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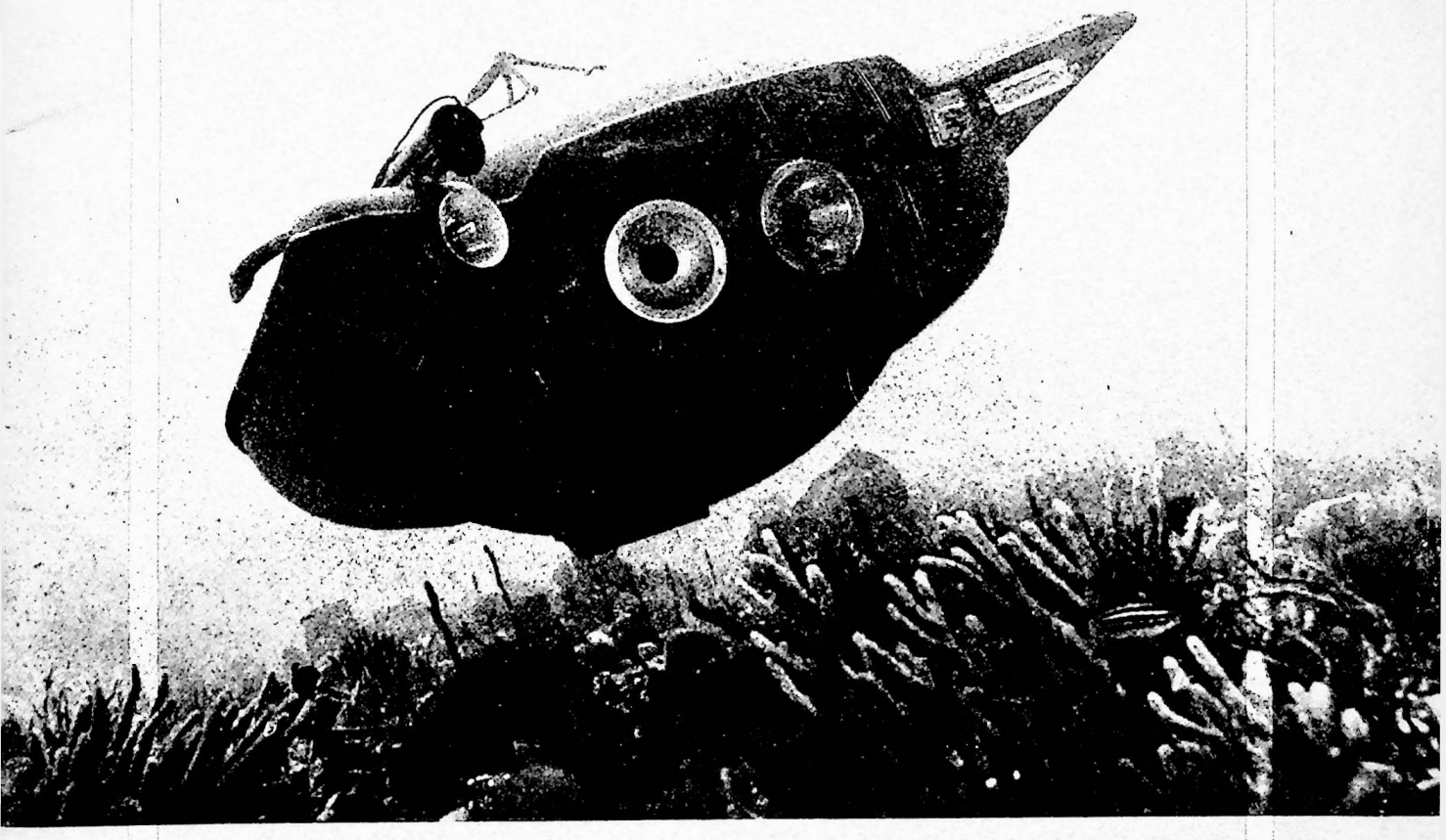

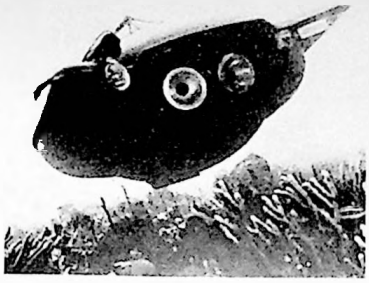

COVER STORY

Prowling through an undersea wilderness, and having all the appearances of a science fiction space ship, the Diving Saucer continues to demonstrate its unusual capability in deep-sea research.

The submersible was conceived by the world famous underseas explorer Jacques Yves Cousteau, and was developed by his research organization, the French Office for Undersea Research.

The Westinghouse Deepstar-4000 in America is in part based on that of the Diving Saucer which has been operational since 1959 and has made over 425 dives.

The nine-ton Deepstar-4000 obtains its electrical power from three lead-acid batteries with a total capacity of 400-ampere hours at 115 volts output. Each battery weighs 1000 pounds and has a minimum service life of two years.

Equipment located inside the pressure sphere includes a gyrocompass, a two-way radio, tape recorder, two echo sounders and a fathometer.

External equipment includes an underwater telephone, a high-intensity movie lamp with remote control, mountings for a movie camera, strobe flash and 70-mm still camera, a prosthetic arm with sample collecting tongs, a sample basket and lights for illuminating the ocean.

Two 4.4-inch diameter windows low in the front of the submersible allow observation by the crew.

See Research in Oceanography on page 6

Electronics Digest

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Electronics Digest

THE ELECTRONICS MAGAZINE FOR HOME AND SCHOOL

VOLUME FOUR/NUMBER TWO

September/October 1970

William M. Palmer, *W5SFE*
Editor

IN THIS ISSUE . . .

IN THE NEXT ISSUE . . .

A programmed self-study lesson D. C. circuits especially helpful for students and hobbyists; how to build a WWV converter for reception of signals from the National Bureau of Standards; how to build an old time loose coupler and crystal detector radio receiver that is a great addition to a replica collection for radio amateurs, students and hobbyists; and a feature article on the first change in wire-making processes for nearly 4,000 years - - - a space-age development in America.

EDITORIAL CONTRIBUTIONS: All material must be accompanied by return postage and will be handled with reasonable care, however, publisher assumes no responsibility for return or safety of artwork, photographs, or manuscripts. Inquiry should be made prior to submitting manuscripts for publication.

ELECTRONICS DIGEST September/October 1970 (Vol. 4, No. 2). Published bi-monthly at 2615 West 7th Street, Fort Worth, Texas 76107. By Electronics Digest Periodicals, Inc. Annual subscription rate is $2.50 (6 issues) in the United States and possessions and Canada; all other countries $4.00 annually. Application to mail at second-class postage rates is pending at Fort Worth, Texas.

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SCIENCE REPORTS

New developments in the field of electronics

New Ceramic Device Stores, Erases, Alters, Images for Large Information Displays

Think of an erasable, reusable 35 mm slide on which an operator can electronically erase all or part of the image, add new material, and reproject a new image on the screen.

Scientists at Bell Laboratories are investigating these devices which store images until they are electronically erased or changed.

Called ferpics (ferroelectric ceramic picture devices), the devices are made of material first announced by Sandia Corporation.

The ferpic device is a sandwich structure consisting of transparent electrodes, a photoconductive film and a thin plate of fine-grained ferroelectric ceramic. To change the stored information in this simple structure, a new technique, called "strain-biasing" was developed by Bell Labs scientists. The basic ferpic sandwich is bonded to a transparent substrate which is then flexed so as to stretch or "strain" the material.

In an ordinary film slide an image is stored in the form of variations of transparency across the film. In a ferpic the image is stored as a variation of the "birefringence" of the ceramic plate, i.e., as a variation in the way the plate transmits polarized light.

In one mode of operation, a scanned laser beam records an image on the photoconductive film—one picture element at a time as in a TV picture. A voltage applied to the transparent electrodes develops a field across the ceramic. When the field is removed, the image remains stored on the ceramic plate. The image stored in the ferpic device can be viewed by putting light polarizing sheets over it, or the image can be projected on a screen using polarized light in a conventional projection system.

To erase the image, the entire structure is flooded with light in the presence of a reversed electric field; the plate is then ready to store another image.

Bell Labs is exploring this device in the hope of obtaining efficient, low-cost solid-state information displays with features that are difficult to obtain in present display systems. Because the image stored in the ferpic device can be projected, very large displays can be obtained. Also ferpic slides can retain images for a long time without electrical power. A TV set must be fed signals continuously to retain an image; once power stops, the image fades.

At the present stage of development, Bell Labs scientists have demonstrated that ferpic devices can store and display, with high resolution, black and white images that fade only slowly. Thus present ferpics are suitable for the display of, for example, written text or figures, since such applications, while exploiting the unique image storage capabilities of the device, would not place severe demands on the speed or lifetime of the ceramic material. Meanwhile, Bell Labs scientists are continuing to study the properties of the material.

Ferpic devices are based on the electrooptic properties of fine-grained, lead zirconate-lead titanate, ferroelectric ceramic materials recently announced by Sandia Corporation. Bell Labs scientists, Dr. Allen Meitzler, Dr. Juan Maldonado, and Dr. David Fraser were the first to demonstrate the storage of high resolution images in these materials using ferpic devices.

Mini-computer With Two Sets of Registers Brings Spherical Trig Calculations to Slaved Radar Systems

MIAMI, Fla.—A new Automatic Radar Data-Control system solves complicated coordinate transformations problems by coupling a minicomputer to a special processor to make spherical trigonometry calculations for designating radar antenna parameters to within 20 yards of range and 0.1 mil of angle.

The system, called ARDC, was developed by Milgo Electronic Corporation here and has been installed at the Fort Hauchuca, Arizona missile range.

The firm has designed the system so that a Varian 520/i general purpose digital mincomputer combines with a specially-designed Milgo Trigonometric Processor to solve coordinate transformation range problems by transferring 24 bits of data bidirectionally without requiring complex programming routines.

The Varian computer and the Trigonometric Processor allow the system to follow a target to the horizon and then they make the complex calculations needed to tell another radar unit downrange exactly where to pick up the target on its own horizon and lock onto it. This coordinate transformation involves breaking radar polar coordinates down into Cartesian coordinates, making a series of rotational calculations about each x, y, and z axis, and then transforming back into polar coordinates for the next radar system.

The time required for making these P/C and C/P calculations has been greatly reduced through the combined use of the Milgo Trigonometric Processor and the Varian 520/i.

Two sets of hardware registers, including index registers, permit the 520/i to run dual programs on an interrupt basis. A single 1.5 millisecond instruction transfers control between programs or between processing and I/O programs. Data can be manipulated in multiples of 8-bit bytes, so that arithmetic can be performed in 8, 16, 24 or 32-bit lengths within the same program. A set-precision feature in the 520/i allows program precision to be changed at any time.

The Trigonometric Processor is integrated with the 520/i by means of a Direct Memory Access port facility, which provides for the transfer of data words and commands contained in memory. The configuration is such that the 520/i programming capability lets data be extracted from memory or placed into memory without having to interrupt the sequence of operations being performed by the 520/i program.

The dual-register 520/i in conjunction with the Trig Processor allows the ARDC system to select from up to three inputs from another antenna downrange, speeding up the time required to lock onto the target as soon as it appears off the horizon. The ARDC also provides two outputs, one for another processor and one for a special range control station which maintains a plotboard display of the total system's activity.

The system uses a high-speed optical printer for hard copy tabulation of all data, and an analog tape recorder for after-the-fact analysis.

"We selected the Varian 520/i for this job because we needed the cost advantage of a minicomputer, the established reliability of a reputable manufacturer and the dual function programming feature necessary for interfacing with the Trigonometric Processor," said Edward G. Parsons, vice president and director of Milgo.

Parsons pointed out that another approach to radar antenna control system calculations was solved in the firm's Automatic Radar Control and Data Equipment system (ARCADE) with another Varian minicomputer, the 622/i expandable (from 4,096 to 32,768 18-bit words) model. This system generates antenna movements from instructions received along telephone lines from another antenna station, and also processes tilt, beam axis, refraction and other operational factors.

While not so sophisticated as the ARDC system using the 520/i, the ARCADE system is currently in use at five locations at the White Sands Missile Range in New Mexico, with three more presently being installed.

Environmental Expert Says Nuclear Power Plants Are Best Energy Source

UNITED NATIONS, N.Y.,–Nuclear power plants, because they are safe and the most pollution-free source of electricity, are the best way of meeting mankind's growing demand for energy, a Westinghouse Electric Corporation environmental expert said recently.

Dr. James H. Wright, director of the company's environmental systems department, told an international symposium that 1,000 large nuclear power plants could operate normally at one site without exceeding safe radiation limits for the nearby public.

And although heat discharges from such plants have caused no major problems, the ecological stresses that could develop as the plants increase in number can be prevented by environmental management, he said.

Dr. Wright addressed a symposium on the environmental aspects of nuclear power sponsored by the International Atomic Energy Agency in cooperation with the U.S. Atomic Energy Commission.

