NOVEMBER / DECEMBER 1970
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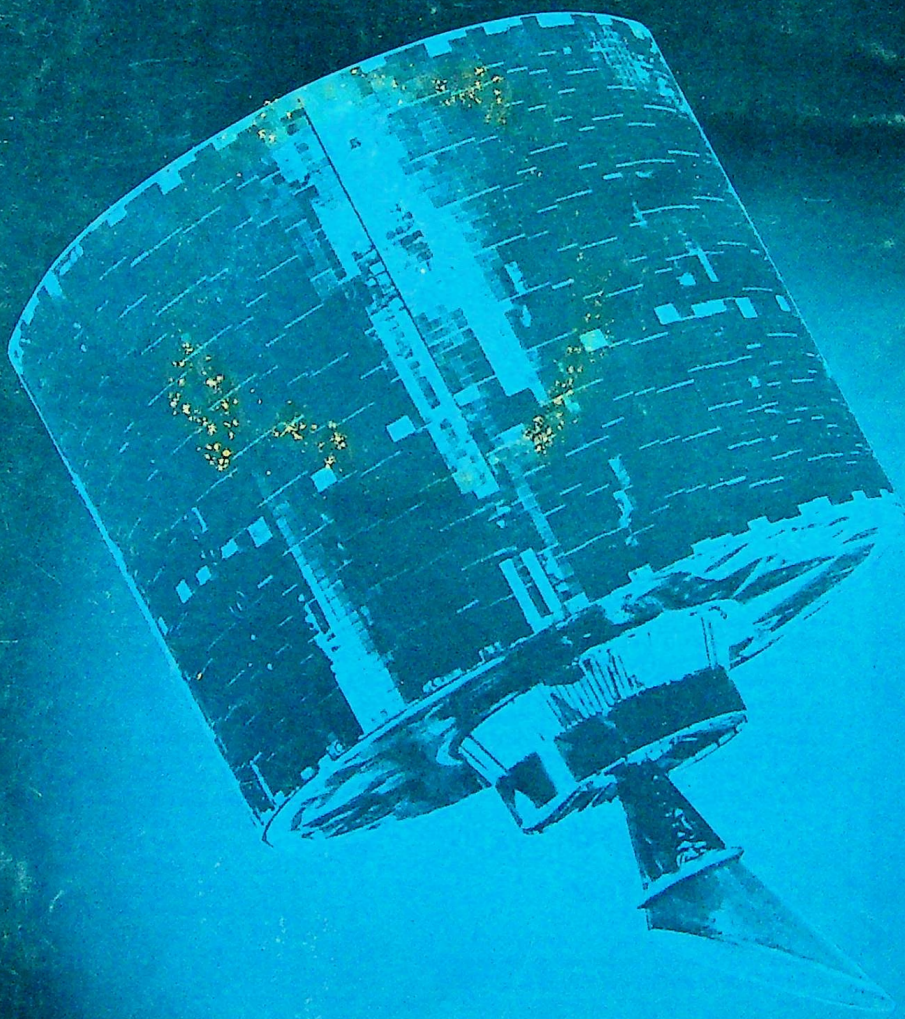
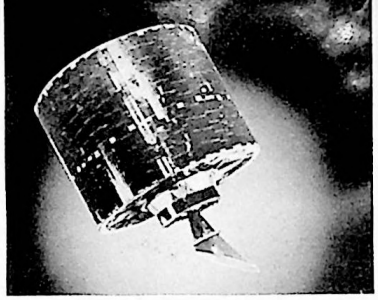
Electronics Digest



Season's Greetings



COVER STORY

And finally . . . mankind set in the heavens a star which he had built from the resources of nature to relay with the speed of lightning his talking pictures of events as they happen. With his handiwork he gave a new key of knowledge to people from the four corners of the earth — and the people of every nationality, kindred and tongue became neighbors in reality. This giant step in space and time protends a new era of understanding . . . a new hope for a world at peace.

You will hear more of this star, which we know as INTELSAT (International Telestar Satellite), for it is only a beginning . . . a milepost for mankind.

Only sixty-nine years ago, December 15, 1901, the people of our country read the Sunday newspaper with tingling excitement as it related the amazing feat of Guglielmo Marconi who had sent and received a signal without wires across the Atlantic Ocean — from Poldhu, Cornwell, England to St. John's, Newfoundland. But it was only a beginning . . . a milepost for mankind.

These two events represent mileposts of incalculable importance along man's great journey since the beginning. As he now stands, perhaps at the crossroads of civilization, may his steps be such that the generations who may appraise our way of life a thousand years from now may say of us: "This was their finest achievement . . . peace on earth, goodwill toward men."

Editors Note: Mr. James H. Kilcoyne, Jr., Information Office for Communications Satellite Corporation, reports to Electronics Digest that major networks have made inquiries during the past two Christmas seasons regarding the possibility of transmitting religious services from the Holyland via INTELSAT. Mr. Kilcoyne further stated that, "With regard to the future, technically there is no reason why it could not be done as soon as the earth station in Israel goes into service sometime in 1972."

Electronics Digest

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Electronics Digest

THE ELECTRONICS MAGAZINE FOR HOME AND SCHOOL

VOLUME FOUR / NUMBER THREE

November/December 1970

William M. Palmer, *W5SFE*
Editor

IN THIS ISSUE . . .

IN THE NEXT ISSUE . . .

A programmed lesson in electronics, Magnetic Effects and Electromagnetism; Use of Electric Power Reduces Air Polution; a new series of student-paced audio/visual training programs for the electronics technician curriculum of Chaffey College . . . read about it in News Digest; another old time radio project for the home or school museum . . . Old Time Loop Antenna, which may be used in a radio project to be published in a future issue of Electronics Digest.

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 November/December 1970 (Vol. 4, No. 3). Published bimonthly 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.

Printed in the United States of America

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SCIENCE REPORTS

New developments in the field of electronics

Westinghouse Has New System to Help Prevent Airplane Hijacking

Pittsburgh, Pa.—Westinghouse Electric Corporation has developed a new type of electronic "gun detector" to detect and identify weapons being carried aboard airliners.

The Westinghouse security systems division is developing a version of the equipment for evaluation under daily full-scale airport service, William S. Perkins, general manager of the division, reported recently.

The gun detector was developed at the Westinghouse Research Laboratories by W. J. Carr, Jr., R. C. Miller and G. T. Mallick, Jr.

One element of the detector is a passageway about seven feet high, three feet wide and three feet deep through which airline passengers move at normal walking speed. The presence of a pistol or of a carbine or similar weapon, concealed on the person or in a handbag or an attache case, activates electronic circuitry that triggers an alarm.

The new Westinghouse system has several advantages over previous weapon detectors designed to deter airplane hijacking:

- it detects and identifies weapons of small size and mass, which might otherwise be carried aboard a plane unnoticed;
- it ignores, with high reliability, common objects such as radios, cameras, aerosol cans, keys, flashlights, hairdryers, and other objects that customarily trigger false alarms;
- it responds rapidly—within the three-foot walking space — and thus causes a minimum of delay in airport operations.

SYSTEM PINPOINTS SMALL WEAPONS

"The danger and expense of airplane hijackings have become intolerable," Mr. Perkins said, "and dictate that the best modern electronic technology be applied toward a solution of the problem. We believe that this Westinghouse development is a major step in this direction."

Mr. Perkins said that the new gun detector can pinpoint within the system's walkway a weapon as small as a 22-caliber revolver, which weighs about seven ounces and is about four inches long. Weapons carried in a shoulder holster, belt holster, trouser pocket, or otherwise concealed on the person or in an attache case will activate the system's alarm.

The Westinghouse gun detector is classified as an alternating-current electromagnetic device, relying upon solid state and computer technology in its operation. No further details of the system's construction or operation were disclosed by Westinghouse.

"We believe that this new security system will effectively spot potential airplane hijackers and reduce the false alarms from 'innocuous' objects that cause embarrassment to both airline customers and airline officials," Mr. Perkins said.

