee	550	PWR/W	Wisconsin Public Service Company (Wisconsin Power and Light Company, Madison Gas and Electric Company)	1972
Puerto Rico					
Central Aguirre	Aguirre	583	PWR/W	Puerto Rico Water Resources Authority	1976
Site Not Selected					
	Unit 1	1,230	PWR/B&W	Tennessee Valley Authority	1977
	Unit 2	1,230	PWR/B&W	Tennessee Valley Authority	1978
	Unit 1	1,200	BWR/GE	Middle South Utilities	1980
	Unit 2	1,200	BWR/GE	Middle South Utilities	1981

Electronics Jr. T.M.

General-Purpose Audio Amplifier

The three-transistor circuit which makes up the general-purpose amplifier can be used in a variety of ways by the student, hobbyist or experimenter

Special Science Project

The three-transistor circuit which makes up the general-purpose amplifier can be used in a variety of ways by the experimenter. It will boost weak audio currents from a microphone until they are strong enough to drive the self-contained loudspeaker. The output of a crystal cartridge is another signal source which may be used to produce audible signals. The amplifier also has application as a signal-tracing test instrument. If you want to check an audio signal at some point in another transistorized project, the signal can be introduced to the amplifier's input terminals and heard in the loudspeaker.

Output power is just a fraction of a watt, but adequate for experimental purposes. At full volume, the speaker can generate enough sound to make extremely low level input signals plainly audible.

Circuit Operation

The schematic diagram of the over-all amplifier in Fig. 5-1 appears more complicated than it actually is – close examination will reveal that the three transistors are wired quite similarly. The hookup forms what is commonly known as a cascade circuit. The signal is applied to the input terminals and is successively built up as it passes from one transistor to the next.

Notice that all the circuitry lies between the two long horizontal lines representing the positive and negative leads from the battery. The lower, or positive leg, contains a switch to afford a convenient means for controlling the power supply (B1). The base of each transistor connects to the negative leg, through a resistor, for operating bias. These are R1, R3 and R6. Other resistors, namely R2 and R5, comprise the loads for the collectors of the first two transistors. However, the load for the final output stage is the primary winding of T1. It transfers energy to the speaker winding.

Tracing of the signal pathway commences at the left side of the schematic

(Continued on next page)

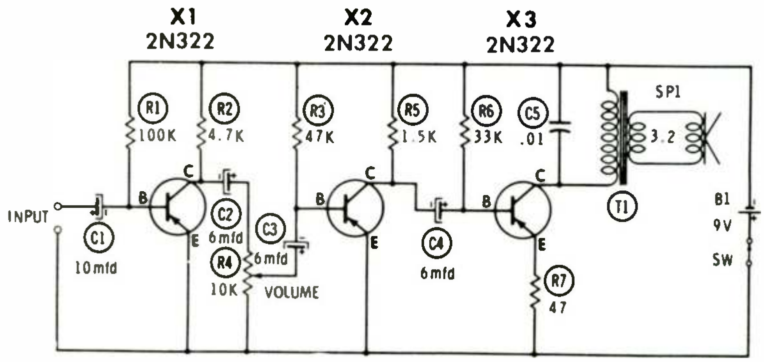


Fig. 5-1. General-purpose audio-amplifier circuit.