Dr. Wright's department works with the electric utility industry in identifying and solving environmental problems associated with power generation and transmission.

He said the worldwide demand for energy is growing three to five per cent a year.

"Of all forms of producing and using this energy, electrical power is the most efficient form of energy production and creates the least amount of environmental pollution, " he continued. "A detailed examination of environmental factors further reveals that nuclear power provides the most pollution-limiting means for producing electric power.

"The discharge of heated water into natural water systems has not developed any major problems yet, but continued growth in electrical power production may cause damaging environmental stresses to occur in some areas," Dr. Wright said.

"Through environmental management, society will be able to utilize the heat dissipation capability of many bodies of water without significantly altering the natural ecosystem. Processes for utilizing discharge heat in aquaculture, agriculture and urban systems offer further opportunities whereby the benefits of nuclear power may be extended in the years ahead."

Dr. Wright said that all bodies of water naturally absorb and dissipate heat. Adding discharge heat from power plants simply increases the burden on the natural heat-dissipation process of lakes and streams, he explained.

After a study has been made to understand the existing ecology of a water system, he said, "projections can be made regarding the effects of heated discharge into the system. Where the projections show no detrimental effects from the heated discharge, the water system should be used to serve society's needs in the same way that other natural resources can be utilized without damage if carefully managed."

"Where the projections indicate significant and measurable damage to the ecosystem, alternate cooling systems for nuclear plants can be incorporated," he said.

In discussing radiation standards, Dr. Wright said that a large nuclear reactor would have to operate with all of its uranium fuel in a failed and leaking condition to release even the minute amounts of radioisotopes now established as an allowable maximum by the U.S. Atomic Energy Commission. In practice, such operation would be impossible.

Dr. Wright also noted that the emission limits set by the AEC provide a much lower exposure to the public than the Federal Radiation Council (FRC) recommends, thus providing an additional safety factor.

Dr. Wright said plant operation at normal design levels would result in an exposure to the general public of no more than one-tenth of a millirem per year. This is 1/1700th of the FRC's recommended maximum exposure of 170 millirem per year from all manmade radiation sources.

"It is obvious that more than 1,000 large nuclear plants could be operating on the same site" at normal design levels without exceeding the FRC-recommended exposure to the nearby general public, Dr. Wright said. It is the best way to meet tomorrow's energy needs.

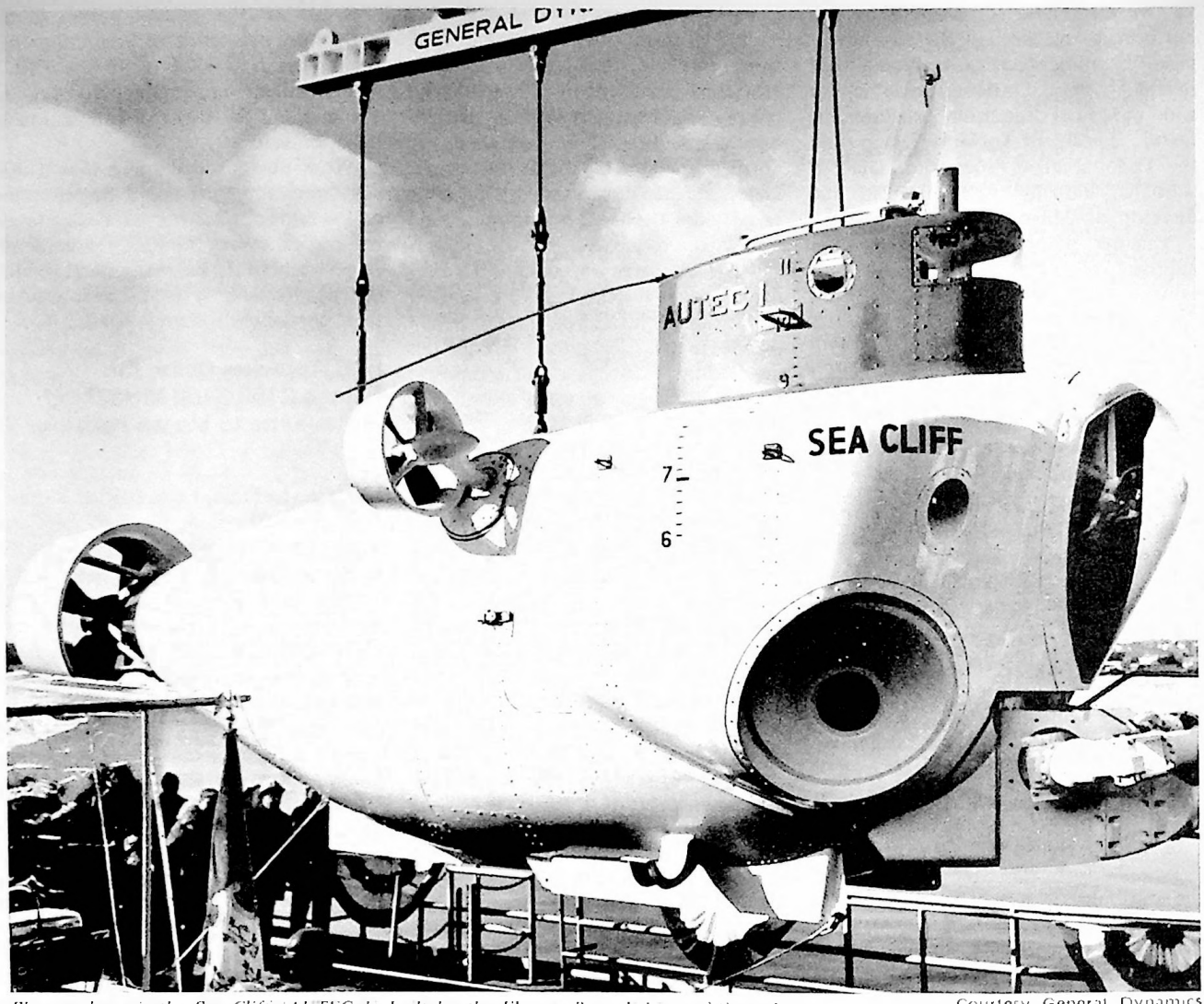
FCC Approves Color TV For the 2150-2160 MHz Band In Response to Varian Petition

Copiague, L.I., N.Y.–In response to a petition by Micro-Link, part of Varian's Solid State Division, the Federal Communications Commission on July 29, 1970, amended its rules to permit full 10 MHz utilization of a previously unused portion of the microwave spectrum.

The 2150-2160 MHz microwave band is available to existing or proposed common carriers for providing omnidirectional TV transmission to receiving locations having directional antennas. The equipment developed by Micro-Link consists of a traveling wave tube TV transmitter, plus a microwave downconverter for use with standard television receivers. The system may be used by anyone wishing to provide closed circuit TV programs for employee training, management communications, or other applications involving television transmission to many remote locations within a radius of about 20 miles. Each group of receivers is remotely turned on or off by means of coded signals so true closed circuit operation is assured. Future applications could extend to closed circuit transmission of plays, films, tapes, market reports, sports events, newspapers, plus possible use by physicians in keeping up to date on the latest medical techniques and pharmaceutical advances.

Called STV (Subscriber Television), the new service is expected to fill the need of many municipalities and major industrial and commercial organizations for employee communications and advanced education, and for programs of special interest to specific groups who would subscribe to the service and originate their own program material.

Organizations interested in providing the transmission service may contact D.D. Milne, Marketing Manager, Micro-Link Products/Varian Solid State Division, 1365 Akron Street, Copiague, N.Y. 11726.



Shown above is the Sea Cliff (AUTEC I) built by the Electric Boat division of General Dynamics during christening ceremonies December 11, 1968. The AUTEC research submersibles were built for the U. S. Naval Ship Systems Command for use in projects sponsored by the Office of Naval Research at Woods Hole Oceanographic Institution in Woods Hole, Mass.

Courtesy General Dynamics

Research in Oceanography---A Giant Step in the Future of Mankind

New developments in America's research of the vast ocean world might astound even a science writer with Jules Verne's flair

by William M. Palmer

Historical Notes

In the picturesque little town of Fredericksburg, Virginia, beside the Rappahannock river, it was Tuesday, January 14, 1806, a day like any other day - - - perhaps uneventful to most of its people. Yet, as history and individual achievement unfolded years later, Americans were to recognize an event which took place in the little town on that date as a most memorable one for the field of oceanography . . . the birth of Matthew Fontaine Maury.

Matthew Maury, who is considered to be the first oceanographer, was born on a farm, the seventh in a family of nine children. His parents, Richard and Diana Mainor Maury, were of French Huguenot and Dutch ancestry.

Although valuable observations in oceanography were made over a period of many years by men of the sea like Captain James Cook (1768-80) and the polar explorers Sir John Ross in the north (1829-33) and Sir James Ross in the south (1839-43), Matthew Maury was the first to bring together in a meaningful form, these scattered observations of the ocean's ways. From the information gathered from the pages of sailor's logs, Maury was able to chart the first sea lanes, and showed how winds and currents could impede or aid both sail and steam-powered ships as they

traversed the sea routes of that day. His discoveries were said to have saved ship owners and merchants millions of dollars through reduction of travel time for sea voyages. The first wind and current chart was issued by Maury in 1847, and it received world-wide acclaim - - - nothing like it had ever been seen before. Maury's methods and plans were adopted at an international Congress at Brussels, Belgium, in 1853.

In 1902, at Stockholm, Sweden, the International Council for the Exploration of the Sea was founded. Many nations of the world, including the U. S. and Canada, have built or fitted out special research ships for work in this field of science.

The International Oceanographic Congress was held in New York City, August 30-September 12, 1959, under joint sponsorship of the American Association for the Advancement of Science, the United Nations Educational, Scientific and Cultural Organization, and the Special Committee on Ocean Research of the International Council of Scientific Unions. It was reported that twelve hundred people from 54 countries attended the historic meeting.

The Oceanographic Congress provided the first opportunity for marine biologists, marine geologists, chemical and physical oceanographers from all over the world to exchange ideas and scientific information of common interest. The seminar covered subjects of great importance including biogeography, environmental influences on populations, physiology of marine organisms in relation to their environment, the influence of land masses on the distribution of organisms, nutrient relationships, and balance between living and dead matter in the sea.

Deep-Sea Research Vehicles

The vast ocean world covers 70 percent of the earth's surface and in much of its mysterious depths, which have been hidden from man since the beginning, are areas of enormous natural resources which mankind must explore and develop under priority programs in order to meet the economic needs of the exploding world population in the decades just ahead.

In order to conduct essential research and exploration of vast areas of the ocean environment, which must precede resource development programs, special self-propelled submersibles have had to be designed to provide sufficient working space and operational capability to permit scientific teams to descend thousands of feet to the ocean floor to conduct their observations, surveys, and special work assignments.

Man has made incredible progress in the development of research submersibles over the past four decades - - - ever since his first tangible breakthrough in the late 1920's with a deep-sea vessel called the Bathysphere.

The Bathysphere, the world's first deep-sea vessel, was designed by a biologist, William Beebe. It was spherical in shape, of heavy steel construction, and featured several small observation windows made of three-inch quartz glass.

The Bathysphere, with its crew of two was lowered from a mother ship on the surface by means of cables to a record depth of 3,028 feet in 1934. Thus, Beebe was the first man to observe and photograph the strange marine life existing

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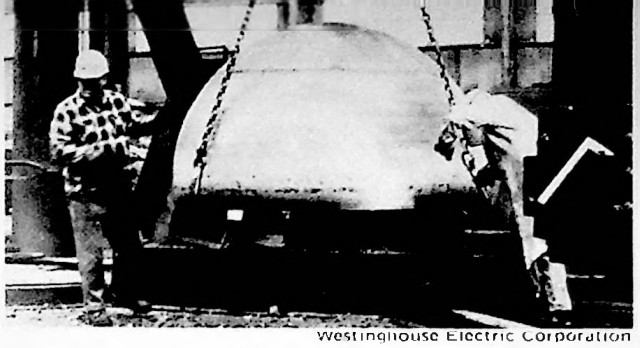
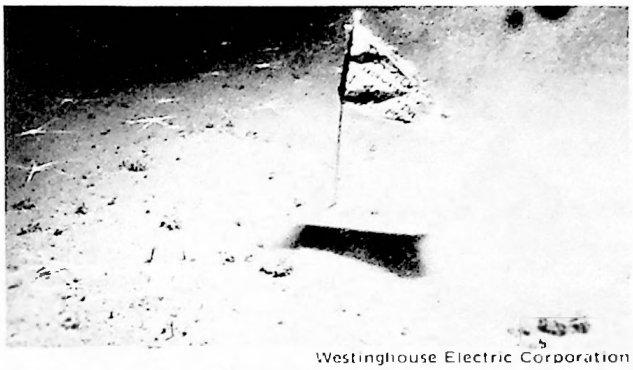


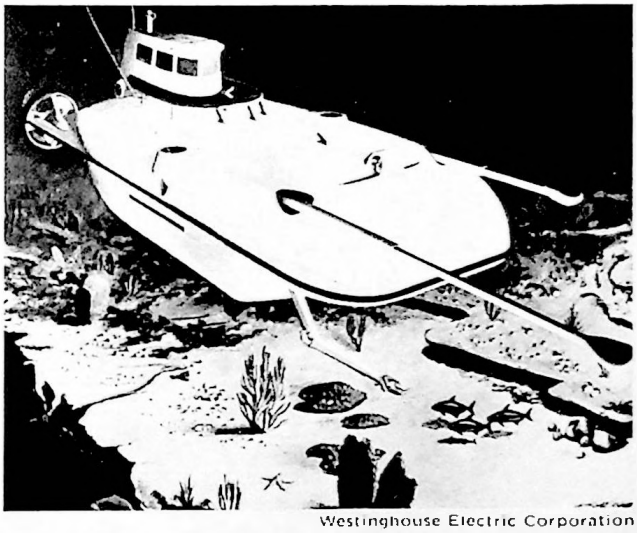
Westinghouse Electric Corporation

Shown being removed from the spinning machine where it was formed into a hemispherical shape is half of the hull of the Deepstar-20,000 submersible, a three-man vehicle weighing about 40 tons and allowing a payload of more than a ton for scientific instruments and equipment. Its diving depth of 20,000 feet will enable the super-submersible to reach 98 percent of the bottom of the worlds oceans.