New X-Ray Image Tubes Lowers Radiation Dosages While Providing Brighter Images

Palo Alto, Calif.—Two X-ray image tube types are now available from Varian /EMI for use primarily in medical applications.

When used with modern diagnostic X-ray equipment, the new image tubes provide such major advantages as:

1. Extremely detailed, bright images of the workings of the body are available while using lower X-ray dosages, thus providing genetic health safeguards.
2. The improvement in information transfer resulting from better X-ray detection is especially promising in the diagnosis of cardiac ailments.
3. The output is intense enough to permit motion picture filming of the information presented, or the pickup of the information by TV cameras for closed circuit TV presentation.

The image tubes, which are available with 15 cm input, 15 mm output and 22 cm input, 20 mm output, are also well suited for nondestructive testing of such products as electronic solid state components, guidance mechanisms, and metal ingots.

MEDICAL APPLICATION DESCRIBED

The primary application of these devices currently is in the medical diagnostic field. X-ray penetrating a patient under examination are converted by the device into a visible light pattern, showing the internal structure of the human body in much the same way as does the familiar X-ray film, with the added advantage that continuous motion studies of the body can be made.

The luminous output energy of the device is sufficient to allow motion picture filming of the information presented. Also, the same light output images from the device can be picked up by television cameras for closed circuit TV distribution to several terminals, thus permitting video tape recording as well as direct viewing.

In addition to enhancing direct visual observation, the tubes are well suited to produce high quality still and motion pictures at reduced X-ray doses.

PRINCIPLES OF OPERATION

The X-ray image tube is a vacuum device whereby X-ray energy is converted into visible light energy.

A large area X-ray sensitive spherical "converter" is located immediately inside the large diameter end of the tube enclosure. This element converts X-ray energy into photo-electrons by a multiple conversion process. Therefore, when an X-ray beam falls upon the X-ray sensitive input pack, a pattern of electrons is emitted into the vacuum in direct relation to the incident X-ray pattern; the more intense the localized X-radiation, the greater the corresponding localized electron emission.

This large area pattern of photo-emitted electrons is accelerated and focused onto a small phosphor screen located at the small diameter end of the tube and is greatly reduced in size compared with the original electron pattern. The phosphor screen converts the incident electrons into visible light energy.

The X-ray-to-electrons converter (the X-ray sensitive input pack) shows higher absorption and hence increased information extraction than conventional converters. The quantum efficiency of

(continued on next page)

(continued from page 5)
the converter, expressed by the ratio of emitted electrons to incident X-ray quanta, is appreciably higher than for conventional X-ray-to-electron converters, yielding a very high output brightness for normal values of the incident X-ray flux.

The resulting tube yields higher brightness, better information extraction and improved noise and resolution figures.

For information, write: Varian/EMI, 601 California Ave., Palo Alto, Calif. 94303. In the U.K., write: EMI, Hayes, Middlesex, England.

Westinghouse and Johns Hopkins Develops Balloon Pumping Device To Assist Failing Hearts

Pittsburgh, Pa.—Westinghouse Electric Corporation announced today that researchers are developing intra-aortic balloon pumping equipment to assist failing hearts of coronary attack victims.

The project, a team effort of Westinghouse and Johns Hopkins University, is the first part of a program at the Westinghouse Research Laboratories to develop temporary heart assist systems. The program is funded by the National Heart and Lung Institute.

Intra-aortic balloon pumping is an experimental technique for saving victims of cardiogenic shock, a condition that may follow heart attack and kills thousands of Americans yearly. The left ventricle of the patient's heart is unable to pump enough blood.

A long, slender balloon looking something like a narrow sausage is inserted in the aorta, the main artery leaving the left ventricle. The balloon automatically inflates and deflates in rhythm with the patient's heart beat.

It expands in between heart beats, forcing blood into the circulatory system and, most importantly, into vessels that supply the injured heart itself. It collapses just before the heart squeezes, so that the heart pumps blood into a nearly empty aorta that gives little back pressure, thus relieving the heart of part of its work load.

The balloon is at the end of a long, hollow tube called a catheter. It is threaded up to the aorta through an incision in the groin, where a main artery—the femoral artery—is most accessible.

Pumping is controlled by electrical signals from the patient's own heart, called EKG signals, that are sensed by electrodes taped to his chest. The ability of the device to interpret EKG signals and recognize when to act, called a logic function by engineers, operates even during episodes of irregular heartbeat.

Intra-aortic balloon pumping is an emergency procedure that is used until the crisis is over.

Prototype devices are now undergoing pre-clinical evaluation and refinement.

Dr. Joseph M. Evans, manager of biosciences and medical systems research at the Westinghouse Research Laboratories, is project leader. The Johns Hopkins effort is headed by Dr. V. L. Gott. H. F. Minter and L. C. Vercellotti of the Westinghouse Laboratories manage research groups developing sub-systems for the project. G. E. McGinnis, formerly of Westinghouse, directed early project planning.

"Developing components that will never fail in use is a major goal of the project," Dr. Evans said.

He cited balloon design as an example. Project scientists devised a method to make polyurethane balloons without forming any seams, which could be weak points where rupture might occur.

The equipment also contains fail-safe mechanisms. In the remote event that a balloon should develop a leak, for instance, pressure sensors would detect the failure and immediately stop the pumping. The gas used to pump the balloons is carbon dioxide, which could be safely absorbed by the blood.

New Power Analysis System Records Malfunctions Without Surveillance

Data Research Corporation, Fort Lauderdale, Florida, has developed the Data Power Sentry, a complete power analysis system that monitors and records power malfunctions continously for weeks at a time without surveillance. The package is comprised of a recording device, transient detecting electronics, and a timing reference, all housed in a single unit. No other equipment is necessary to obtain a full and accurate long term diagnosis of power malfunctions.

The first time a power surge or leakage occurs outside predetermined limits, Data Power Sentry detects the violation, clocks its precise time of occurrence, activates the recorder, permanently records the information on the easy-to-read chart, and generates instantaneously a clearly visible alarm light. Thereafter, the recorder operates continously and is capable of recording all successive transients automatically for more than four weeks unattended. A time marker is generated on the chart every thirty minutes to allow accurate determination of the time of each transient.

Units can be purchased to run four inches per hour, two inches per hour or one inch per hour providing respectively one, two, or four weeks of continuous unattended recording. The instrument is a simple plug-in unit that can be carried by hand with ease. It weighs only 14 pounds, is 8½ inches high, 11 inches wide, 11 inches deep and includes a handle.

Apollo Laser Reflector Experiment Uses Minicomputer As Calculation And Control Instrument

Austin, Tex., — A standard Varian 620/i general purpose digital computer is employed at the McDonald Observatory of the University of Texas here to aid scientists at the University of Maryland and other institutions to measure precisely the time it takes to reflect a laser beam off the moon.

The university's 107-inch telescope, the third largest in the world, was specifically modified to send a beam of coherent light to the array of reflectors left on the lunar surface by the crew of Apollo 11.

Two basic tasks have been assigned the experiment's equipment: 1) to generate a laser beam pulse whose absolute time of generation is known to one or two microseconds (1 epoch); and 2) to measure the time interval between the pulse leaving the telescope and returning, to an accuracy of several hundred picoseconds, thereby giving information on the moon's position at a specific time to an accuracy of inches.

The Varian 620/i, controls the laser, displays the data and measures the time between a pulse generated by a laser and its return after being reflected by the moon. The system fires a light pulse of known duration and then calculates the time interval between its origination and the reception.

It is also necessary to know, within a few microseconds, when the pulse was due to return, so that a receiving window can be opened in order to minimize the effect of noise and ambient light.

With the laser pulse synchronized with an atomic clock, via a radio link, the lunar ephemeris was precalculated and stored by a computer onto magnetic tape. Thus all additional calculations were done in the minicomputer's memory without resorting to tedious precision routines otherwise necessary.

The McDonald laser system will be updated in February 1971, Apollo 14 is scheduled to place a newly designed second reflector on the moon.