PARTS LIST

- R1 – 100K ½-watt resistor (962 B 1800 $ .12)
- R2 – 4.7K ½-watt resistor (962 B 1800 $ .12)
- R3 – 47K ½-watt resistor (962 B 1800 $ .12)
- R4 – 10K carbon potentiometer (271-1443 $ .99)
- R5 – 1.5K ½-watt resistor (962 B 1800 $ .12)
- R6 – 33K ½-watt resistor (962 B 1800 $ .12)
- R7 – 47-ohm ½-watt resistor (962 B 1800 $ .12)
- C1 – 10-mfd 15-volt electrolytic capacitor (272-1002 $ .35)
- C2, C3, C4 – 6-mfd 15-volt electrolytic capacitor (272-1001 $ .35)
- C5 – .01 mfd disc capacitor (926-4517 $ .18)
- X1, X2, X3 – 2N322 ($ .64 ea.)
- T1 – Audio output transformer, 1K primary, 4, 8, 16-ohm secondary (705-0521 $6.92) transistor type.
- SW – SPST toggle switch (275-602 $ .39)
- B1 – 9-volt transistor battery (23-464 $ .35)
- SP – Speaker, 3½-Inch PM-type, 3.2-ohm (40-1202 $2.39)
- Misc. – Plastic instrument cabinet, 6 13/16" x 5 9/32" x 2 15/16" (769-1508 $ .89); binding posts (270-1542 $ .99); push-in-terminals (270-325 .69/pkg. of 5); knob (904-0926 $ .76); battery clips (270-325 .69/pkg. of 5); perforated board.

Prices subject to change.

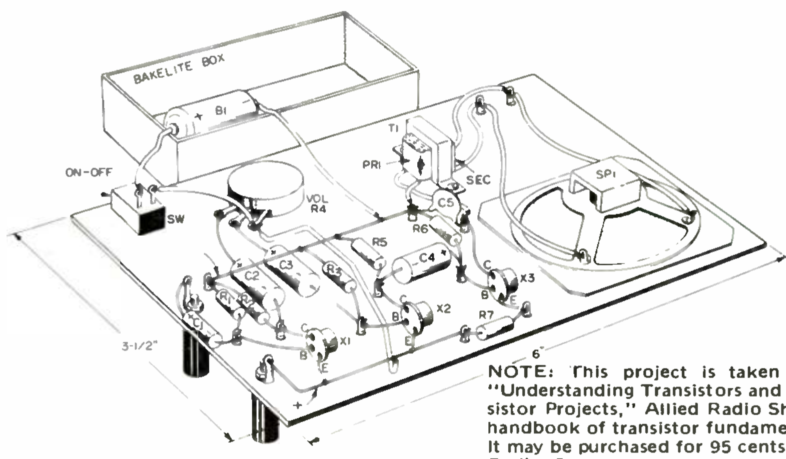


Fig. 5-2. Pictorial of general-purpose amplifier.

NOTE: This project is taken from "Understanding Transistors and Transistor Projects," Allied Radio Shack's handbook of transistor fundamentals. It may be purchased for 95 cents from Radio Shack Stores throughout the U. S. and Canada.

General-Purpose Amplifier

(Continued from preceding page)

at the input terminals. We'll assume that a microphone has been connected to this point and is introducing an AC signal to the base of X1. Capacitor C1 blocks bias arriving through R1, but allows the microphone signal to pass unimpeded. In conventional fashion, the signal adds to or subtracts from the bias, and a corresponding, but larger, current change appears at the collector. The function of load resistor R2 is to cause the amplified energy to appear at the collector terminal. Note that if the load were removed, and a direct connection made from collector to the negative battery terminal, the signal would be lost to the power supply. However, the 4.7K resistor (R2) makes the signal available to C2, a coupling capacitor which transfers the signal to the volume control. C2 provides the same blocking action to DC as did C1. Thus, the negative supply voltage to the collector of X1 is prevented from reaching the next circuit point.

Volume control R4 enables amplifier gain to be varied. Signal energy distributes itself along the resistance element and drops to zero at the lower end of the control. The slider selects the desired level and couples it through capacitor C3 to the base of the second transistor, where additional amplification takes place. The final, or output amplifier, feeds transformer T1. The primary winding presents a load of approximately 1,000 ohms, and permits maximum energy to be transferred by the transistor. As the signal passes through T1, an impedance transformation occurs – from 1,000 ohms down to approximately 3.2 ohms, the load imposed by the speaker. Thus, the function of T1 is that of an impedance-matching device. The speaker voice coil, with an impedance of 3.2 ohms, would receive little power from the transistor if connected directly into the higher-impedance collector circuit.