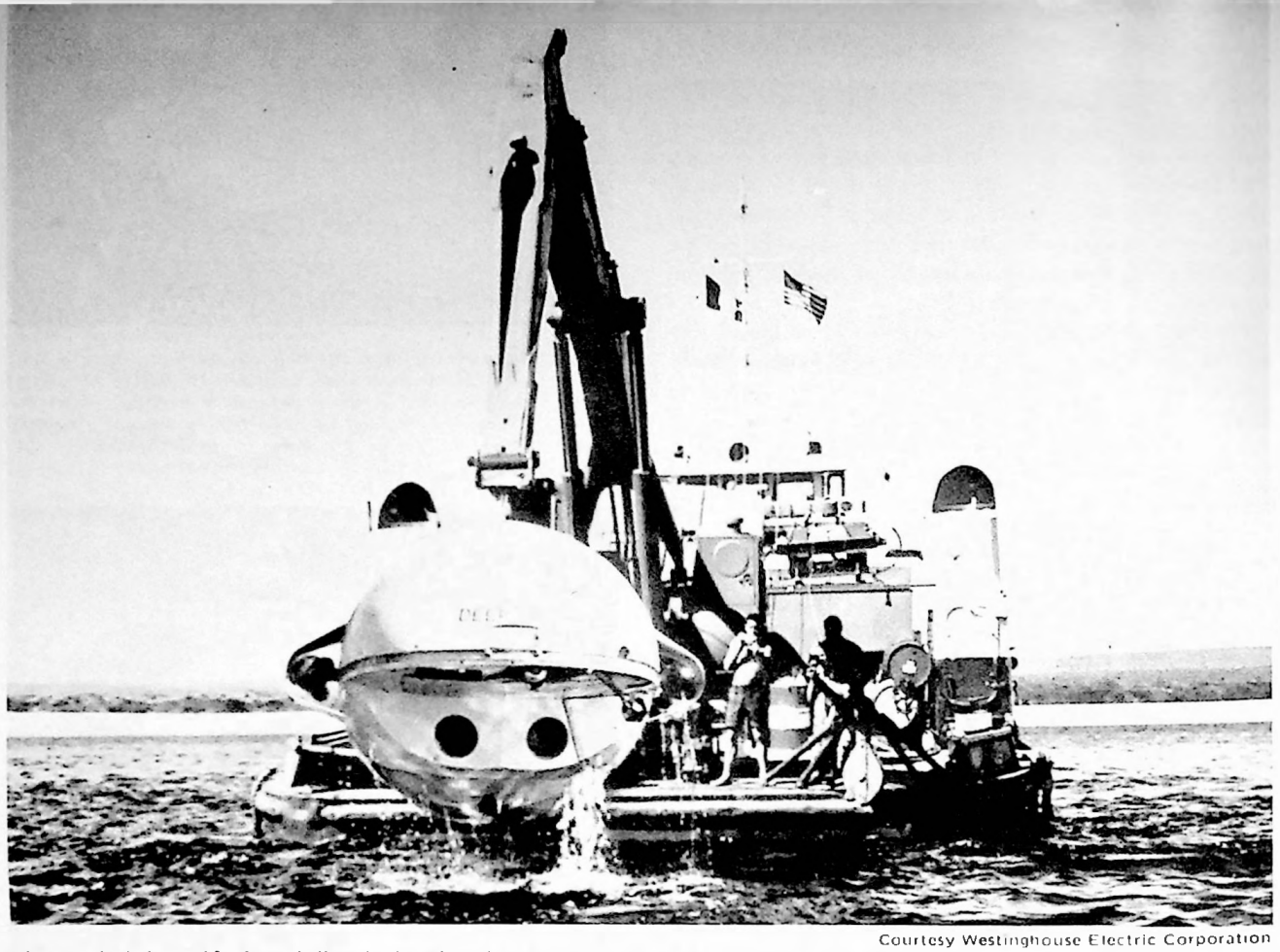
Westinghouse Electric Corporation

The three-man crew of the Deepstar-4000, Westinghouse's deep-diving undersea vehicle, took this photo of the ocean floor during the submersible's first 4000-foot dive on May 11, 1966. The dive was the last major hurdle in testing of the vehicle. It took place 15 miles southwest of Point Loma, Calif. The crew planted the flag with the submersible's mechanical arm and picked up samples of the brittle starfish and sea urchins that can be seen on the ocean floor. The Deepstar-4000 was the first of a family of undersea vehicles planned by its builder, the Undersea Division of the Westinghouse Defense and Space Center.



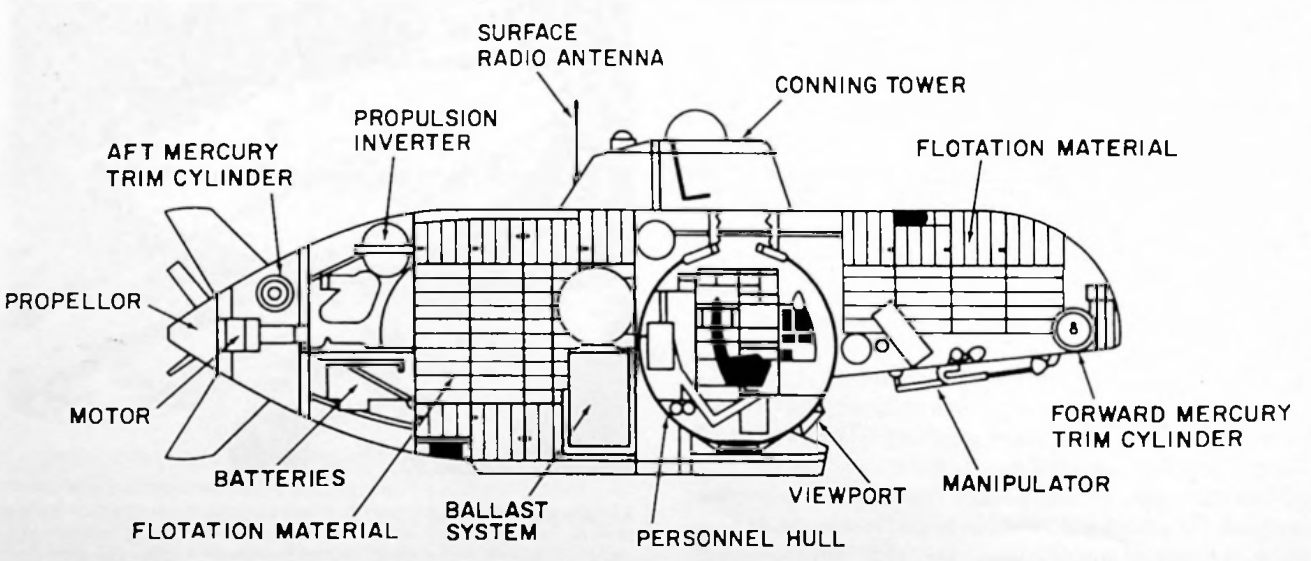
Westinghouse Electric Corporation

The Deepstar-2000 undersea research vehicle, shown in this artist's sketch, was developed at the Westinghouse Electric Corporation's Ocean Research and Engineering Center near Annapolis, Md. The submersible, similar in design to the existing Deepstar-4000 which has made over 400 dives, was ready for operations in early 1969 and was assigned to the Westinghouse Research Laboratories' Ocean Research Laboratory at San Diego, Calif. It is used in research efforts and as a test bed for prototype instrumentation. The submersible is 20 feet long, 7 feet wide and capable of carrying two scientists and a pilot to depths of at least 2000 feet. It will operate for as long as eight hours at a maximum cruising speed of three knots.



Courtesy Westinghouse Electric Corporation

The Burch Tide, a 136-foot shallow-freeboard surface support vessel of approximately 120 tons, serves as mother ship for Deepstar-4000. A 33-ton hydraulic crane, with a 12-ton lifting capacity, on the ship and a lifting eye atop the submersible are used to launch and retrieve the diving vehicle. Other facilities aboard the Burch Tide are battery chargers, air compressor, oxygen supplies, and vans housing a shop for field maintenance, photo darkroom electronic test equipment, storage and spare parts. Three living vans provide quarters for the Westinghouse team and other participants.



Courtesy Westinghouse Electric Corporation

Above is an artist's cutaway drawing of the Westinghouse Deepstar-20,000 research submersible. A glass fiber laminate fairing encloses the hull and other subsystems such as propulsion, flotation, variable ballast, vehicle trim, and the vehicle sensors. The three-man vehicle will weigh about 40 tons and will be able to carry over 2,000 pounds of scientific instruments and equipment. Its diving depth of 20,000 feet, will enable it to reach 98 percent of the bottom of the world's oceans.

(continued from page 7)

in the mysterious deep-sea world.

Although it represented a giant step for deep-sea research, the Bathysphere was unwieldy and limited both as to personnel work space and maneuverability.

During the succeeding years, Professor Auguste Piccard designed and built a number of improved versions of this type of deep-sea vessel one of which was the Trieste. On January 23, 1960, the Trieste with a crew of two descended to a record depth of 35,784 feet in the Challenger Deep of the Marianas Trench in the Pacific. But like the Bathysphere, it still could not be used to survey large areas, maneuver sufficiently to perform useful work, or to propel itself at reasonable speeds.

During the past decade a number of undersea research vehicles have been developed that have given new impetus to oceanographic study. Among these newer submersibles is the Diving Saucer conceived by the world famous undersea explorer, Jacques Yves Cousteau and developed by his research organization, The French Office for Undersea Research.

The Westinghouse Deepstar-4000 design is based in part on that of the Diving Saucer which has been operational since 1959, and has made over 425 dives.

The nine-ton Deepstar-4000 obtains its electrical power from three lead-acid batteries with a total capacity of 400-ampere hours at 115 volts output. Each battery weighs 1000 pounds and has a minimum service life of two years.

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External equipment includes an underwater telephone, a high-intensity movie lamp with remote control, mountings for a movie camera, strobe flash and 70-mm still camera, a posthetic arm with sample collecting tongs, a sample basket and lights for illuminating the ocean.

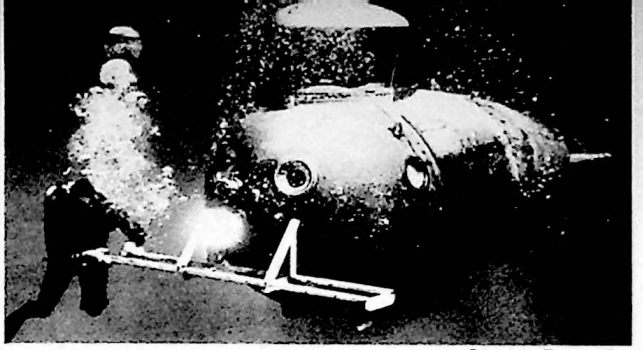
Two 4.4-inch diameter windows low in the front of the submersible allow observation by the crew.

One of the most recent undersea research submersible to be developed is the Westinghouse Deepstar-20,000. The three-man vehicle, which can carry more than a ton of scientific instruments and equipment, has the capability to reach 98 percent of the bottom of the world's oceans.

Another important name in undersea vehicles is General Dynamics, designer and builder of more than 250 submarines—from the U. S. Navy's first, Holland, to the nuclear-powered Nautilus—and as well as a number of outstanding research-and-work submersibles.