Electrostatic Principle Speeds Computer Line Printing

Called Statos-21, the new printer produces computer output copy at 5,000 lines per minute — an entire page of computer-generated text per second. The electrostatic principle allows silent operation

Special Report

Palo Alto, Calif.,–A new computer output hard copy printer–four times faster and one-half the cost of existing mechanical line printers–has been developed by the Graphics & Data Systems division of Varian Associates here.

Designated the Statos 21, the new printer operates on-line at 5,000 lines per minute – an entire page of computer-generated text every second – and typically costs only $15,300 in a complete configuration. Units currently in use print at 1,100 lines per minute, but cost nearly $40,000.

The first of a new Statos family, the Model 21 used 640 writing heads, or styli, across an 8½-inch page width rather than rotating belts or drums of type. It also can produce on-line such graphics as maps and charts at the same high speed.

This electrostatic writing principle allows totally silent operation, of timely significance because of the National Bureau of Standards' recent report that the noise levels in data processingcenters are becoming hazardous to hearing. Impact printers, readers and keypunch equipment create distracting noise which causes costly errors in simple programming and are otherwise anachronistic in fourth generation computer environments.

In the Statos 21, the paper is sped quietly along at any computer directed rate up to 10.5 inches per second. The paper transport is the only moving part, bringing new reliability to one-line, high-speed printing.

An important option for the Statos 21, Varian said, is a variable forms control, which permits printout on any assortment of business forms, such as requisitions, purchase orders, invoices, special labels, etc. This forms control option is based on read-only memory and provides any sequence of spaces between lines of type. It represents a state-of-the-art improvement over the magnetic tape and paper tape loops used for forms control in conventional line printers.

In making the announcement, Varian said it will provide a total hardware and software package. "We will provide the end user with a completely functional unit that is plug-to-plug compatible with existing peripheral equipment," said N. M. Johnson, Varian product manager.

"We designed a family of line printer/plotters that is easily interfaced and whose input requirements and format are in keeping with standard computer practice," he added.

The firm also underscored its modularity of design, whereby a variety of line printer configurations each tailored to a specific application will be available to data processing service companies, government and industrial in-house data processing centers, software houses, engineering computation centers and systems users.

Engineering computation centers can apply the graphic printout features of the Statos 21 to check engineering drawings prior to completion of final drafting, and plotting engineering test data for fast distribution. Additionally, CRT display copy capabilities in interactive terminals is offered by the Statos 21, especially in the area of military command and control systems.

Time-share houses also have a need for faster line printing terminals in order to match more closely the speed of voice-grade communications lines. Information subscriptions services can install the fast printers in subscribers' offices economically. Remote printers for label preprinting are now feasible also, both for mailing and item identification purposes as well as for the production of invoices, purchase orders and other standard paperwork required for daily large business operation.

The Statos 21 also offers the benefit of fast dissemination of sales charts, graphs and tabulated data, which field personnel can distill quickly and easily to gather the exact information they require. For the first time, the businessman who is used to reading charts and graphs for fast and meaningful interpretation of data, can now receive tham directly from a computer instead of stacks of time-consuming numerical printouts.

Varian's STATOS-21 produces computer output hard copy at the rate of 5,000 lines per minute–an entire page of computer-generated text every second. Employing the electrostatic writing principle, the new printer allows totally silent operation. Shown in this photo is production control specialist Mary Jane Pack using the electrostatic printer/plotter in Varian's Palo Alto (Calif.) computer center.

Courtesy Varian Associates

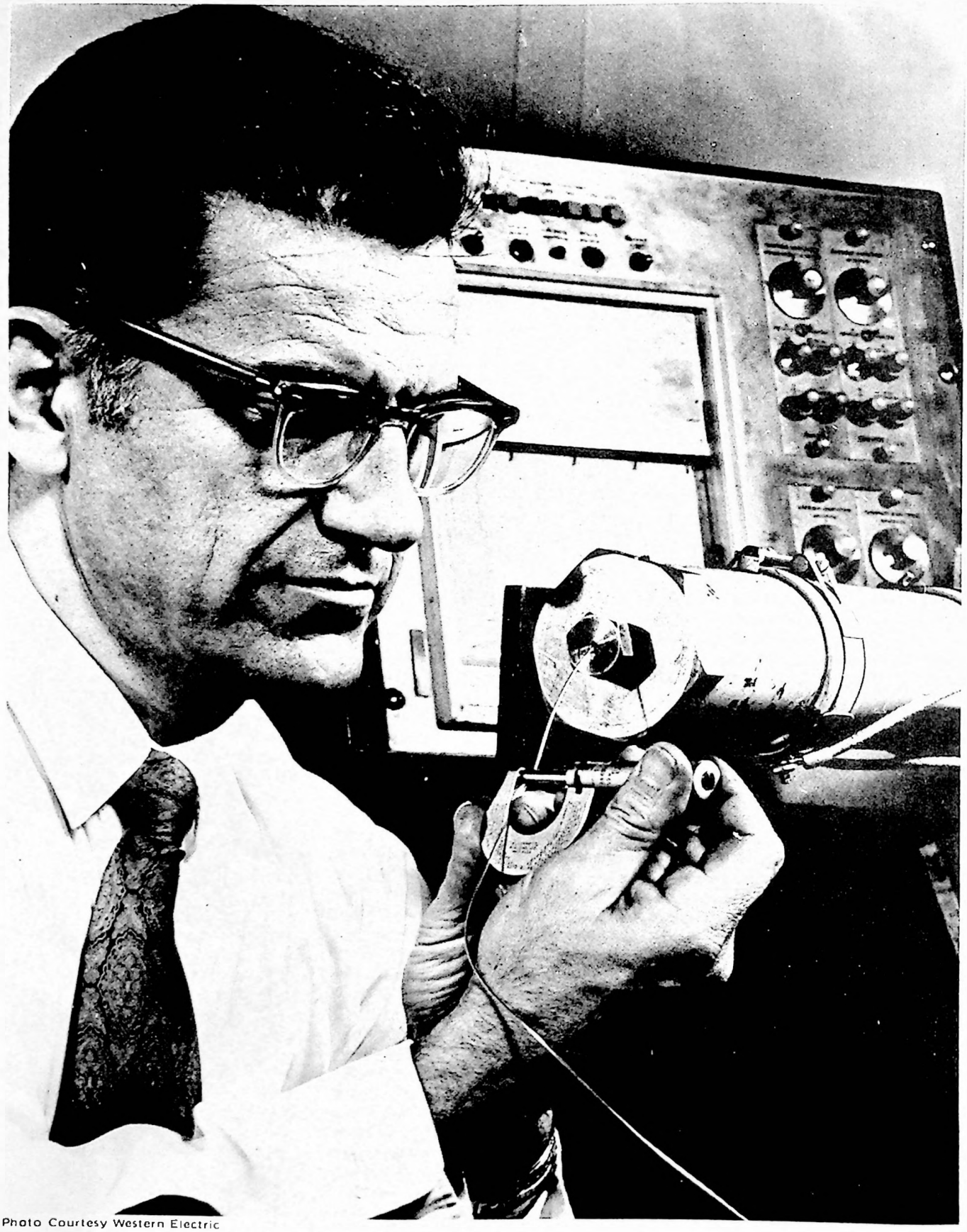


Photo Courtesy Western Electric

Frank Fuchs, Jr., of Western Electric's Engineering Research Center, examines aluminum wire made by an experimental version of the continuous hydrostatic extruder -- a process which represents the first change in the making of wire in 4,000 years. Western Electric is the manufacturing and supply unit of the Bell System.

After 4,000 Years, a New Way to Make Wire

A new process invented by Western Electric is the first major change in wire making since jewelers in ancient Egypt began drawing gold wire through drilled stones. The new method squeezes it out like toothpaste—fluid under high pressure does the squeezing

Special Report

A new process invented by Western Electric, manufacturing and supply unit of the Bell System, represents the first major change in wire making since jewelers in ancient Egypt began drawing gold wire through drilled stones. Instead of drawing the wire, as has been done for nearly 4,000 years, the new process squeezes it out like toothpaste. Fluid under high pressure does the squeezing.