Construction

The pictorial in Fig. 5-2 shows the layout and wiring for a general-purpose amplifier. The Parts List contains all the parts needed. Most components are mounted on one side of a piece of perforated phenolic board. If the board is cut to the dimensions shown, it will fit into a standard bakelite instrument cabinet. Tapped holes in the corners of the cabinet permit the board to be fastened in place by 6-32 x ¼" machine screws.

Begin assembly by mounting the larger components first. The speaker is held to the underside of the board by two machine screws and nuts. Holes already perforated in the board enable sound to reach the outside. If a solid material, such as hardboard, is chosen for the chassis, be sure to provide these holes before the speaker is finally mounted. Next, the other large components – switch, potentiometer, transformer, and binding posts – are attached. This leaves a small area at the lower left for resistors, capacitors, and transistors. The layout of these parts generally follows that of the schematic. There are two lengths of bare wire which serve as the positive and negative legs from the battery. These may be installed by anchoring their ends to clips or other supports which are pushed into perforations in the board.

With this basic framework completed, the small parts are installed, starting from the left side, as the input terminals. Additional clips are added where necessary to provide tie-points for component leads. Each transistor is mounted with three clips for attaching emitter, base, and collector wires. As assembly progresses, be sure to observe the proper lead connections, especially for the transistors and electrolytic capacitors. The electrolytics are often marked for polarity, with a "+" at one end. If this sign is missing, the side of the capacitor with a small indentation is considered positive. Alternatively, the plus side may have a red marker.

The proper connections for the transformer are given in the instructions which accompany the component. The primary winding, or 1,000-ohm side, must connect between the transistor collector and negative battery lead. (The two leads can be connected in either direction.) Secondary, or 3.2-ohm connections, may similarly be reversed, as long as they terminate at the speaker lugs. (In obtaining a speaker, you are apt to encounter units which have a voice coil rated at 10 or 11 ohms. No great loss in volume will occur if such units are used with 3.2-ohm transformer winding.)

The final step in construction is mounting the battery. It is the only part which is fastened inside the cabinet. Run 6-inch lengths of hookup wire from the battery clips to the rest of the circuit so the board can be lifted out of the cabinet without removing the battery. A small metal tab cut from a piece of scrap metal is used to hold the battery firmly in place. Drill two holes in the ends of the strap and through the bakelite cabinet for attaching screws and nuts.

Testing

After all wiring has been checked for errors, the amplifier is ready for trial. First, the over-all current consumption can be measured. Set up your VOM to read approximately 10 milliamperes DC, and connect the probes across the power switch; the positive probe must go to the switch lug which connects to the positive battery terminal. The other meter lead goes to the remaining switch terminal. Be certain that the power switch is in the off position, since the meter completes the circuit and allows the circuit to draw current. If the amplifier is working properly, the meter will indicate somewhere in the vicinity of 9 milliamperes. This represents the total current utilized by the transistors. Mark down the figure you measure for reference. If, at a future date, you suspect the amplifier is not functioning properly, recheck current consumption to see if it is still close to the original value. Several months of operation may cause the battery to weaken, indicated by a lowering of current measured at the switch terminals. Now the meter leads are removed and the power switch turned on for further tests.