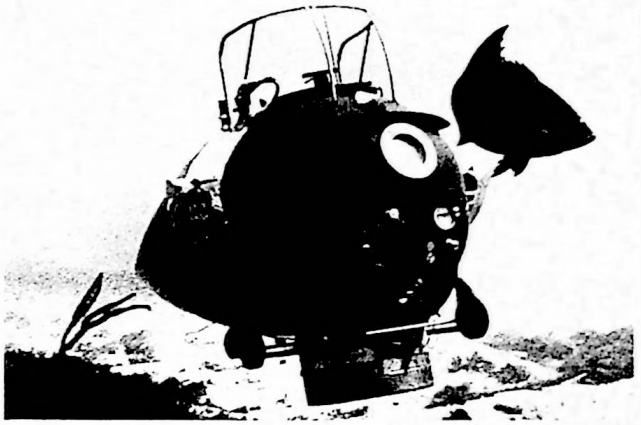
The General Dynamics designed submersible Asherah photographed the 1,500—year—old wreck of a Byzantine galley in the Aegean Sea in one hour. The work would have taken divers several months. It has also performed many other assignments, such as geological studies for the Smithsonian Institution and marine biology work for the Bureau of Commercial Fisheries and the Universities of Rhode Island and Hawaii.

Thus, America invests in the future, not only for her own people but for the benefit of all mankind—that all might share the dividends of our vast scientific research programs.



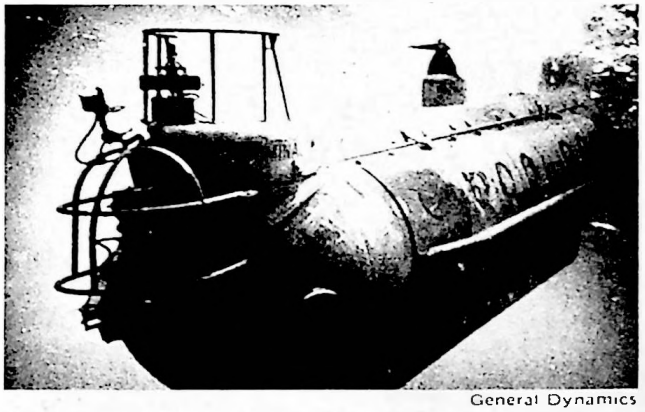
General Dynamics

The mysterious undersea vehicle shown above is the ASHERAH which was designed by General Dynamics for the University of Pennsylvania, principally for archeological research. Equipped with stereo cameras, the submersible photographed the 1,500-year-old wreck of a Byzantine galley in the Aegean Sea in one hour. Without ASHERAH, the work would have taken divers several months. It has also performed many other assignments, such as geological studies for the Smithsonian Institution and marine biology work for the Bureau of Commercial Fisheries and the Universities of Rhode Island and Hawaii.



General Dynamics

The STAR I shown above was General Dynamics' first research vehicle. It was designed as an experimental model to test the reliability of buoyancy materials and systems for navigation, control, communications and life support. The one-man craft performed simulated underwater rescues off Bermuda during the Navy's SEALAB I operation in 1964. The STAR I was also the first submersible to run on a fuel cell. The pioneer vehicle is now on permanent exhibit in the Underwater Museum of the Philadelphia Maritime Museum.



General Dynamics

Shown above is the world's first aluminum submarine, the ALUMINAUT. It was built by General Dynamics for Reynolds International, Inc., to demonstrate the feasibility of aluminum as a hull metal. Designed for a maximum operating depth of 15,000 feet, the ALUMINAUT is able to explore three-quarters of the ocean bottom. The 51-foot craft has a 30.5-hour operating endurance with a crew of one operator and two observers, but will accomodate additional observers on less extended dives. It is equipped with a gyro-compass, speed indicator, fathometer, sonal, underwater and radio telephones, television and bow manipulator.

Television Safety Tips

How to give your television set the tender loving care that will provide not only greater safety but will enhance your enjoyment of this great communication medium

Special Report

PROTECTION AND LOCATION OF YOUR TELEVISION SET

1.

■ When installing an outside antenna, use a lightning arrester which is U.L. (Underwriters' Laboratories, Inc.) listed. Use of such an arrester helps to protect both your TV receiver and your home during a lightning storm.

2.

■ For added protection during a lightning storm, and when the set is to be left unattended for an extended period of time, unplug it from the wall outlet. This can prevent possible damage due to the lightning storm or power line surges.

3.

■ The set has slots, or openings in the cabinet and back for ventilation purposes, to provide reliable operation of the receiver, and to protect it from overheating.

3a.

■ Never cover the slots or openings with cloth or other material.

3b.

■ Never block the bottom ventilation slots of a portable TV set by placing it on a bed, sofa, rug, etc.

3c.

■ Never place the set near or over a radiator or heat register.

3d.

■ Avoid placing TV set in a "built-in" installation, or book shelves, unless proper ventilation is provided.

4.

■ Avoid exposing the set to rain or excessive moisture as this may result in damage and a potential fire or shock hazard.

OPERATION OF YOUR TELEVISION SET

5.

■ Operate the set only from an AC power source as indicated on the cabinet back. If you are not sure of the type of power supplied to your location, consult your television dealer or local power company. (Continued operation at line voltages substantially greater than the set's rating will shorten the life of the receiver, and might even cause severe damage). NOTE: For those sets designed to operate from battery power, refer to the Operating Instructions.

6.

■ Adjust only those controls on the back of the set that are covered in the operating instructions. Improper adjustment of other back controls may result in possible damage and will require the services of a technician to restore proper operation.

7.

■ It is advisable to turn the set "off" when it is not being viewed. This will extend the useful life of the set.

Reprinted Courtesy Electronic Industries Association

FOR YOUR PERSONAL SAFETY

8.

■ If the set is equipped with a polarized AC line plug (one blade of the plug is wider than the other), this plug will fit into the power outlet only one way. This is a safety feature. Should you be unable to insert the plug fully into the outlet, try reversing the plug. Should this then fail to fit, contact your dealer for assistance. Also, if you should want an extension cord for this polarized plug, your dealer can supply you with a U.L. approved polarized extension cord. Do not defeat the safety purpose of the polarized plug.

9.

■ Do not remove the back cover of the set as this can expose you to very high voltage and other hazards.

10.

■ Never push objects into the set through cabinet slots, as it is possible to touch dangerous voltage points.

11.

■ If the cabinet has been damaged do not operate the set as a shock hazard may exist. Have it checked by a service technician before use.

12.

■ Never operate the set if liquid has accidentally spilled into it. Have it checked by a service technician before use.

13.

■ Always clean the face of the picture tube when the receiver is turned off. Do not use water or excessive liquids.

IF THE SET DOES NOT OPERATE PROPERLY

14.

■ If you are unable to restore normal operation by following the "Service Check List" in your Operating Instructions, do not attempt any further adjustments. Turn the set off, and call your dealer or service technician.

15.

■ Secure service whenever the set is damaged or fails, or whenever a distinct change in performance indicates a need for service.

16.

■ It is normal for some TV sets to make snapping or popping sounds, particularly when being turned on or off. If the snapping or popping is continuous or frequent, consult your dealer or service technician.

CONTACT AUTHORIZED SERVICE REPRESENTATIVE

17.

■ Never attempt to add, or permit a technician to add, accessories (such as extension speakers, or outlets for record players or tape recorders) to a set that has not been designed for this purpose, since such additions may result in a serious electrical shock hazard.

18.

■ Never place the set on an unstable TV cart or stand.

19.

■ When replacement parts are required, have the service technician verify that the replacements have the same safety characteristics as the original part. Unauthorized substitutions may result in fire, shock, or other hazard.

20.

■ Upon completion of any service or repairs to the set, please ask the service technician to perform the safety check described in service literature for the receiver.

WHAT YOU SHOULD KNOW ABOUT COLOR TV

What Goes Into a Repair Service Call

People sometimes complain about the charges for service calls at the home to repair radio, or television receivers. Many people do not realize the factors involved. That charge is not determined solely by the time to make the repairs.

Operating a dependable service business requires organization, competent management, and a substantial capital investment. So don't judge service charges solely by the time spent in your home. When the top-notch technician knocks on your door, many costs have been incurred just to get him there, ready to do the job.

Before you Call For Repair Service

1. Make sure the power cord is properly connected to the electrical outlet and the antenna lead-in wires are securely fastened to the antenna terminals on the back of the cabinet. Check to see that the bare antenna leads are not touching each other.

2. If the receiver appears dead (no picture or sound on any channel) after it is turned on, push the red circuit breaker located on the back of many late model sets. Refer to instruction book.

3. Variation in color when switching from one channel to another is normal. It can be corrected with the color and tint controls.

4. Occasionally you may notice color variations during a color program. This may happen when the TV station switches from one camera to another, between a "live" show and film or tape, or between network and local shows, or to a commercial.

5. If the sound is normal but you have no picture, turn the brightness control full on and try another channel.

6. If the picture is normal but you have no sound, adjust the "fine tuning" control with volume control full on. Try another channel.

7. If you can't get color, try another channel. Advance the color or chroma control. Try adjusting fine tuning control.

8. When faces are green or purple or red, adjust the "tint" or "hue" control knob for natural flesh tones.

Let's Look At Repair Service

1. It is not uncommon for a technician to request the chassis be taken to the shop for service. This does not always indicate a major repair. The use of precision service equipment which cannot be carried by technicians may be required. In most cases this may mean the payment of a service and delivery charge.

2. It is not unusual for a technician to replace a tube that is bad and a few days later, a different tube goes bad. Customers sometimes think there should not be a charge for the second call. If the technician had replaced a doubtful tube, however, the customer may think he is putting in parts that are not needed.

3. A technician may have to make a second call since he does not have a needed part with him. To have all the parts in his truck, he would have to carry more than 500 different tubes, 10 different color picture tubes and 10,000 parts. Obviously, this is impossible.

4. It is considered excellent service if a call can be made on the next working day. The normal time may vary from two to three days.

5. As it is difficult for a service call to be made at a specific time, or after working hours, the customer can expedite repair and perhaps save overtime charges by arranging to be home when the serviceman arrives.

6. An intermittent condition which sometimes develops in a TV set is most difficult to locate as it must show up for a sufficient time to allow for diagnosis. It is usual to take the set to the shop where it can be observed until the trouble develops.

7. Most dealers and service shops cannot provide loaner sets when a set is taken to the shop for repair.

Reprinted Courtesy Electronic Industries Association

history's hall of honor

BIOGRAPHICAL SKETCHES OF GREAT MEN IN ELECTRONICS

John Bardeen

American Physicist

Born May 23, 1908

John Bardeen was born May 23, 1908, in Madison, Wis., the son of Dr. Charles R. and Althea Harmer Bardeen. His father was professor of anatomy and dean of the Medical School at the University of Wisconsin.

He received his BS and MS degrees in electrical engineering from the University of Wisconsin in 1928 and 1929. As a graduate research assistant in electrical engineering at Wisconsin, Bardeen was first introduced to the quantum theory by Prof. J.H. Van Vleck, one of the first Americans to master the subject.

His graduate work on mathematical problems in applied geophysics led Bardeen to a position at Gulf Research Laboratories in Pittsburgh, working on the development of methods for the interpretation of magnetic and gravitational surveys.

Because he felt his interests were more in pure than in applied science, Bardeen left his well-paying job at Gulf in 1933, in the midst of the depression, to take graduate work in mathematical physics at Princeton University. It was here, under the leadership of Professor Eugene Wigner, that he first became interested in solid state physics.

Wigner, a world leader in quantum theory, was Bardeen's advisor for his doctoral thesis at Princeton and stimulated his interest in applying quantum theory to the electronic structure of solids.

Before finishing his thesis Bardeen was offered a position as a Junior Fellow of the Society of Fellows of Harvard University, then an infant organization. His PH D was awarded by Princeton in 1936.

During his three years at Harvard, from 1935-38, Bardeen again had an opportunity to work with Van Vleck and helped interpret experiments of Professor P. W. Bridgman on the properties of matter under high pressure. Here he first became interested in interactions between electrons and lattice vibrations in metals, which was later to prove important for the theory of superconductivity.

Bardeen was an assistant professor of physics at the University of Minnesota from 1938-41. There he first attempted, unsuccessfully, to construct a theory of superconductivity, the strange phenomenon which causes certain metals to lose their resistance to the flow of electric current at a temperature near absolute zero.

During World War II, from 1941-45, he was a physicist at the Naval Ordnance Laboratory.

In 1945 he joined the solid state research group at the Bell Telephone Laboratories, where their semiconductor research led to the discovery of the transistor principle. On Dec. 23, 1947, he and two other Bell Labs scientists, Walter Brattain and William Shockley, showed that a small piece of the element germanium could be made to amplify a speech signal about forty times. In 1956 the three were awarded the Nobel Prize for this discovery of the transistor effect.

In May, 1950, when he heard about the isotope effect from Serin, Bardeen resumed work on superconductivity.

After coming to the University of Illinois in 1951, Bardeen continued his experimental and theoretical research in solid state physics. He was appointed a member of the University of Illinois Center for Advanced Study in 1959.