Western Electric researcher, Frank Fuchs, Jr., explained the process—known as continuous hydrostatic extrusion—May, 1970, at the Third International Conference on High Pressure at Aviemore, Scotland.

Developed at Western Electric's Engineering Research Center in Princeton, New Jersey, continuous hydrostatic extrusion offers a number of important advantages over conventional wire drawing. These include lower equipment costs, cheaper maintenance, greatly reduced space and power requirements, less wire breakage, and reduced labor. There are also indications that wire made by hydrostatic extrusion is stronger than drawn wire of the same gauge.

Most of these advantages are possible because high pressure increases a metal's ductility and because the compressive fluid also serves as a lubricant. These fact, Western Electric introduced hydrofactors combine to make metals easier to form or extrude through a die. In static forming into its manufacture of metal parts in 1964.

Engineers have been intrigued with the idea of using the process to manufacture wire for many years, but until now, nobody knew how to feed wire rod into a high-pressure chamber on a continuous basis. Although some researchers have managed to extrude short runs of wire from single billets of metal, such processes are of limited commercial value.

Western Electric researchers, headed by Mr. Fuchs, solved the problem by "viscous drag feeding"—a method of using a fluid to force wire rod through the high-pressure chamber and out of the die. A fluid, such as warm beeswax, is pumped through the chamber in the direction of the die. Under high pressure this fluid becomes sufficiently sticky to adhere to the rod and drag it along.

Western Electric

Frank Fuchs, Jr., of Western Electric's Engineering Research Center in Princeton, N.J. Mr. Fuchs headed the research team that developed Western Electric's revolutionary wire-making process.

The choice of fluid is critical, because strange things can happen under high pressure. The wrong kind of fluid can become too dense for easy movement, or even turn into a destructive solid. Even an otherwise suitable fluid can impede movement of the rod by adhering to the chamber walls as tenaciously as it does to the rod. The viscous drag extruder minimizes this problem by liquifying a thin layer of the fluid at the chamber's surface with localized heating.

Another fluid is pumped into one end of the chamber under very high pressure to reduce the wire rod's diameter in the "die." Strictly speaking, this is not actually a die, since it serves only as a shaped container for the high pressure fluid. There is no metal-to-metal contact as there would be in a true die. The shape of this die-like container has been determined with the help of computers for optimum efficiency.

A prototype production machine incorporating all of these features is presently being designed and built by

(continued on page 10)

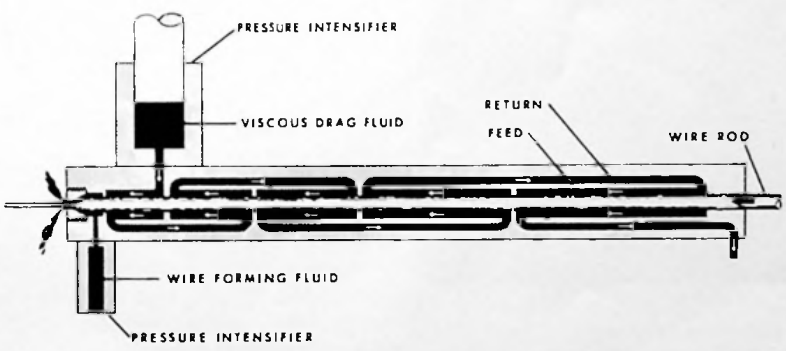


Photo Courtesy Western Electric

Wire rod is fed into the continuous hydrostatic extruder and dragged through the high-pressure chamber by a viscous fluid such as warm beeswax. The multiple chambers create the proper stress and pressure relationship. Actual deformation of the rod is done by forming fluid in the die, so that there is no metal-to-metal contact. Intensifiers (left) inject the viscous-drag fluid and the forming fluid at high pressures.

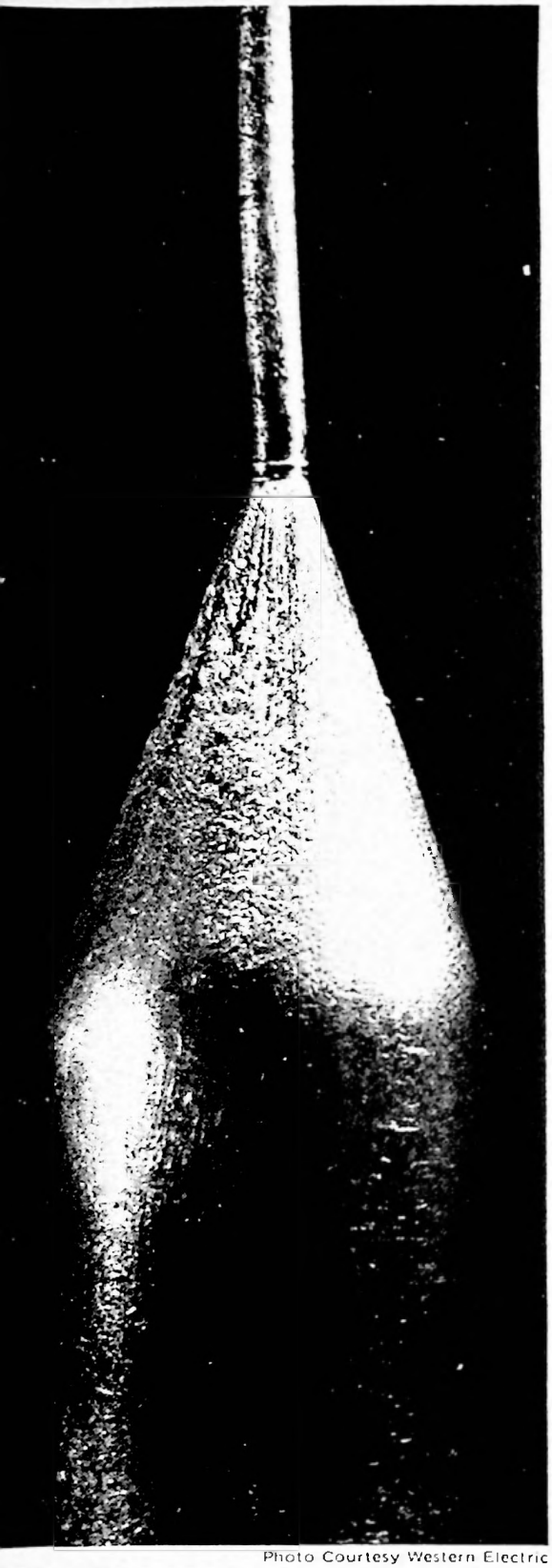


Photo Courtesy Western Electric

Continuous hydrostatic extrusion can reduce standard 3/8" aluminum rod to 0.3 percent of its original cross-section area in a single die. Conventional drawing can reduce wire rod to only 83 percent of its original cross-section area in a single die. Shown here is a typical reduction from 3/8" aluminum rod to 17-gauge wire.

(continued from page 9)

Western Electric for installation in Atlanta, Georgia. Due for completion by the end of the year, this prototype machine will produce aluminum wire at speeds up to 4,000 feet per minute in sizes as small as 24 gauge (0.02).

Only one pass through a single "die" will be required, regardless of the size of wire being made. Conventional wire making requires drawing the wire through as many as 24 dies in tandem on two different machines. Wire destined for reduction to the smaller sizes must first be drawn through 12 dies on a No. 1 machine and then spooled and stored. It is later drawn through more dies on a No. 2 machine and respooled.

Western Electric's new machine will eliminate the need for all such intermediate storage and handling. It will also require less space, being smaller than a typical No. 1 wire drawing machine installation. Although the process will initially be restricted to the manufacture of aluminum wire, it is ultimately expected to be used in the production of copper wire as well.

Mr. Fuchs, who has nearly 50 patents to his name, was also responsible for a method of machine-forming waveguide that is still playing a vital role in the production of military radar and transcontinental microwave relay systems. Working with Mr. Fuchs on the continuous hydrostatic extrusion project are John W. Archer, John S. Cartwright, Peruvemba Venecatesan, Nazeer Ahmed and John Shaffer—all of Western Electric.