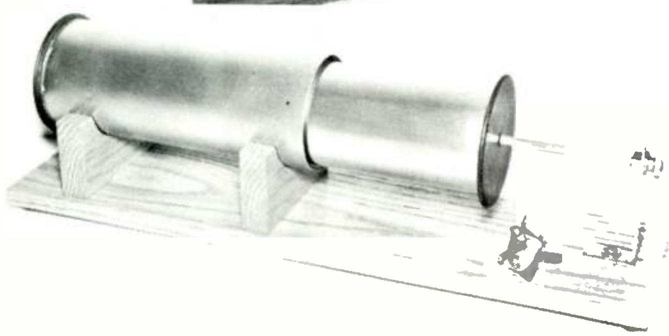
A significant test can be conducted by providing an input signal and noting the AC signal level at the output of each transistor. As mentioned earlier, various inputs are possible – microphones, crystal cartridges of the phono type, or the output of a radio tuner. If none of these is immediately available, hook the leads of an earphone to the input and speak into it. Adjust the VOM to read approximately 2.5 volts AC, and attach either probe to the positive leg from the battery. Clip the other probe to a .1-mfd capacitor, which serves to block the flow of DC to the meter as the tests are being performed. The free end of the capacitor will serve as a probe which can be shifted from one circuit point to the next. While you speak loudly into the earphone, touch the probe to the collector lead of the first transistor, X1. The AC signal at this point has undergone only one stage of amplification, but there should be enough energy to give some indication on the meter. With a full-scale setting of about 2.5 volts AC, the meter needle should kick slightly in step with your voice.

Now move the probe to the second collector and note the increase in signal energy. Here, the needle moves much further up the scale. Measuring at the last collector terminal, X3, shows the greatest gain. In some cases, the meter may have to be set to its next higher scale to avoid pinning the needle.

Old-Time Sliding Metal Tube Variable Condenser

These sliding tube variable condensers were used by wireless experimenters in receivers and transmitters in 1912, and earlier. Make this replica for your home or school museum

By Art Trauffer



Photos by Art Trauffer

Fig. 1 This view shows the size of the 1912 Sliding Metal Tube Variable Condenser compared with a Variable Capacitor of about the same capacity made in the 1970's!

The old-time projects in back issues of *Electronics Digest* took us pretty far into the history of radio, but here is a project that takes us to 1912, or earlier. In the early days of radio (or "wireless" as it was called then) many of the devices were large and crude compared with today's standards: the sliding metal tube variable condenser shown in Figure 1 is a good example. Note the size of the 1912 variable condenser compared with a variable capacitor of the 1970's of comparable capacity. The 1912 condenser is 16½" long overall.

Now make a replica for your home or school museum to see the astonished expressions when you tell people it is a variable condenser, and that you can use it to tune in local broadcasting stations!

Construction Details

Most of the details are shown in the illustrations, so little need be said here. The main problem is finding a pair of suitable metal tubes, because most of the measurements given in the illustrations will depend on the sizes of the tubes you use. Since it isn't easy to find suitable metal tubing around 3" in diameter, you may either have to use tin cans, as the writer did, or have a sheet metal shop roll you a pair of tubes from lightweight tin, aluminum, copper, or brass. If you have a pair of tubes made in a shop, remember that the smaller tube must telescope within the larger tube as closely as possible in order to get the required capacity for your condenser. Using two tin cans, the writer aimed for a maximum capacity of about 365 pf.

If you use a pair of pressure spray cans, as the writer did, be sure that all the pressure is out of the cans before you saw off the ends of the cans. Scrape the enamel off the outsides of the cans using a sharp knife blade, then use sandpaper or a kitchen cleanser powder to give you a smooth satin finish.

Figures 2, 3 and 4, show how the condenser is put together. Note in Figure 2 that the sliding metal sleeve is soldered into a hole in the exact center of the bottom of the smaller tin can. If you have a metal tube rolled in a tin shop you will have to solder a metal disc over one end of the tube for this sleeve.

The diameters of the insulated end discs for the metal tubes will depend on the diameters of the tubes. The writer jigsawed these end discs from 3/16"