In 1957, he and two graduate students, J. R. Schrieffer and Leon Cooper, developed the B-C-S theory of superconductivity which has won international scientific acceptance as providing a correct description of this phenomenon. (Schrieffer is now at the University of Pennsylvania and Cooper is at Brown University.)

Bardeen married Jane Maxwell in 1938. They have three children: James Maxwell, William Allen and Elizabeth Ann (Greytak).

He is a fellow of the American Physical Society and has served APS as a member of its council, 1954-57; as associate editor, 1949-51 and 1956-58, as vice president elect and then vice president, 1966-68, and as president in 1968-69.

Bardeen has been a member of the National Academy of Sciences since 1954. He is also a member of the American Association for the Advancement of Science, the American Academy of Science and the American Philosophical Society.

He served on the U. S. President's Science Advisory Committee, 1959-62, and has been a consultant and member of the Board of Directors of the Xerox Corp., Rochester, N. Y. since 1960.

(Continued on page 16)

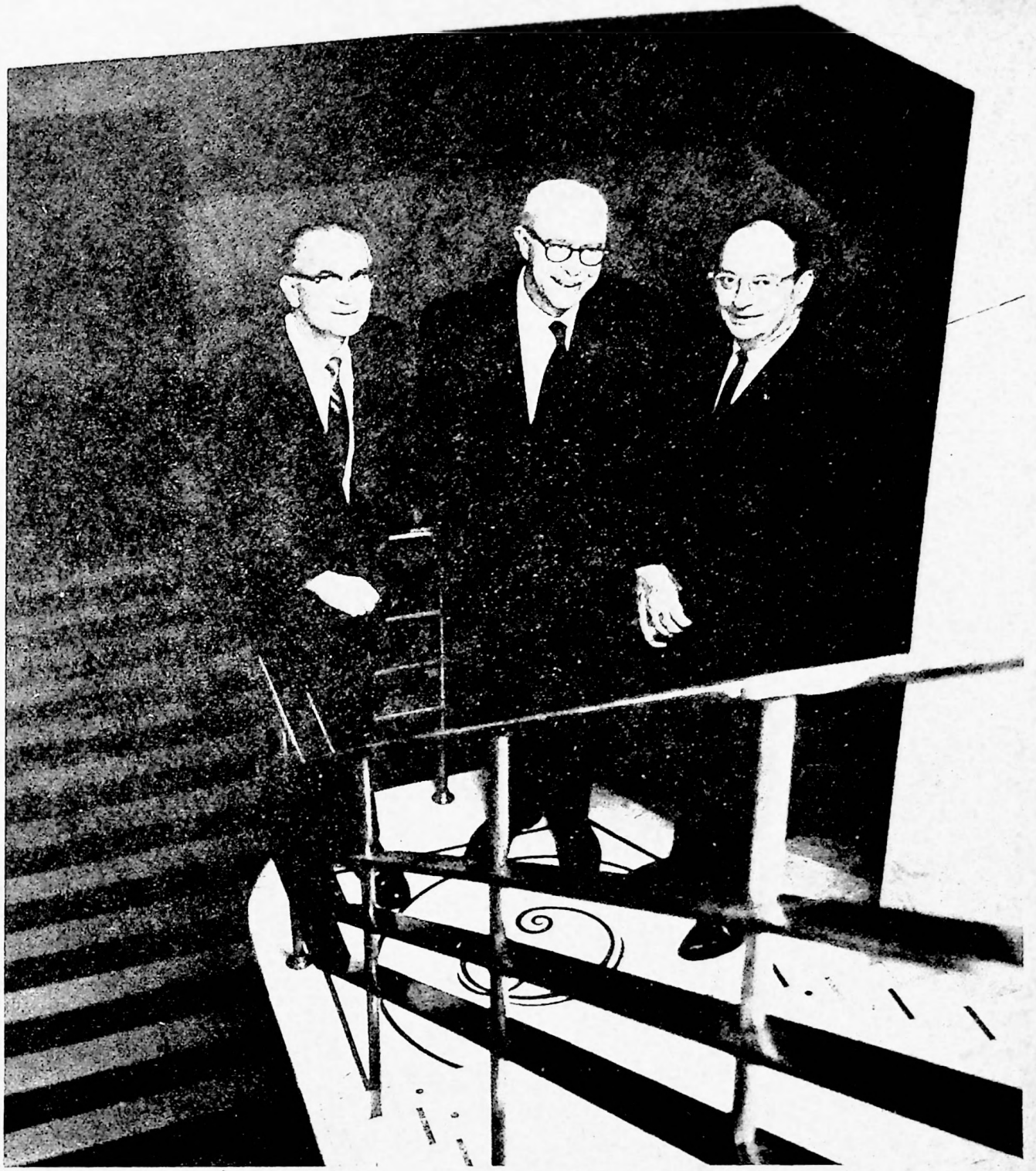
Information Courtesy Universtiy of Illinois

Courtesy University of Illinois

John Bardeen

American Physicist

Born May 23, 1908



Courtesy Bell Telephone Lab

The co-inventors of the transistor are shown above left to right: William Shockley, Walter H. Brattain, and John Bardeen. In 1956, they shared the Nobel Prize in Physics in recognition of their momentous discovery. The distinguished physicists are members of the elite National Academy of Sciences. Their contributions to transistor technology revolutionized the electronics industry throughout the world.

history's hall of honor

BIOGRAPHICAL SKETCHES OF GREAT MEN IN ELECTRONICS

John Bardeen

(Continued from page 13)

Bardeen also has been a member of the advisory committees for Harvard University, Princeton, University of Virginia and the National Bureau of Standards.

His fields of research are theoretical physics, solid state and low temperature. He is author or co-author of more than a hundred research papers.

Bardeen has received six honorary degrees: from Union College, Schenectady, 1955; University of Wisconsin, 1960; Rose Polytech, 1966; Western Reserve, 1966; University of Glasgow, 1967, and Princeton University, 1968.

Other honors and awards include the Stuart Ballantine Medal from the Franklin Institute, Philadelphia, 1952; Buckley Prize, American Physical Society, 1954; John Scott Medal, City of Philadelphia, 1955; the Nobel Prize in physics, 1956; Fritz London Award in low temperature physics, 1962; Vincent Bendix Award of the American Society for Engineering Education, 1964; the National Medal of Science for 1965, awarded February 1966; and the Michelson-Morley Award, Case-Western Reserve, 1968.

On May 23, 1968, the University of Illinois physics department and Materials Research Laboratory, along with the Xerox Corp. and Bell Telephone Laboratories, held a symposium, "Solid State Physics and Technology, The Last Thirty Years," in honor of Bardeen's 60th birthday.

Bardeen has said that he prefers research in a university climate and life in a university atmosphere over a career in industry. The limitations necessarily found in applied research in industry are absent in basic research done in a university, where a broader scope is possible.

Bardeen's work on superconductivity gave science the key to its understanding and paved the way for dramatic progress in this field of research during the past decade.

The niobium-tin superconductors discovered in 1954 were found to be capable of carrying very large currents and generating intense magnetic fields greater than 100 thousand gauss (the unit of magnetic field density) when wound on into the form of a cylindrical coil or solenoid. Since then the discovery of new superconductors have made possible super solenoids that will produce more intense magnetic fields.

The true importance of discoveries exploiting the phenomenon of superconductivity may not be realized for many years. However, some scientists envision great potential in the area of long range space flights where the principle might be applied in building a super magnetic shield to protect space travellers against deadly radiation. It will undoubtedly find many new applications in the design of electrical/electronic apparatus for space-age industry and health care.

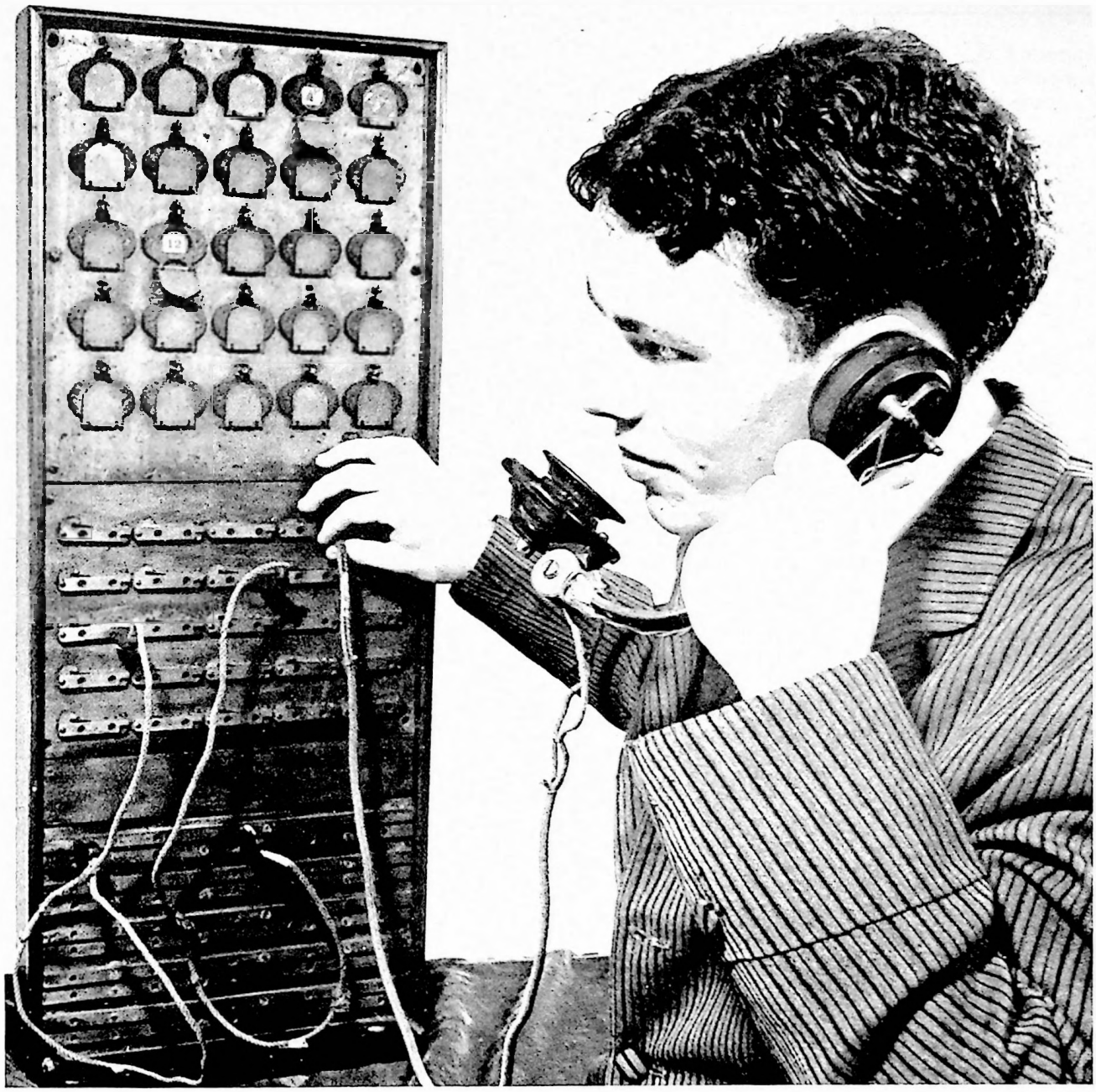
Future generations may well classify the discoveries on superconductivity during the past decade as one of mankind's greatest achievements - - - the legacy of our men of science like John Bardeen.

Bell Telephone La

A few years ago approximately 30 metals with superconducting properties were known. Today more than 1,000 of these superconductors are known. In this photo a Bell Telephone Lab scientist B.T. Matthias has achieved the highest superconducting transition temperature–above 20.7 degrees K (zero degrees K, or Kelvin, is equivalent to minus 460 degrees Farenheit). The phenomenon of superconductivity has been a major factor leading the understanding of the behavior of metals at low temperatures.

FROM AN ALBUM

The World's First Switchboard Designed for Telephone Use --- Western Electric's "Universal Switch" Made in 1880



Courtesy of Western Electric Company

LATEST IN SWITCHBOARDS. *Western Electric's catalogue for 1880 featured the "Universal Switch," patented only one year before. In 1968 employee Bill Tracy poses with old board, phone and jacket of the period, duplicating a sketch in the catalogue. This was the world's first switchboard specifically designed and manufactured for telephone use. Western Electric is manufacturing and supply unit of the Bell System.*

SOMETHING NEW IN ELECTRONICS

Electronics Digest assumes no responsibility for, and does not necessarily recommend a product or service. News of new products or services is reported for informational purposes only.

PUBLICATIONS / SERVICES / PRODUCTS

Science Fair Electronics Announces the "Psychostrobe" Variable Speed Strobe Light

Science Fair is putting out a new electronic project kit called the "Psychostrobe," which will be on the market after October 15. This variable speed strobe light contains a xenon flash tube which operates at high or low intensities.