Background Information

THE DISCOVERY OF HIGH-PRESSURE PHENOMENA

The effect of high pressure on the properties of metal was first noted by P. W. Bridgman in 1912. His early work dealt with the behavior of steel and copper cylinders collapsed by immersion in high-pressure fluid. The pressures used ranged up to 180,000 psi. One of the effects noted was that under these conditions, the plastic flow was much more extensive than that normally encountered before rupture.

Continuing his research into high-pressure physics, Bridgman concentrated on methods of generating high fluid pressures. During World War II, he developed piston and cylinder equipment that could be used for laboratory experiments at pressures up to 450,000 psi. Bridgman used this equipment to confirm the dependence of ductility on pressure.

In addition to simple tensile tests under pressure, Bridgman made uniaxial compression tests on hollow cylinders, primarily using alloys of steel. He also made compression tests on materials such as tungsten carbide, diamond and sapphire rod and conducted experiments in the use of pressure to punch holes in steel plate. This period culminated in Bridgman's receipt of a Nobel prize in 1946 and was extremely productive of fundamental data relating to the behavior of materials under high pressure.

Since Bridgman's time, others have duplicated and improved on his techniques for deforming metals under pressure. In Russia, Vereschagin worked with slightly higher pressures and experimented with other kinds of metals. He was one of the first to extrude shaped rods under high pressure. In Scotland, H. L. D. Pugh has used similar equipment to perform tensile tests and to draw wire. And, in this country, A. Bobrowsky has performed tensile tests under pressure of such difficult materials as tungsten, beryllium and molybednum.

THE HISTORY OF WIRE MAKING

Circa 3745 BC—Approximate time of Queen Shubab of Sumeria, whose crown is said to have been made of wire leaves. The wire was probably of hammered gold or silver.

Circa 2750 BC—A necklace of gold wire (unearthed by archeologists at Denderah, Egypt) was apparently worn by the Pharoh of this period.

2nd Millenium BC—Hammered gold rod being drawn through holes in stones to produce gold thread for jewelry in the Egypt of the Pharaohs.

79 AD—Destruction of Pompeii. A relic of bronze wire rope found in the ruins indicates that the manufacture of wire rope was well developed by this time. The relic is the earliest known example of wire made of materials other than precious metals. It is also the first known use of wire for other than decorative purposes.

11th Century—Earliest written reference to iron drawing dies. Reference made by the monk, Theophilus, in a Latin manuscript. Theophilus tells how lead and tin wire was drawn through three or four holes in an iron draw plate.

14 Century—A number of commercial wire drawing establishments operating in France, Germany and England.

Also, first use of water wheel to power a wire mill. Before the water-driven mills, wire was drawn through dies by artisans called Schockenziehers (shock drawers) in Germany. The Schockenziehers attached the wire to their belts and lunged forward, producing about a foot of wire per lunge.

This method was still being used in parts of Sweden and Russia as late as the mid-18th century.

17th Century—Hard steel wire is drawn for first time. Process made possible by use of a new lubricant—urine! In later centuries, stale beer was used.

19th Century—First use of steam to power a wire mill.

20th Century—Introduction of wire drawing through a continuous series of dies. Previously wire was respooled after each die reduction.

WIRE DRAWING AT WESTERN ELECTRIC

Wire has been a major Western Electric product since the company was founded 100 years ago. With the exception of small amounts of magnetic wire for memory devices and precious metal wire for contacts, most of the wire manufactured is for communications transmission. While the major portion of this wire is drawn from copper, a smaller, but rapidly increasing, amount of aluminum wire is also made. Most of this wire is insulated and then made into multi-conductor cable.

The metal rod used to make the wire is produced by continuous casting and then hot rolled to 5/16 inch (copper) and 3/8 inch (aluminum) diameters. Reduction of the rod to wire size begins in a No. 1 wire drawing machine, which can reduce rod down to No. 14 gage (.064 inch) wire at speeds up to 10,000 feet per minute. Input to the No. 1 machine is continuous, new coils of rod being welded to the one in process. Nine to twelve tungsten carbide dies are used to reduce the wire.

For the smaller gages normally used in cable, the wire coming out of the No. 1 machine must be spooled for later redrawing in a No. 2 machine. Here, too, the process is continuous, with new wire being welded on at the supply end of the machine. The No. 2 machines often run in tandem with plastic insulating machines, and all the output is respooled for future use. The No. 2 machines use about ten diamond dies. Production speed is typically between 3,000 and 4,000 feet per minute.

The processing cost of wire is only a fraction of the total cost of copper wire, materials costs being the major contributor. Important contributors to the cost of processing are the purchase price of the machines and their maintenance, the cost of dies and their maintenance, and wire breakage.

THE THIRD INTERNATIONAL CONFERENCE ON HIGH PRESSURE

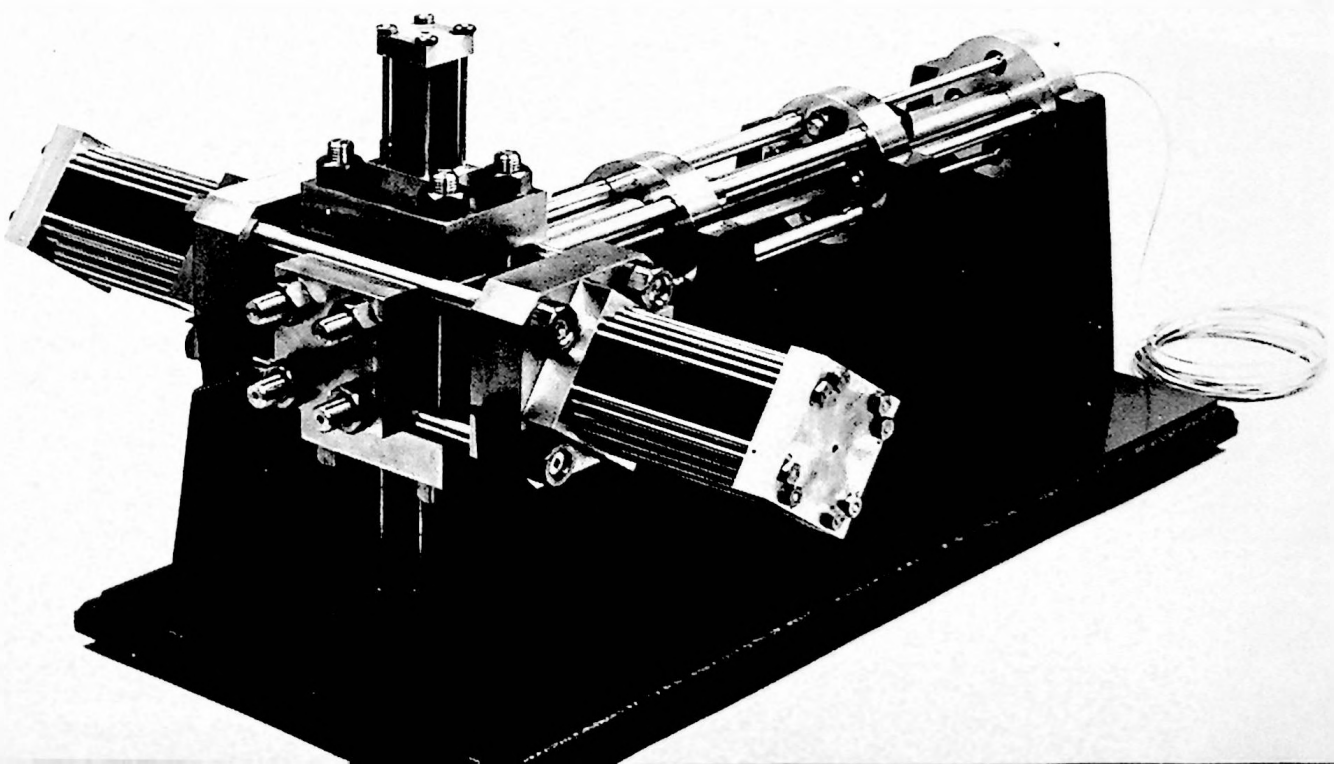
The Third International Conference on High Pressure, held in Aviemore, Scotland, May 11-15 this year, is supported by the Royal Society and by the Institution of Mechanical Engineers. The first such conference was held in LeCreusot, France, in 1965, and the second, in Schloss Elman, Germany, in 1968. The theme of the third conference is "Solids Under Pressure."