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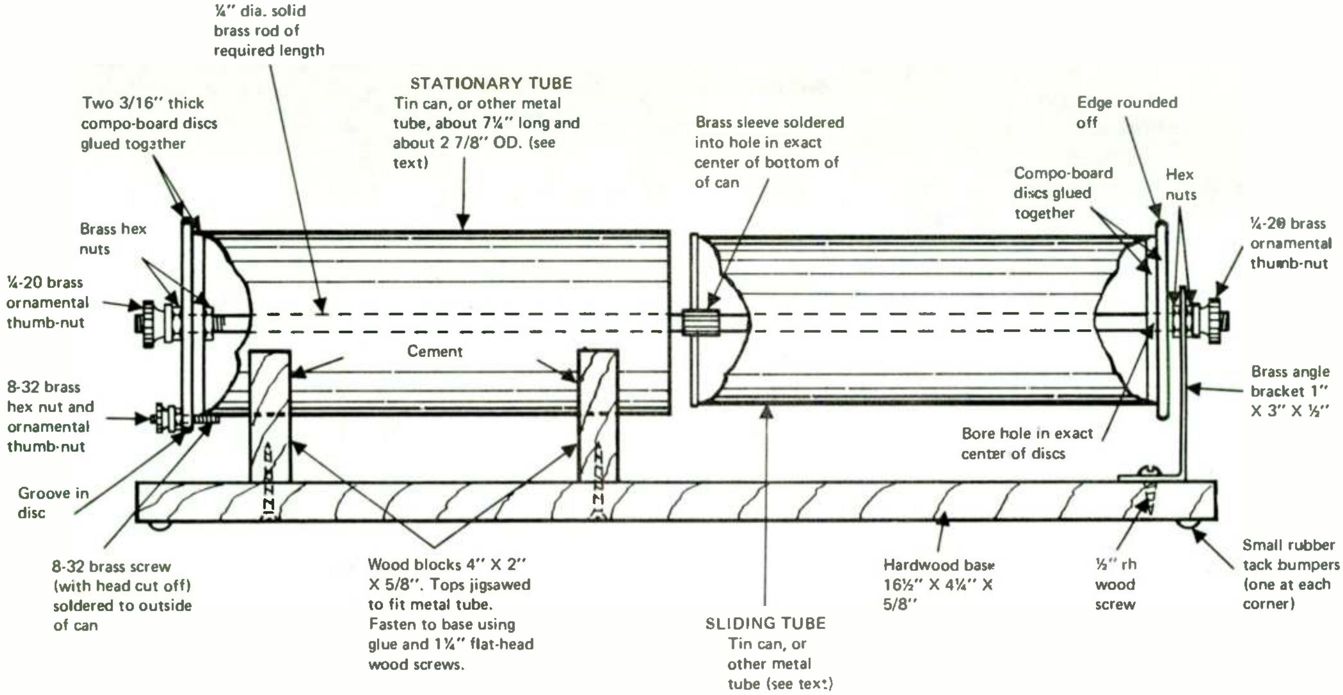