It requires high voltage across the cathode and anode, which is provided by the power supply, and a trigger pulse from the trigger circuit. Storage capacitors provide the power required to ionize the flash tube.

Strobes enable the experimenter to determine accurately the speed or rate of objects in motion or to enjoy as entertainment. The kits will be available for $19.95 in Allied Radio Shack stores.

Knight-Kit Rhythm Console

Add ten perfect rhythms to your band's sound, or provide a precise percussive accompaniment for backing a soloist with Knight-Kit's new Rhythm Console.

The Knight-Kit Model KG-393 Deluxe Rhythm Console electronically creates the sounds of bass drum, snare drum, claves, cowbell, maracas and high and low bongos with amazing realism through your microphone or instrument amplifier.

At the touch of a button it produces perfectly timed rhythms for swing, twist, slow rock, rhumbs, mambo, beguine, cha-cha, bossanova, tango or waltz. You can control the volume and tempo of the beats, and the sound of cymbals can be added in varying amounts to all rhythms except the rhumba, mambo and cha-cha.

Assembly of this solid-state kit is truly easy due to Knight-Kit's new "modular concept". Most parts are already soldered to the printed circuit boards, and critical circuits are wired and tested at the factory. All you need do is wire the interconnections, following the carefully detailed, step-by-step assembly instructions.

The Knight-Kit Model KG-393 Deluxe Rhythm Console is priced at $99.95, complete with 10ft. output cable for connection to any amplifier. AC operated. Size, 3½x12¼x11½".

Knight-Kit products are available exclusively through Allied Radio Shack. Sold through all Allied Radio Shack stores or by mail. Full details in the new 460 page Allied Radio Shack 1971 catalog. Available for $1.00 (refundable) from Allied Radio Shack, 100 N. Western Avenue, Chicago, Illinois 60680.

New Burnishing Tool For Precious Metal Electronic Surfaces

A new cleaning-burnishing tool for plated, etched, or screened hybrid microelectronic circuit patterns is available. According to the manufacturer, the device is useful for spot cleaning of precious metal surfaces being prepared for bonding or soldering operations. Without changing electrical properties the product removes oxides, resin, grease and other foreign material from metals, ceramics and plastics and other surfaces. Burrs on metal or plastic parts are quickly removed with the length-adjustable tool. The product is also useful on copper-plastic PC boards.

For additional information contact Starnetics Company, 10639 Riverside Drive, North Hollywood, Calif. 91602.

Edmund Scientific Announces Low Cost Air Pollution Tester

Learn just how bad air pollution is with the very first low-cost, survey-type tester in the world. With it you can quickly and easily determine quantitative results in the threshold limit ranges set by the American Conference of Government Industrial Hygientists.

Reported to be highly sensitive and accurate, the Air Pollution Tester Kit (No. 71,349) offered by Edmund Scientific Company contains 2 Ampoules each to test for Carbon Dioxide, Carbon Monoxide, Hydrogen Sulfide, Nitrogen Dioxide, and Sulfur Dioxide. Depending upon concentration, this supply is sufficient to test two to four times for each gas.

Science and ecology educators will find the new Edmund Scientific tester especially useful on field trips . . . sampling the air at industrial sites . . . discovering what chemicals are polluting our atmosphere . . . and experimenting with the effect chemicals have on plants.

The kit features an attractively designed, sturdy, plastic air samplins pump, and includes scales for determining results, coupling tubes, (10) break - tip Ampoules, and a complete set of instructions.

Testing is simple. The pump draws air through an Ampoule, containing an impregnated chemical specific to the pollutant. The length of stain, that appears inside the Ampoule, indicates the concentration of gas in the air. Testing only takes minutes.

Replacement Ampoules are available in individual packages of four each.

For additional information write to: Edmund Scientific Co., 380 Edscorp Bldg., Barrington, N. J. 08007.

New Galaxy "550 Line" 5 Band SSB Transceiver For Radio Amateurs

Galaxy Electronics announces the GT-550, 5 Band SSB Transceiver with a line of matching accessories for coverage of the 80, 40, 15, and 10 meter amateur radio bands.

According to the manufacturers report, the GT-550 features solid-state circuits where they provide maximum performance and reliability.

The GT-550 Transceiver is a 5 Band SSB transceiver designed for either mobile or fixed station use. Although it is a compact 11¼" x 12 3/8 x 6" and weighs only 17 pounds, it has 550 watts SSB power, 360 watts CW!

For further information please send a postcard marked "GT-550, 10/70" to new products editor, Electronics Digest, 2615 West 7th Street, Fort Worth, TX 76107.

AVA Publications Offer Much Helpful Information

The American Vocational Association provides the vocational, technical and practical arts fields with valuable booklets and pamphlets not available elsewhere. Recently issued publications include the following.

Principles of Vocational Education: A Review of the Historical Background with a Focus on the Present. 4 x 9, 12 pages. Single copies, .50. Order number 27369 (January 1970). First in a series of thought-provoking articulations of basic ideas and beliefs about vocational education. Based on a presentation by Dr. Melvin Barlow of UCLA.

To obtain these publications, make check payable to American Vocational Association and send with order to Publications Department, AVA, 1510 H Street, N.W. Washington, D.C. 20005.

NEWS DIGEST

Alexanderson Papers Donated to Union College

Schenectady, N.Y.—Ernst F.W. Alexanderson, the electronics pioneer, whose invention first made possible home television reception, has donated his collected papers and documents to Union College, the college announced recently.

Alexanderson gave the first home demonstration of television in Schenectady, N.Y., in 1927, using high frequency neon lamps and a perforated scanning disc. He gave the first public demonstration of television on Jan. 13, 1928.

He initially gained an international reputation in 1906 when he constructed the first high frequency alternator which made possible long distance radio transmissions.

His inventive career spanned more than half a century during which time he was credited with 321 patents. His final patent was the 1955 invention of the color television receiver.

Alexanderson, now 92, lives in Schenectady. He received an honorary degree from Union College in 1926.

Educated in his native Sweden and in Germany, he came to the United States in 1901 to visit the famous scientist Charles Steinmetz who worked for the General Electric Company and taught at Union College.

Alexanderson was hired by GE in 1902 on the recommendation of Steinmetz and continued to work full time for the company until 1948 and as a consultant for another decade. After his formal retirement, he also served as a consultant for the Radio Corporation of America for whom he developed the color television receiver.

General Electric Company

Even at the age of eighty-seven Dr. Alexanderson was still spending every morning studying the use of semiconductors.

The value of his pioneering work in radio was illustrated dramatically in 1923, when his son was kidnapped from in front of the family home, but was found unharmed when a broadcast description led to the recovery of the child and the capture of the kidnappers.

The Alexanderson papers is a complete collection of his work including five filing cabinets of notes, correspondence and unedited reports and manuscripts.

These have been placed in the Union College archives along with a collection of Charles Steinmetz papers and those of another engineering pioneer Ernst Berg.

Computer Has Own Phone Line—Answers in Crisp Touch-Tones—At University of Illinois

URBANA, ILL.—A computer in the University of Illinois at Urbana-Champaign has its own telephone line and number which it answers in crisp touch-tones.

It tells students and staff if jobs submitted for computation have been finished, and can jar a caller with the answer "Boooooooo" meaning, "You goofed."

Service activities of the university's department of computer science annually involve 300,000 student assignments and 150,000 research projects from over the campus.

Everyone wants to know when his job is done.

An older answering service involves tape recordings made hourly which recite job numbers completed. This can become long and involved because as a result of extra handling or needs, the jobs are not necessarily run in sequence.

Anyone calling in has to listen to the whole two-minute recording. Then he wonders if his own job has been finished since the recording was made.

Now the computer answers with last-second information. This is how it works: The caller, using a standard 12-button touchtone phone, calls the computer's number, then punches out the digits of his job number and a query symbol.

The computer answers with high, middle or low—"bee," "bah" or "boo"—touch-tones (2,205 cycles per second, 1,1785 cycles or 1,017 cycles).

Answers and their meanings go like this:

"Baaaaah boo boo boo"—job has not been loaded.

"Baaaaah bah bah bah"—job is in system.

"Baaaaah bee bee bee"—job is out, completed.

"Boobahbee"—busy, wait.

"Beebahboo"—computer not working.

"Boobahbeeboobahbee"—time-sharing is off.

"Boooooooo"—wrong job number, you goofed.

Prof. Harry G. Friedman Jr. says that since the computer now has only one telephone line, both the tape and touchtone answers will be available until more lines are installed.

Touchtone phones are being placed in the computer center, at five points on the campus which through the university's Illinet computer network have direct access to the machine.

From these, or his own phone if it's a 12-button touchtone, anyone, student or professor, can call and hope his answer is "Baaaah bee bee bee" and not "Baaaah boo boo boo."

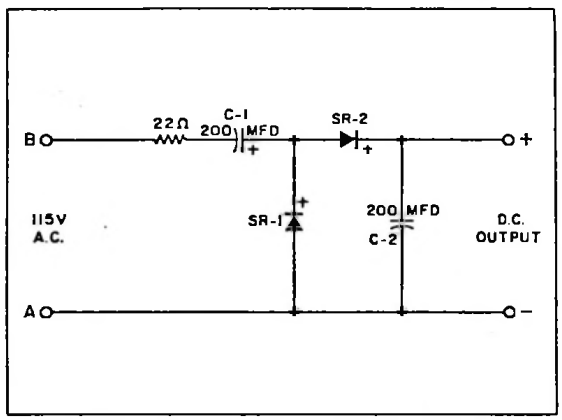
Good News For Hams Who Are Handicapped

The Radio Amateur's Handbook published by the American Radio Relay League, is now available on magnetic tape from the Division for the Blind and Physically Handicapped. Nineteen reels long, this handbook is considered the standard manual of amateur radio communication—a valuable aid to both the beginning or experienced radio amateur.

Readers may borrow the book (order number MT 4184) by writing to the Division for the Blind and Physically Handicapped, Library of Congress, Washington, D.C. 20542. The handbook can also be purchased from Science for the Blind. For price and ordering information write Science for the Blind, 221 Rock Hill Road, Bala-Cynwyd, Pa.

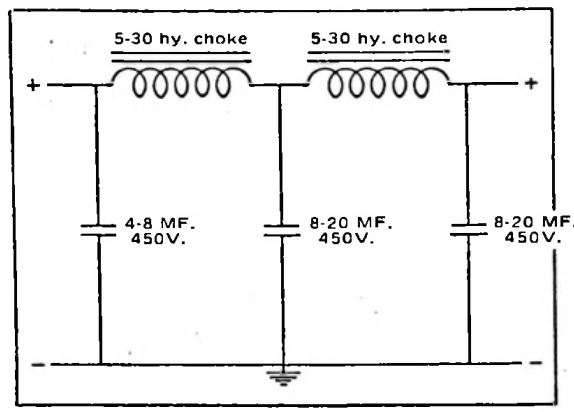
Tips on Understanding Radio Power Supplies

Half-Wave Selenium Power Supply



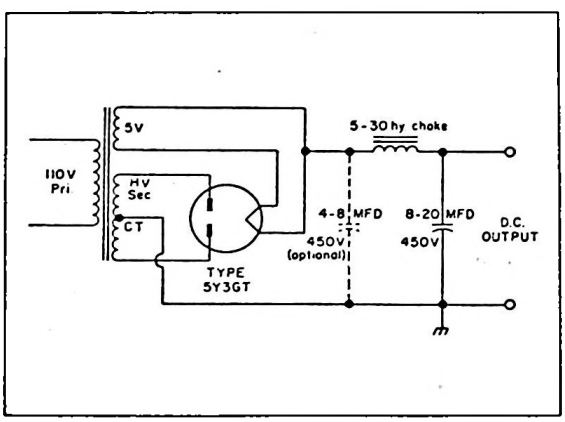
This selenium rectifier power supply delivers DC output at twice the AC line potential without a step-up transformer. When point A is positive with respect to B, current flows through SR1 charging C1 to peak line potential. On the next half cycle point B is positive with respect to A and the charge stored by C1 plus the line potential flows through SR2 developing a voltage equal to twice the line potential across C2.

Power Supply Filter



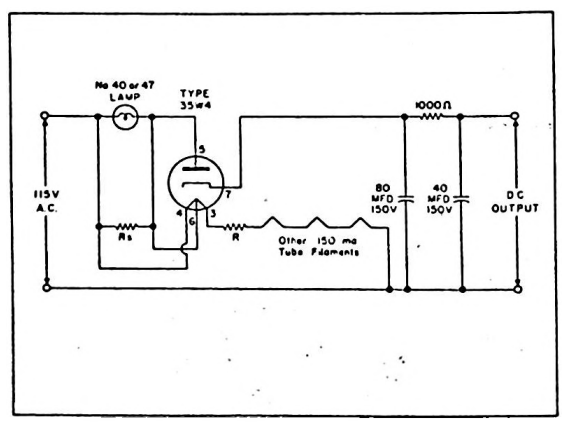
The function of the filter is to smooth pulsating voltage, supplied by the rectifier output, into steady DC voltage. Filter networks may be single or double-section types; the latter provides better smoothing. Filter chokes should have high inductance and low DC resistance. Current-carrying capacity must exceed total plate current of all tubes plus any voltage dividers or bleeder resistors. Capacitor voltage ratings should be higher than voltage between plus and minus.