The Royal Society, more fully, the Royal Society of London for Improving Natural Knowledge, is one of the oldest scientific societies in Europe. It was founded in 1660 and became "royal," when the king joined in 1661. From its beginnings until the present day, the Royal Society has been involved with all aspects of science and takes its members from all disciplines. An idea of the quality of its members can be had from the fact that its president (from 1703 to 1727) was Sir Isaac Newton. It has sponsored some of the world's most famous and important scientific ventures, ranging from the voyages of Captain Cook to Babbage's development of his "calculating engine"—the forerunner of today's computer.

The Institution of Mechanical Engineers is similar to the American Society of Mechanical Engineers in this country. It is a professional society dedicated to the promotion and exchange of information relating to mechanical engineering. It has the usual library and internal publications and boasts a membership of 58,000. Like the Royal Society, it is headquartered in London.

Scale model of the continuous hydrostatic extrusion machine being built by Western Electric. Due for completion near the end of the year, this machine will be able to extrude aluminum wire at up to 4,000 feet per minute in sizes as small as 24 gauge (0.02 inch). The actual machine will be about 14 feet long. Wire rod will be continuously fed into the rear of the machine (right) and will emerge from its front end (left) as wire.

Photo Courtesy Western Electric



Varian Associates

Nurse in a physician's office dials the Boeing Automatic EKG Processor, where a Varian Data Machines 620/i minicomputer with 8K core of 16-bit words converts analog data and formats it on magnetic tape for feeding into a larger processor. Results can be returned to the physician via teletype or mail, and can be either a straight qualitative interpretation or an actual diagnosis alerting the doctor to specific cardial malfunctions.

Computer System Diagnoses Electrocardiograms for Physicians

A new diagnostic system called Automatic EKG Processor was developed to provide a cardiologist or general practitioner with a computer interpretation of pertinent measurements in EKGs

Philadelphia, Pa., – A 35-pound low-cost Varian mini-computer here is acting as the cost-saving front end for a dual-computer system which processes, analyzes and actually diagnoses electrocardiograms for physicians. The system was unveiled Sunday (Oct. 25) at the annual Public Health Convention in Houston, Texas.

Called the Automatic EKG Processor, the system was developed by the Boeing Company's Computer Services Division, Northeast District, to provide a cardiologist or general practitioner with a computer interpretation of the amplitudes, durations and other pertinent measurements of heart cycle segments in EKGs.

Using the system, the customer – usually a physician – has the option of receiving his EKG results via teletype or mail, depending upon his requirements. "Recent developments in the field of electrocardiography have made possible the analysis and processing of EKGs using third generation computer techniques," said Frank Sambuco, Boeing Computer Services Unit chief of Time Critical Systems.

"The low price of the Varian 620/i keeps system costs down, and the mini-computer's convenient instructional repertoire has allowed us easily and quickly to digitize and tape format each EKG for entry into a central IBM 360/65 processor," he added.

Besides hospitals and a GP's or heart specialist's office, the system is expected to find wide application in large industry plants, airlines, military dispensaries –

any place where regular physical checkups are required and EKGs taken.

The taking of the EKG by the user is by standard procedure, and the technician or nurse attaches electrodes to the patients in the usual manner. This is either a classical EKG, which concists of two leads on the arms, two on the legs and six on the chest, or a three-lead EKG for a vector measurement. The EKG cart in use at Boeing is manufactured by Marquette Electronics, Inc., Milwaukee, Wis. The nurse then dials via touch tone keyboard a telephone number at the central Boeing facility identifying her origin with two digits and the patient with six. This links the EKG cart with the digital computer system, via three-channel multiplexing and transmission as a composite analog FM signal over common voice grade telephone lines.

At the Boeing Center, the composite signal is demodulated, yielding the three original EKG data channels. The 620/i, a general purpose digital computer with an 8K core of 16-bit words, an A/D converter and peripheral digital tape transport, collects each signal from a special Boeing interface. This interface controls system calibrations and band limits the data, minimizing noise effects while still preserving the integrity of the original EKG signal information.

The 620/i then converts from analog to a digital representation and formats on magnetic tape to store the data for further analysis. The tape is taken to the central processor which then examines the heart cycle intervals in terms of amplitude in millivolts and durations in seconds. Part of the software comprising the system was obtained from the U.S. Department of Health, Washington, D.C.

Results are then sent back to the user via teletype or mail. The computer can include in these results either a qualitative "within normal limits" analysis, or an empirical diagnosis, such as "left ventricular hypertrophy," or "myocardial infarction." This alerts the doctor and allows him to pinpoint on his original EKG strip a specific cardial malfunction and subsequently to validate the diagnosis or to conduct further tests. The entire cycle, from sending to return of results, can range from one to two hours.

"This automatic EKG processing system makes the doctor's job easier and saves him precious time . . . all for a minimal cost," Sambuco said. "The Varian's easy interfacing and its instructional capabilities make it ideal for this type of digitizing and formatting at the front end of a dual system," he added.

Varian Associates

At the Boeing Center, this Varian Data Machines 620/i general purpose digital minicomputer acts as a cost-saving front end for the Automatic EKG Processor being unveiled in October at the Public Health Convention in Houston, Texas. The 620/i is a 16-bit word machine expandable from 4,096 to 32,768 words in core and weighs only 35 pounds.

Science Talent Search Competition Begins For High School Seniors

Washington, Nov 10 — A total of $67,500 in scholarships and awards are at stake as thousands of high school seniors across the nation prepare to compete in the 30th annual Westinghouse Science Talent Search.

Edward G. Sherburne, Jr., director of Science Service, the national organization that administers Science Talent Search through its Science Clubs of America, said rules and instructions for the competition have been mailed to more than 50,000 principals and science teachers of secondary public, private and denominational schools throughout the United States.

A panel of judges will select an honors group of approximately 300 students from the total number of entries. From the honors group, 40 finalists will be selected, all of whom will receive expense-paid five-day trips next spring to Washington, D.C., where the final competition is held each year. From the 40 finalists, 10 students will win the major scholarship prizes. The top award is a $10,000 four-year scholarship. The other scholarships are: two for second place of $8,000 each; three of $6,000, and four of $4,000 each. The 30 finalists who do not win scholarships will receive single-payment awards of $250 each. All members of the honors group who do not win top scholarships are specially recommended for scholarships to leading colleges and universities.

Scholarships and awards for the young scientists and other financial aid that makes Science Talent Search possible are provided by the Westinghouse Educational Foundation, which is supported by Westinghouse Electric Corporation.

Explaining the general rules of the Search, Mr. Sherburne said that contestants write a report on an independent scientific research project which they have undertaken. Schools also submit scholastic records for each entrant along with teacher evaluations of the student's abilities. Completed entries must reach Science Service headquarters in Washington, D.C., by midnight December 15, 1970, in order to qualify for the competition.

Presiding over the Search is a six-man board of judges headed by Dr. David Axelrod, a New York biologist who supervises the selection techniques.

Unlike many other scholarship competitions, the Westinghouse Science Talent Search has no rule prohibiting winners from accepting additional scholships from other sources. And while designed primarily to discover and encourage science talent at an early age, the Search also has served to focus public attention on the need for better science education.

While participating in the expense-paid trip to Washington, the 40 national winners will tour government and private research centers, have individual discussions with many of the nation's leading scientists, meet with their Congressmen, engage in panel discussions, and sightsee in Washington. On the last evening of their visit, the finalists attend a black-tie awards banquet that is climaxed by the announcement of the top 10 scholarship winners. Many past Science Talent Search groups have been received at the White House.

Some 565,374 high school seniors have participated in the Search since it was begun in 1942. Of these, 86,013 have completed the exhaustive final requirements. During the past 29 years Westinghouse scholarships and awards of $721,000 have gone to 1,160 young men and women, while 9,173 students have been named members of the honors group.