Fig. 2 Details for Sliding Tube Variable Condenser

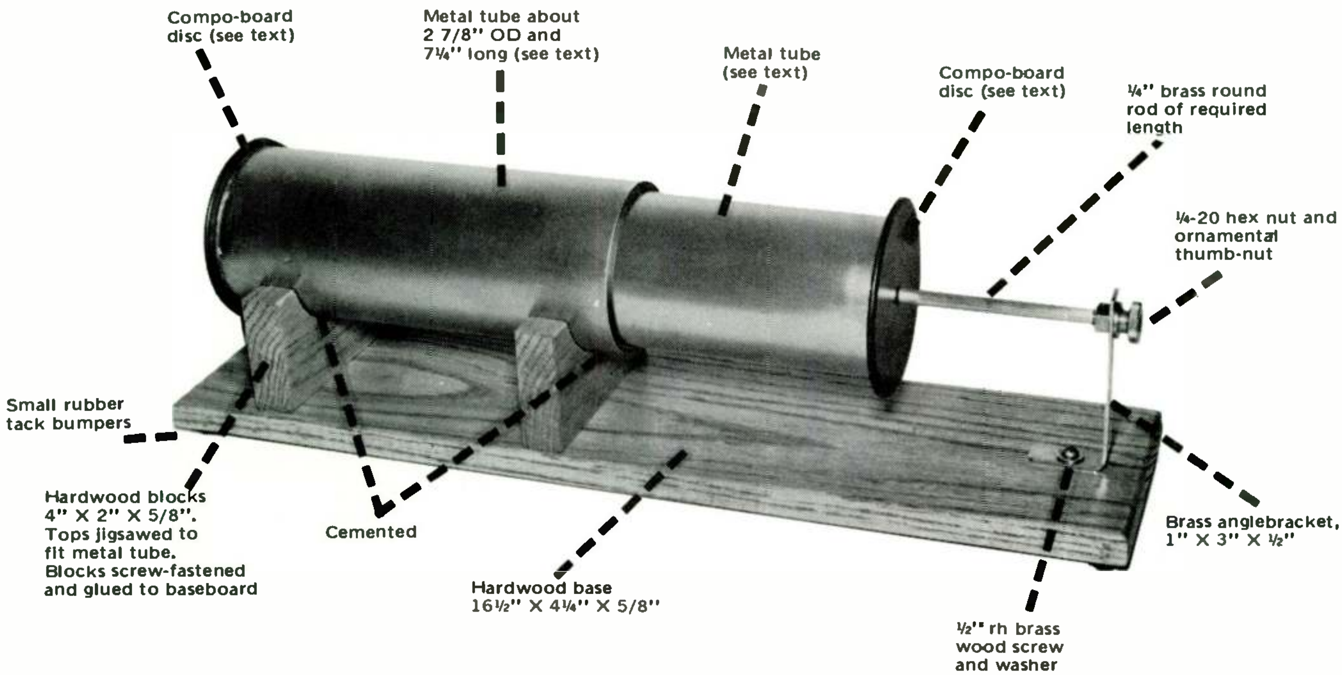

Fig. 3 The completed Sliding Metal Tube Variable Condenser (The two rear binding posts not shown in this view)

(Continued on next page)

Old-Time Radio

(Continued from page 32)

compo-board, rounded off the edges of the outside discs with sandpaper, and painted the outside discs with flat black paint to make them look like the hard rubber used in the old days.

Old-Time Wireless Receiver

Now, if you would like to rig up an "old-time wireless receiver" to demonstrate how the sliding tube condenser can be used to pick up local broadcasting stations, proceed as suggested in the completed project illustrated on page 32. The simple schematic diagram is shown in Figure 5. You can wind the simple tapped coil yourself, as shown, and the galena-and-catwhisker detector can be designed yourself; or follow plans published in past issues of *Electronics Digest.* Use an antenna about 50' long, a cold water pipe ground, and a sensitive pair of high-impedance magnetic earphones. Crystal earphones can also be used as they are high-impedance.

Note the old-time metal post-type binding posts in the completed project illustrated on page 32 used to receive the tips of the earphone cord. If you cannot find any of these, have some fun making them on a small metal-working lathe, or use the brass ornamental thumbnuts as used on the variable condenser.

The writer used old-fashioned lampcord for wiring up the crystal receiver to give it an old-time look.