Full-Wave Power Supply



The diode used here has one filament and two plates. Current flows from each plate alternately on its positive half-cycle and results in pulsating DC, which is at twice the frequency (120 cycles per second) provided by a half-wave system. The full-wave system, since current flow is more uniform, is easier to filter. The capacitor, shown by dotted lines, increases output voltage but decreases regulation. Use of a power transformer provides higher voltages than those available from an AC-DC supply.

AC-DC Power Supply



The half-wave rectifier circuit shown is commonly used in AC-DC radios. As current flows only on the half cycle when the plate is positive with respect to the cathode, the DC output has a 60 cycle ripple. Large values of capacity are therefore required in the filter network. The voltage drop across R and all heaters should total 115 v. Rs should be 300, 150, 100 ohms for load currents of 70, 80, 90 ma respectively. Rs is not required for loads under 70 ma. The values given are for a type 35W4 tube.

A Programmed Lesson on the PN Diode and Transistor

This self-teaching lesson presents the basic theory essential to understanding modern-day semiconductor diode and transistor functions particularly useful for students, hobbyists, and as a teaching aid for the science instructor

by Wesley A. Vincent BSEE, MSE
Electronic Engineer, Motorola, Inc.

This self-teaching lesson presents the basics necessary for understanding semiconductor diode and transistor action. With a knowledge of the essentials discussed in this programmed article, you'll also be better prepared to understand the theory of other semiconductor devices used in electronics today.

First, start by reading frame 1 and answer ng the question at the end. If you answer the question correctly you'll proceed to the next concept. If your answer is incorrect you'll be asked to further consider the question and select another answer. Do not read the frames consecutively or in numerical order but follow the frames indicated. There are a total of 23 frames in this lesson, however, if you answer each question correctly you'll read only 9 frames.

1 A semiconductor, as the name implies, is not quite a conductor but neither is it an insulator. The basic difference in a conductor, insulator and semiconductor is related to the number of electrons in the outermost shell, or orbital ring, of the individual atoms. The atom, remember, can be modeled after our solar system. In this model the nucleus of the atom which contains protons and neutrons is analogous to the sun, while the electrons revolving around the nucleus parallel the planets revolving around the sun. Of course, the atom is so small that it is impossible to see even with the most powerful microscopes. Atoms of an element may contain up to 8 electrons in the outermost shell. However, only the inert gases contain atoms whose outermost shell is complete. Electrons in an incomplete shell are called valence electrons and determine whether an element will be a conductor, insulator or semiconductor.

QUESTION: A semiconductor contains atoms with which of the following properties?

1) The outermost shell contains a few valence electrons . . . Turn to frame 4.

contd

2) The outermost shell is half filled with electrons . . . Turn to frame 7.

3) The outermost shell is almost completely filled with electrons . . . Turn to frame 10.

2 Your answer is incorrect.
Note that holes and electrons leave behind positively charged donors or negatively charged acceptors when they cross the junction. These fixed charges repel like charges and form a barrier preventing all the holes and electrons from crossing the junction. Choose another answer in frame 11.

3 Your answer is correct.
By introducing small amounts of an element such as arsenic with five valence electrons, the supply of free electrons increases within the semiconductor.

Note, however, that answer 2 is correct also. That is, the conductivity of a semiconductor increases when an impurity extracts electrons. Consider, for example, what happens when boron atoms with a valence of +3 are added to an undoped or "intrinsic" semiconductor. The semiconductor crystal needs four electrons to complete its symmetry, but boron with only three valence electrons upsets this symmetry and captures an electron from a neighboring semiconductor atom. The semiconductor atom then becomes positively charged and may attract an electron from another neighboring semiconductor atom. This process continues with the result that a positive charge called a "hole" is transferred randomly throughout the crystal. The hole contributes to current flow which is positive, or opposite to that of electron flow. Turn to frame 11 and begin reading with the second sentence.

4 Your answer is incorrect.
Atoms which contain a few electrons in their outermost shell are not bound tightly to their nucleus and may be dislodged easily. These atoms make up good conductors, since the electrons that break away from their parent atom are readily available to comprise a current flow. Examples are aluminum with three valence electrons, copper with one or two valence electrons, and silver with one valence electron. Return to frame 1 and select another answer.

5 Your answer is correct.
Holes and electrons cross the junction and combine until acceptors on the P side and donors on the N side create a barrier voltage due to their respective charges. An equilibrium state is reached after the barrier voltage is formed, thereby preventing further electron or hole movement across the junction. Near the junction on both the P and N side, a region called the depletion region is absent of any charge carriers.

QUESTION: If a battery is placed across the junction diode as shown in figure 2, what action takes place?

1) The PN diode is said to be forward biased and current conducts through the diode . . . Turn to frame 12.

2) The PN diode is said to be reverse biased and no current conducts through the diode . . . Turn to frame 9.

3) Current conducts only momentarily, until all free charge carriers cross the junction and combine . . . Turn to frame 19.

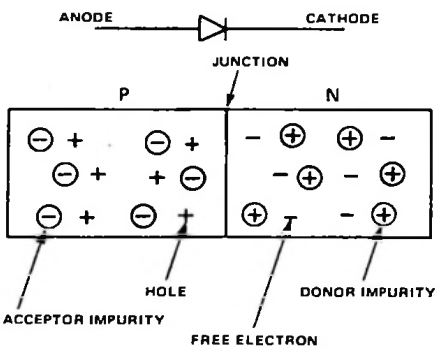


FIGURE 1 (FRAME 11)
THE PN DIODE AND SCHEMATIC SYMBOL. ACCEPTORS AND DONORS REMAIN FIXED WITHIN THE CRYSTAL, WHILE HOLES AND ELECTRONS ARE FREE TO MOVE. THIS DIAGRAM SHOWS THE POSTION OF THE HOLES AND ELECTRONS BEFORE BONDING

6 Your answer is incorrect.
The diode breakdown characteristic occurs under the biasing shown in figure 3, but at high voltages. Return to frame 12 and select another answer.

7 Your answer is correct.
Atoms which contain only a few electrons in their outermost shell are good conductors, while good insulator atoms have their outermost shell almost completely filled. Semiconductors such as silicon or germanium, have their outermost shell half filled and are said to have a valence of $\pm$ four.

A pure semiconductor is actually a very poor conductor and becomes useful for electronic conduction only when additional atoms are added to it. These atoms are called impurity atoms and are said to "dope" the semiconductor. The conductivity of the semiconductor is determined by their presence, but the basic characteristics of the semiconductor does not change. In other words silicon still remains silicon when impurity atoms are added to it.

QUESTION: How could a semiconductor be made a better conductor?

1) Add a small amount of another element capable of supplying extra electrons as current carriers . . . Turn to frame 3.

2) Add a small amount of another element capable of extracting electrons from the semiconductor atom . . . Turn to frame 15.

3) Either of the above . . .Turn to frame 11.

8 Your answer is incorrect.
To increase the current gain we want to decrease the base current. With many free electrons in the base region due to heavy doping, the base current would increase. Usually the emitter is doped heavier than the base to increase current gain. Return to frame 13 and select another answer.

9 Your answer is incorrect.
Holes are attracted to the negative terminal of the battery while electrons are attracted to the positive battery end. Thus, both holes and electrons cross the junction for the diode shown in figure 2. Return to frame 5 and select another answer.

10 Your answer is incorrect
Atoms whose outermost shells are almost completely filled hold tightly to their electrons and do not give up any electrons to allow current flow. Insulators contain these types of atoms. Return to frame 1 and choose another answer.

11 Your answer is correct.
A donor impurity adds free electrons to a semiconductor and causes the semiconductor to become N-type. where N designates the negative charge of the free electrons. The donor position is fixed within the crystal and becomes positively charged after losing an electron. Acceptors on the other hand extract electrons from the semiconductor and allow current conduction through the movement of holes. Acceptors also remain fixed within the semiconductor, and become negatively charged when accepting an electron and creating a hole. Hole movement can be thought of as a positive movement of charge and designates the semiconductor P-type.

Let's now consider what happens when we bond a piece of N-type semiconductor to a piece of P-type semiconductor as shown in figure 1. This arrangement is called a junction diode and is only one step away from the transistor.

QUESTION: When the P and N semiconductor materials are bonded together as shown in figure 1, which of the following processes take place?

1) All of the holes and electrons combine with the result that there are no carriers in either the P or N side . . . Turn to frame 2.
2) Holes and electrons combine until the repelling force of the acceptors on the P side and donors on the N side, prevent further combinations . . . Turn to frame 5.
3) Nothing happens until a voltage is applied across the diode . . . Turn to frame 16.

12 Your answer is correct.
QUESTION: If a battery is placed across the diode as shown in figure 3 what action takes place?

1) Very little current conducts through the diode which is said to be reverse biased . . . Turn to frame 18.

contd

2) Diode "breakdown" occurs even with small voltages . . . Turn to frame 6.
3) Current conduction takes place, similar to a forward biased condition . . . Turn to frame 22.

13 A transistor is formed when an additional semiconductor region is added to a PN diode to form a PNP or NPN arrangement as shown in figure 5. The center region is called the base while the outer regions are called the collector and emitter as shown in the diagram. Let's consider the action of the PNP transistor in the grounded emitter or common emitter circuit shown in figure 6. Common collector and common base configurations are also possible, but the most useful transistor amplifier stage is the common emitter. For normal operation the base-emitter junction is forward biased while the base-collector junction is reverse biased. The forward voltage on the base-emitter junction, forces holes into the base region and electrons into the P region as with the PN diode. However, because of the large reverse bias of the base-collector junction, not all of the holes combine with electrons in the base region. Instead, most of them are attracted to the negative battery terminal at the collector and are said to diffuse through the base region. In the collector, holes combine with electrons that enter from the negative battery terminal which results in electron flow through the output circuit. Some holes combine with electrons in the base region causing base current through resistor R_B. Base current is also produced by electrons from the base crossing the base-emitter junction and combining with holes in the emitter.

Varying the base to emitter bias voltage provides a means of controlling the amount of electron flow between collector and emitter. Note that since most of the holes leaving the emitter do not combine in the base that more current is available in the output collector circuit than in the input base circuit. Thus, the transistor acts like an amplifier with current gain between the base and collector terminals.

QUESTION: How can the current gain of the transistor be increased?

1) Decrease the thickness of the base region . . . Turn to frame 17.
2) Dope the base region of the transistor much more heavily than the emitter region . . . Turn to frame 8.
3) Increase the reverse bias on the base-collector junction for the circuit shown in figure 6 . . Turn to frame 21.

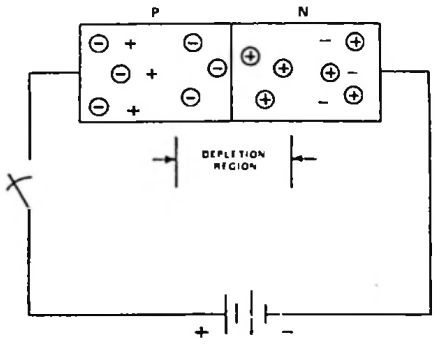


FIGURE 2 (FOR FRAME 5)
WHICH WAY DO THE CHARGE CARRIERS MOVE WHEN THE SWITCH IS CLOSED? (NOTE THAT THE DEPLETION REGION CONTAINS FIXED CHARGES BUT NO CHARGE CARRIERS!

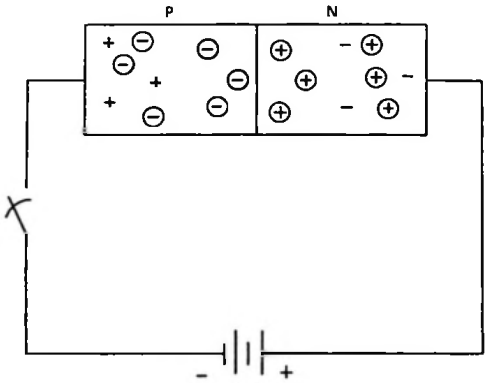


FIGURE 3 (FRAME 12)
AFTER THE SWITCH IS CLOSED, DOES THE DIODE CONDUCT?

14 Your answer is incorrect.
Re-examine figure 8 and choose another answer to frame 17.

15 Your answer is correct.
By introducing small amounts of an element capable of extracting electrons, a semiconductor atom becomes positively charged. The positive charge called a "hole" is then transferred when the semiconductor atom regains another electron from a neighboring atom. This process continues with the result that the hole moves randomly throughout the crystal. The hole with a positive charge contributes to a flow of current positive in nature.