Forty-two states and the District of Columbia are holding their own science talent searches concurrently with the national competition this year, providing many youths with a double chance to win scholarships — and creating greater interest in science careers.

American X-ray Pioneer Honored by Germans

Pittsburgh, Pa.—Dr. John W. Coltman, a research director at the Westinghouse Research Laboratories, was awarded the Roentgen medal on October 10 for his development of the x-ray image amplifier.

The medal is awarded annually by the town of Remscheid, Germany, birthplace of Wilhelm Roentgen, discoverer of x-rays. It is given for major advances in the understanding and use of Roentgen's discovery. Four medals will be given this year, the 75th anniversary of the discovery and a jubilee year in Remscheid.

Dr. Coltman is the only American recipient this year, and only the fourth American among the 37 scientists who have been given the medal. Past winners include the distinguished physicists William L. Bragg, Arthur H. Compton, Max von Laue, and William D. Coolidge.

Dr. Coltman is being honored for his development 22 years ago of the Fluorex image amplifier, a device that electronically brightens a fluoroscopic x-ray image several thousand times.

Roentgen Blaetter, a German x-ray journal, says in an article written for the October issue, "Since the discovery of Roentgen rays (x-rays) surely no other advance has so decidedly influenced modern x-ray diagnostics as the development of the image amplifier.

"Fluoroscopy in daylight, x-ray television, electronic image modification and storage, and x-ray cinematography have been made possible or greatly advanced by electronic image amplification."

The device also decreased significantly the exposure of a patient to radiation, and reduced by even greater amounts the x-ray scatter dose to the radiologist.

The original Fluorex equipment is now in the Smithsonian Institution.

In 1960, in recognition of his achievement, the Franklin Institute of Philadelphia awarded Dr. Coltman the Longstreth medal, given annually for "inventions of high order and meritorious work in science." He is a fellow in both the American Physical Society and the Institute of Electrical and Electronic Engineers

Walter Houser Brattain

American Physicist

Born February 10, 1902

By William M. Palmer

Since the beginning of this century mankind has witnessed the unfolding of countless miracles in electronic technology.

On a windy day in December, 1901, at St. Johns Newfoundland, the famed Italian inventor Guglielmo Marconi sat before a crude radio receiver listening intently for a wireless signal which was to be transmitted from Cornwall, England. After many attempts to pick up the signal, both he and a technical assistant finally heard the first faint wireless signal to cross the Atlantic. It was the letter "S" which was repeated at regular intervals.

In this experiment Marconi used a simple signal detector called a "coherer." It was not very sensitive or efficient, but it marked a beginning.

Many new improved signal detectors followed, including the electrolytic detector and the famous crystal detector of galena and iron pyrites. But they were often erratic and were easily disturbed by mechanical shock. So the search continued.

A breakthrough finally came in the form of the Fleming thermionic valve detector or rectifier – the first electronic detector of wireless signals and the beginning of radio tubes. The valve detector was invented by John Ambrose Fleming (1849-1945), an English physicist and one of the great pioneers in electricity. Fleming applied for a patent covering his invention, which was first called an "oscillaion valve," in England on November 16, 1904. The new thermionic valve (radio tube) offered the important advantage of resistance to mechanical shock and static surges which had produced instability in earlier types of detectors.

The invention of the Fleming valve was a giant step in the field of wireless communication, and it was used extensively by the Marconi Telegraph Company in their receivers of that day.

During this time a fortuitious event was taking shape. Dr. Lee de Forest, a young American inventor, was conducting experiments with the Fleming valve through which he hoped to find a way to make it perform as an amplifier. During that era the amplifier was the "missing link" in new developments in radio communication, coast-to-coast telephone service, and broadcasting. A way had to be found to amplify signals.

After much experimentation de Forest added a length of platinum wire, bent back and forth, between the filament and the plate of the Fleming valve. It produced the desired amplification!

The incoming radio signals were fed to the valve or tube through the "grid" which modulated the flow of electrons from the filament to the plate of the circuit in accordance with the varying current of the signals. The current in the plate circuit was thus made to vary on a larger scale producing a louder sound in the headphones.

The year was 1906 – the name of the new invention: the Audion. Thus was born the three-element vacuum tube which could not only perform as an amplifier, but it could also act as a detector and as an oscillator in producing radio frequency waves.

De Forest's Audion opened the door to infinite potential in the field of electronics. It replaced the arc in radiotelephony – it brought greater efficiency in detection of radio waves, the generation of "carrier waves," and it brought into reality that illusive ingredient called "amplification of sounds" by electronics.

In spite of these incredible accomplishments, men of science continued the never ending quest for more knowledge and a better way of doing things . . . electronically.

Their relentless research has given mankind countless inventions of exceptional merit, but perhaps the greatest in this century may have been the discovery of the tiny but powerful transistor, which was demonstrated for the public on June 30, 1948 – only twenty-two years ago.

This electronic midget was the forerunner of today's solid state radios, stereo phonographs, miniature television

(Continued on page 17)

Courtesy Bell Telephone Labs

Walter Houser Brattain

American Physicist

Born February 10, 1902

history's hall of honor

BIOGRAPHICAL SKETCHES OF GREAT MEN IN ELECTRONICS

Walter Houser Brattain

(Continued from page 15)

sets, incredibly small computer systems and a host of other compact electronic apparatus.

The amazing transistor was the joint invention of three Americans: William Shockley, John Bardeen, and Walter H. Brattain. In 1956, they shared the Nobel Prize in Physics for their momentous accomplishment.

We place in History's Hall of Honer the name of another of these distinguished physicists, Walter Houser Brattain.

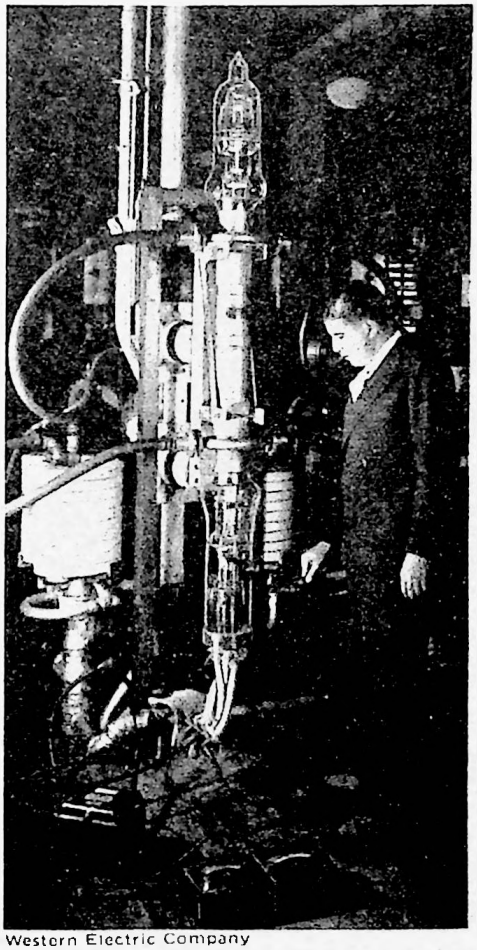
Dr. Brattain was born in Amoy, China, of American parentage, on February 10, 1902. Much of his early life was spent in the state of Washington where his parents owned a cattle ranch. He attended Whitman College, majoring in physics and mathematics. He received his B. S. degree there in 1924, and a M. A. degree from the University of Oregon two years later. In 1929 Dr. Brattain received a Ph. D. degree from the University of Minnesota, and joined the scientific team at Bell Telephone Laboratories a short time later. There he conducted research on the surface properties of solids.

In addition to his work leading to the invention of the transistor, Dr. Brattain's important contributions to science include the discovery of the photo effect at the free surface of a semiconductor, and work which has led to a better understanding of the surface properties of germanium.