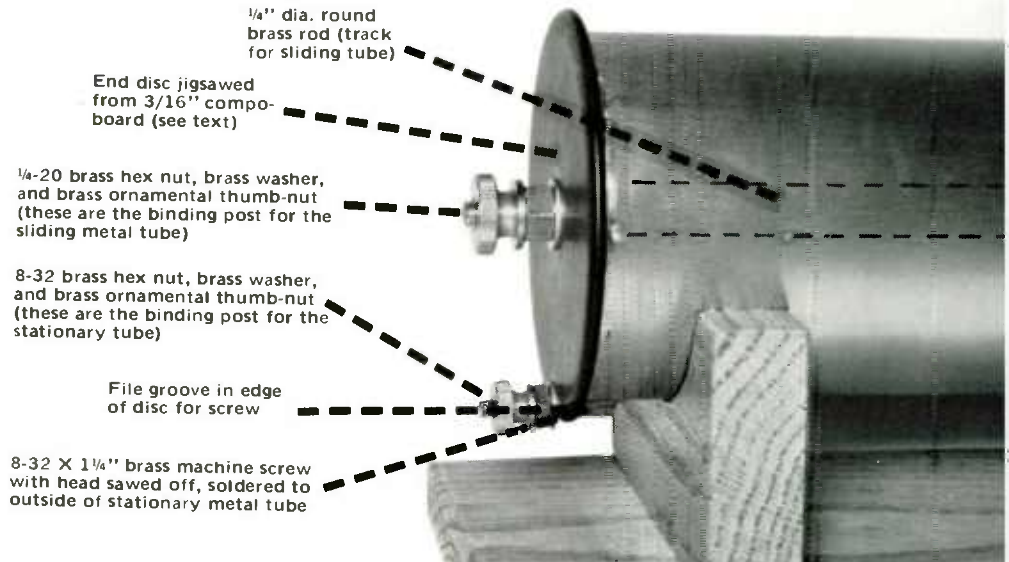

Fig. 4 Rear end details for Sliding Metal Tube Variable Condenser showing the two binding posts.

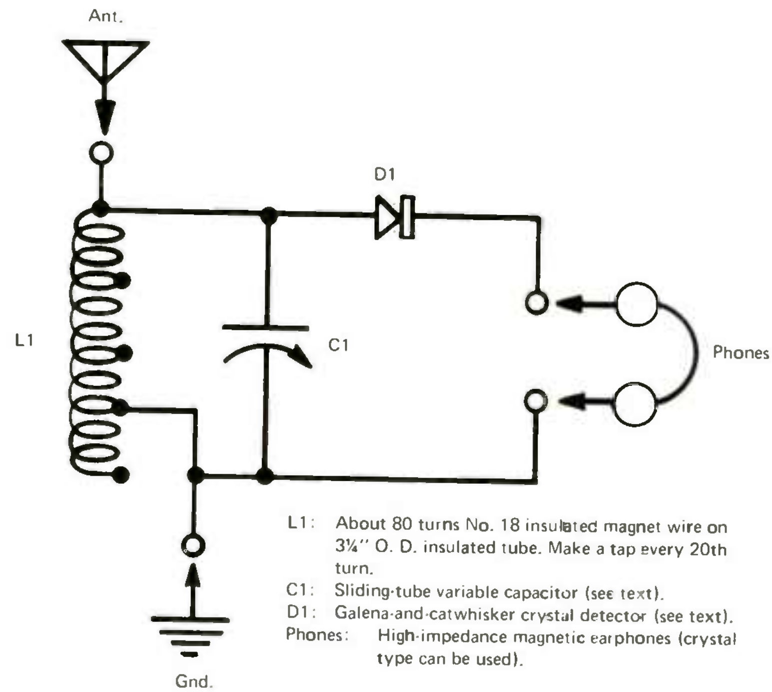

Fig. 5 Schematic Diagram

PARTS LIST

1 metal tube about 2 7/8" OD and about 7¼" long (see text).
1 metal tube slightly smaller in diameter, same length (see text).
One 18" length ¼" dia. round brass rod, cut to required length.
Four ¼-20 brass hex nuts.
Two ¼-20 brass ornamental thumb-nuts.
Two brass washers for above.
Short length brass tube to slide over ¼" dia. rod (slider for sliding tube).
One 8-32 x 1¼" brass machine screw (makes binding post for stationary tube).
One 8-32 brass hex nut.
One 8-32 brass ornamental thumb-nut.
One brass washer for above.
One 1" x 3" x ½" brass angle bracket (holds one end of slide rod).
One ¼" long rh wood screw (for above angle bracket).
Piece 3/16" compo-board (for jigsawing discs).
Two 4" x 2" x 5/8" hardwood blocks (for holding stationary tube to base).
two 1¼" flat-head wood screws (for above wood blocks).
One piece hardwood about 16½" x 4¼" x 5/8" (baseboard).
Four small rubber tack-bumpers (for bottom of baseboard).