Note that answer 1 is correct also. That is, the conductivity of a semiconductor also increases when an impurity adds electrons within the semiconductor. Arsenic with five valence electrons shares four of its valence electrons with a neighboring semiconductor atom. The fifth electron, however, is left to randomly move about the semiconductor. The resistance of the semiconductor then decreases with the additional charge carriers. Turn to frame 11 and begin reading with the second sentence.

16 Your answer is incorrect.
The holes and electrons are free to move within the diode. Apply the rules for attraction and repulsion of like and unlike charges and choose another answer to frame 11.

17 Your answer is correct.
Holes from the emitter find it much easier to pass through a thin base region. The net effect is that fewer holes combine in the base, and the input current is less for a given output current. Hence, the transistor current gain has been increased.

An NPN transistor amplifier stage can be formed by reversing the power supply polarities as shown in figure 7. Figure 8 shows a "family" of curves relating the base current, collector current and collector voltage for an NPN transistor.

QUESTION: For the characteristics shown in figure 8, determine the transistor current gain for a collector current of 15 ma, at a collector voltage of 10 volts.

1) Current gain is 100 . . . Turn to frame 20.
2) Current gain is 50 . . . Turn to frame 14.
3) Current gain is 75 . . . Turn to frame 23.

18 Your answer is correct.
The small current that conducts is called leakage current and occurs when thermally generated hole-electron pairs cross the junction.

The V-I characteristic curve of the diode in figure 4, shows that the diode is essentially a one-way device for reverse voltages less than breakdown. For this reason, the diode is useful as a rectifier to convert a.c. signals to d.c. currents and voltages.

Diode breakdown occurs when charge carriers crossing the junction acquire enough energy to produce additional charge carriers upon collision with semiconductor atoms. An avalanche multiplication process results, with large reverse currents occuring as the breakdown voltage is exceeded.

This completes our discussion of the diode. Turn to frame 13.

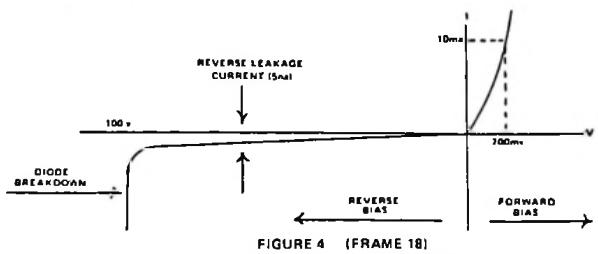


FIGURE 4 (FRAME 18)
TYPICAL VI CHARACTERISTICS FOR A SILICON PN DIODE

19 Your answer is incorrect.
Current is continuous since electrons are supplied by the battery at the negative terminal and new holes are continually being created within the semiconductor on the P side. Return to frame 5 and choose another answer.

20 Your answer is incorrect.
Re-examine figure 8 and choose another answer to frame 17.

21 In actual operation, increasing the reverse bias on the base-collector junction will increase the current gain, but not by significant amounts. Return to frame 13 and choose another answer.

22 Your answer is incorrect.
Apply the laws of attraction and repulsion for the charge carriers and battery terminals, and choose another answer in frame 12.

23 Your answer is correct.
The current gain for a common emitter transistor is commonly referred to as beta (B) or HFE, and is used as a figure of merit for comparing different transistor types.

There are many other parameters used to characterize the transistor. They include maximum voltage and current ratings, frequency dependent parameters and transient times for switching operation. Tradeoffs are made during manufacturing to optimize some parameters at the expense of others.

This frame completes our introduction to transistor and diode operation.

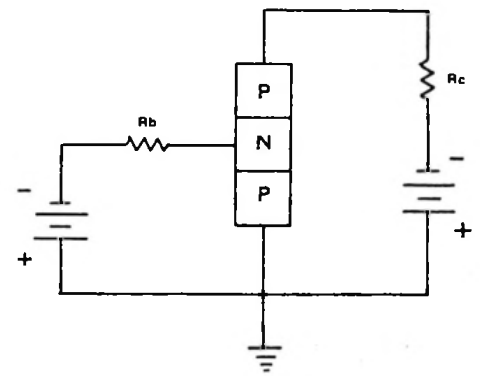


FIGURE 6 (FRAME 13)
PNP COMMON EMITTER STAGE–Rb AND Rc LIMIT THE CURRENT IN THE BASE AND COLLECTOR CIRCUITS RESPECTIVELY

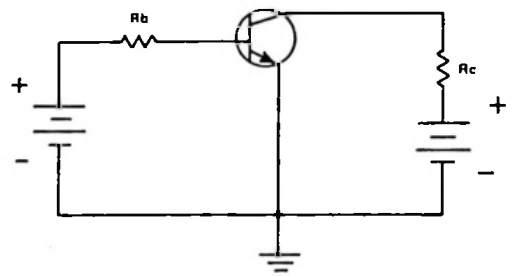


FIGURE 7 (FRAME 17)
COMMON EMITTER NPN STAGE

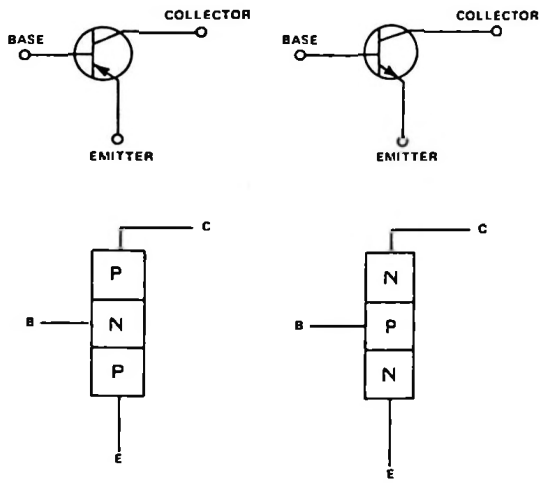


FIGURE 5 (FRAME 13)
PNP AND NPN TRANSISTORS–BOTH TYPES CONTAIN TWO PN JUNCTIONS

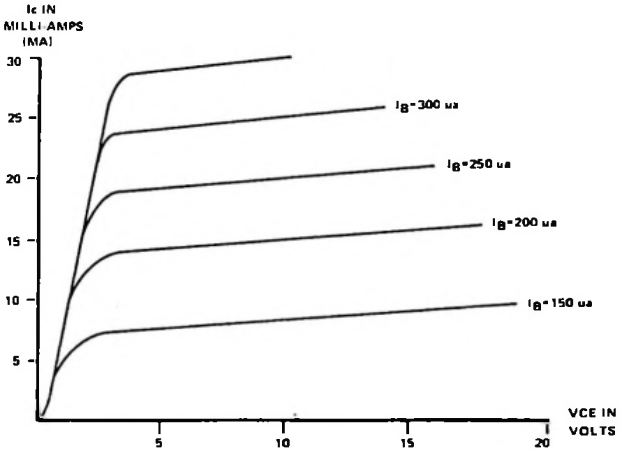


FIGURE 8 (FRAME 17)
CURRENT GAIN CHARACTERISTIC CURVES FOR THE NPN TRANSISTOR IN FRAME 17

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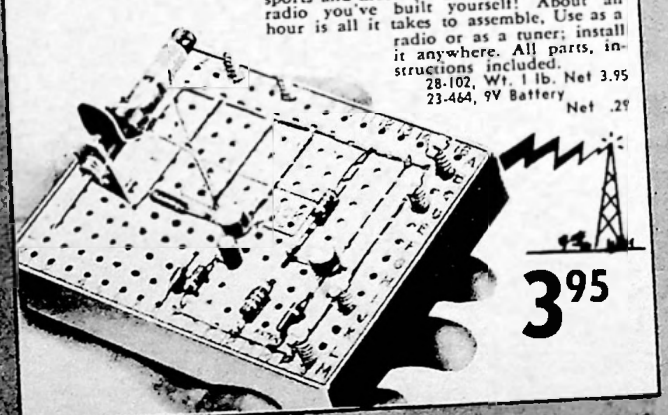

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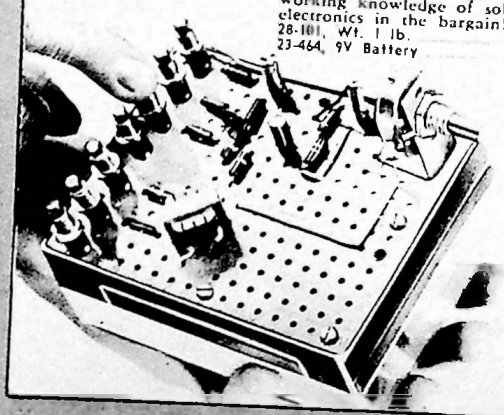

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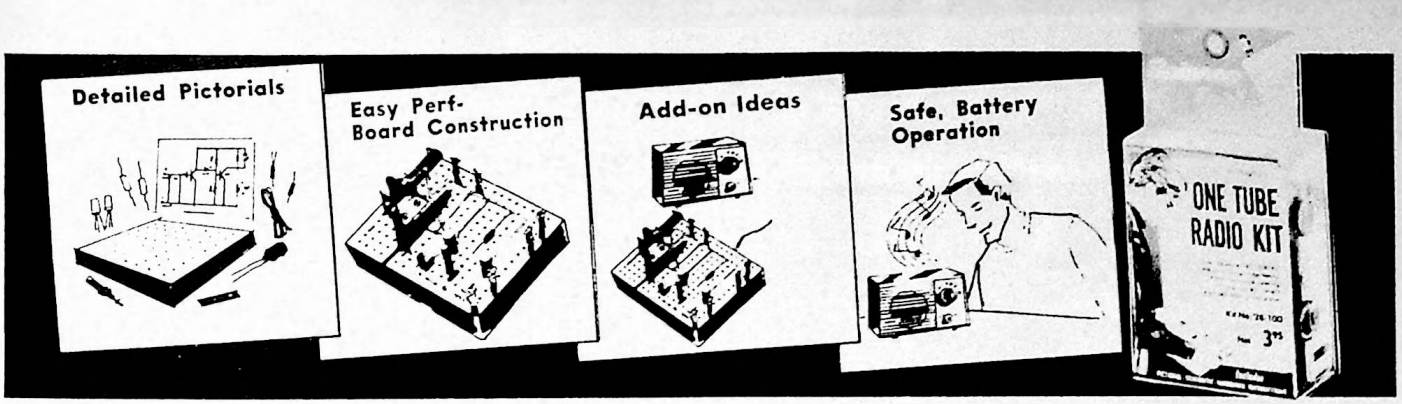

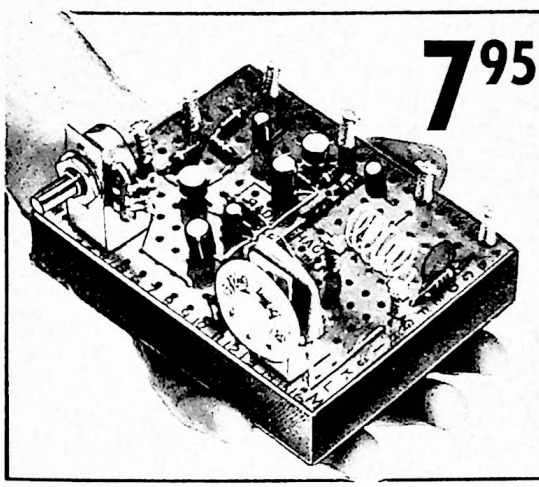

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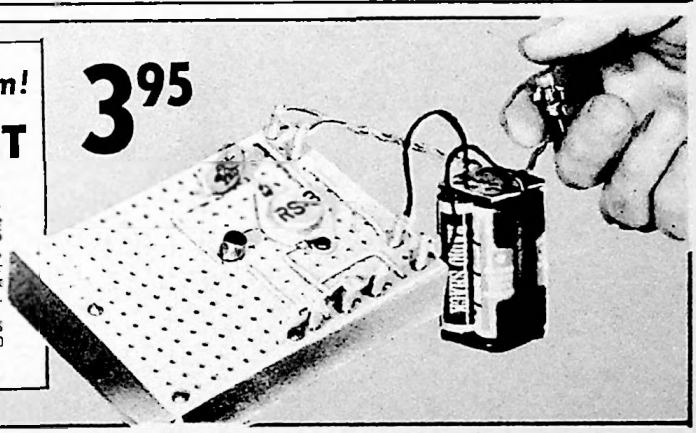

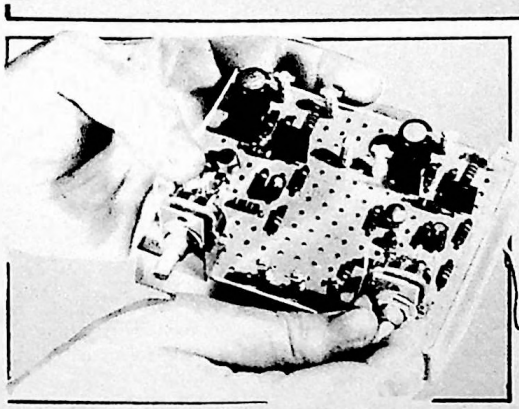

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