OPTIONAL
Insulated tube about 3¼" OD and about 5" long (for coil form).
½ pound No. 18 insulated copper wire (enamelled or cotton-covered).
Two ½" x ½" x ½" angle brackets (hold coil form to baseboard).
One crystal detector stand (see past issue of ELECTRONICS DIGEST for making one).
1 piece galena crystal (mounted or unmounted).
Two binding posts for earphones (see text).
Few feet hook-up wire (see text).
One hardwood baseboard about 16½" x 9" x 5/8".

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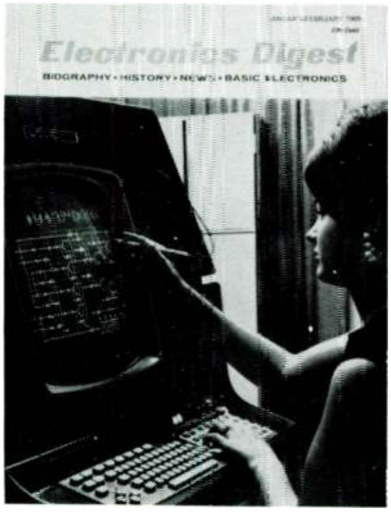

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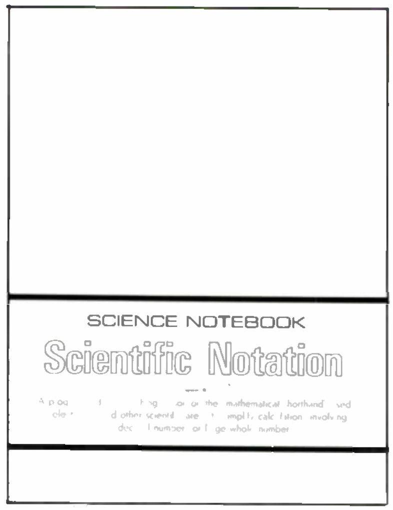

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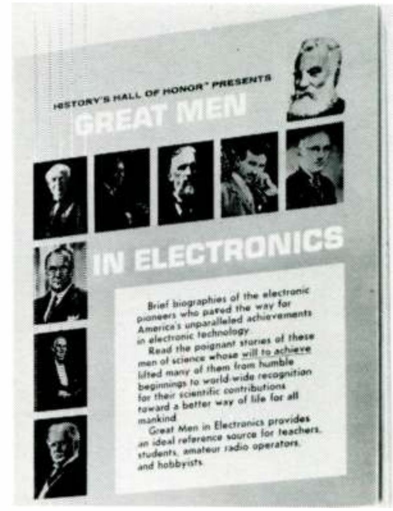

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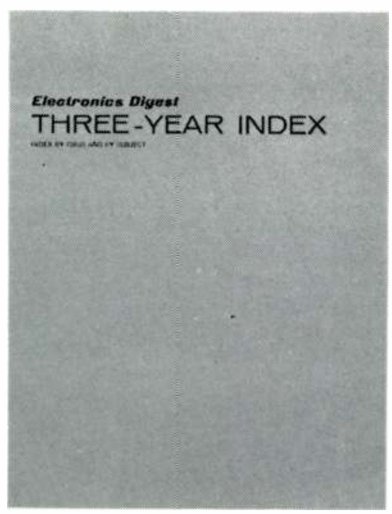

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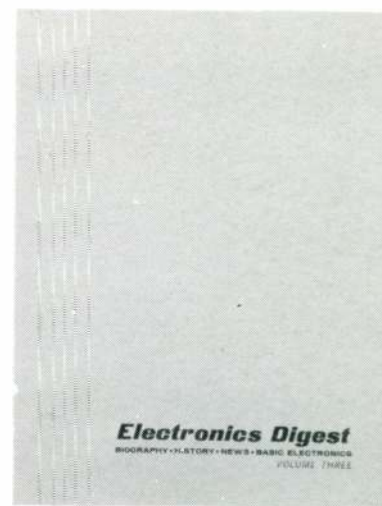

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