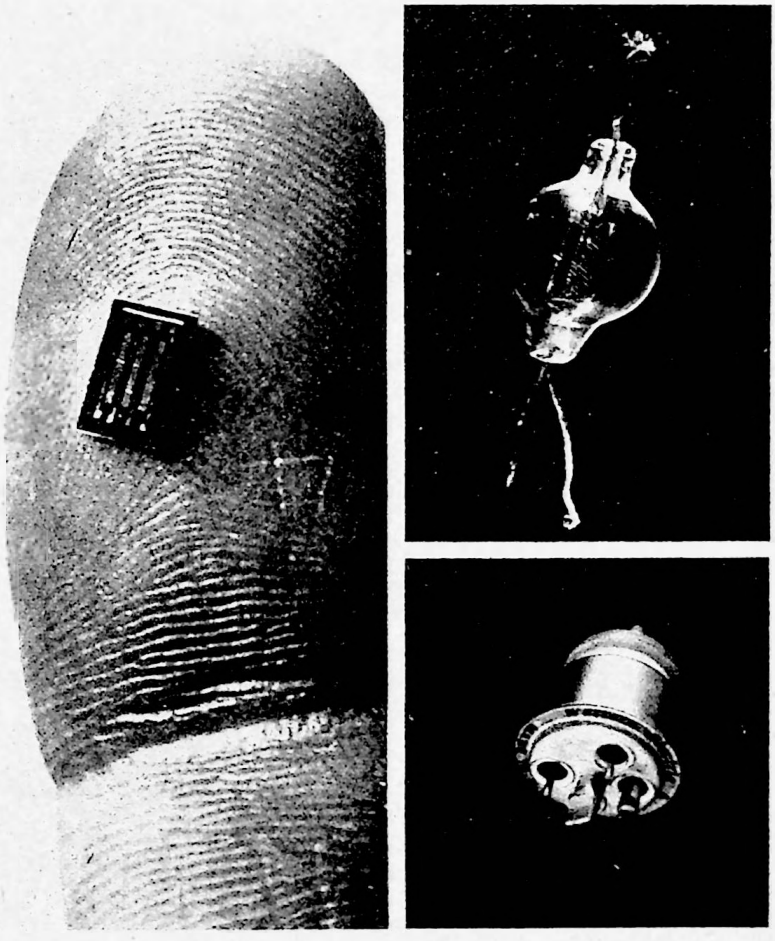
He is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, the American Association for the Advancement of Science, and a Fellow of the American Physical Society. He is also a member of the Franklin Institute, and of the Honor societies Phi Beta Kappa, Sigma Xi, and an honorary member of Epsilon Phi Tau.

He is chairman of the Commission on Semiconductors of the International Union of Pure and Applied Physics, and a former member of the Naval Research Advisory Committee and Defense Science Board. Dr. Brattain is currently teaching at Whitman College.

Dr. Brattains life, and his work in his chosen field of science, exemplifies the unquenchable will to achieve that continues to carry mankind across new frontiers of living – finding the means, scientifically, to cope with an increasingly complex environment.



Western Electric Company



Western Electric's large and small, old and new. On left, one of the largest electron tubes ever made, a 250-thousand-watt radio tube. In center, a semiconductor wafer used in making transistors. Upper right, Company's first high-vacuum amplifier, introduced in 1913. Lower right, 416c tube which amplifies 1,200 telephone calls simultaneously in radio relays – newest tube Western Electric makes for the Bell System.

A STUDY in contrast T.M.

PICTORIAL HISTORY OF ELECTRONICS

Telephones of the Early Days . . . and Today's Desk Set With Touch-Tone Signaling

Courtesy of Western Electric Company

The telephone wall set on left was a sensation in the United States in 1886. To place a call in those days, it was necessary to give the small crank on the side of the telephone one long turn to reach the operator. Then, taking the receiver from the hook, you listened for her to request the number you were calling. She connected you. You hung up the receiver and again turned the crank to ring the other telephone. A few moments later, you again removed the receiver and talked – provided the person you were calling was on the line. In the center is an 1891 cabinet type telephone set – tall as a man and compatible in style with a grandfather clock. Shown on upper right is a 1902 model with exposed ringer. Lower right is today's desk set with a push-button call system, Touch-Tone which is rapidly replacing the dial type.

How to Build a WWV Converter

Your AM radio plus this easy-to-build converter can pick up WWV signals from the National Bureau of Standards---useful in the solution of many scientific and technological problems in communications geodesy, satellite tracking and other areas

Science students, science instructors, radio amateurs, will find this easy to build WWV Converter project a highly useful electronic lab device for use in solving many scientific and technical problems such as radio communications, geodesy, and the tracking of satellites.

The WWV Converter is available in kit form through Allied Radio Shack Stores (Science Fair kit No. 28-133), or you may prefer to build the project from spare parts from your "electronic junk box."

HOW IT WORKS

The 10 MHz signal transmitted by WWV is picked up by the antenna circuit consisting of coil L1 and capacitor C1. The signal is then applied to the base of transistor Q1 through capacitor C2 and amplified. The amplified signal is applied to the base of transistor Q2 through capacitor C4.

Also applied to the base of transistor Q2 is a signal generated by the oscilator circuit surrounding transistor Q3. The crystal (x) determines the frequency which is generated and is in this case 11.630 MHz.

In transistor Q2, the two signals are "mixed." The frequency of the signal coming out of transistor Q2 is the difference between the first two signals. (11.630 MHz – 10.000 MHz = 1.630 MHz or 1630 KHz)

The 1630 KHz signal is applied to the tuned circuit consisting of capacitor C5 and coil L2. This circuit is so designed that the 1630 KHz is radiated by coil L2 and can be picked up on a standard AM radio.

OPERATION

Your WWV Converter is quite simple to operate. First connect a 9 volt transistor radio battery (Radio Shack Cat. 23-464 or 23-152). Now turn the slug

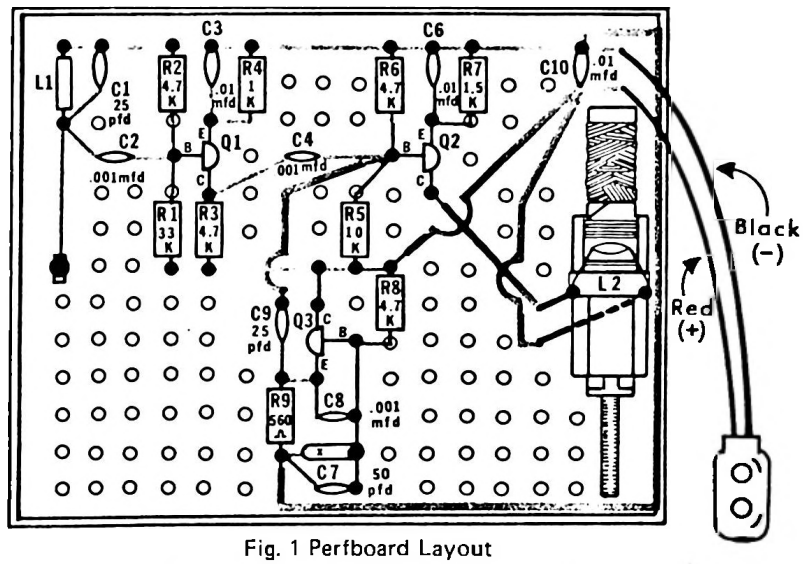


Fig. 1 Perfboard Layout

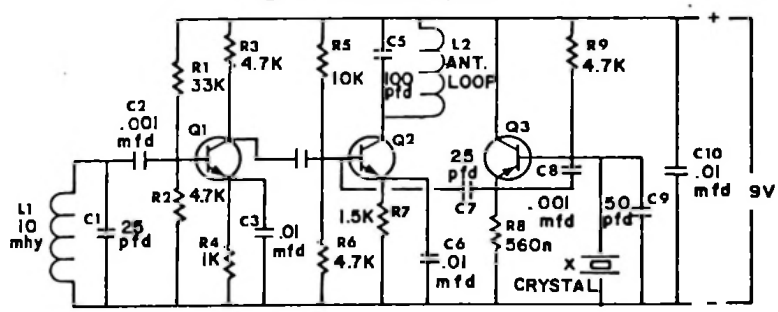


Fig. 2 Schematic Diagram

(the metal screw sticking out of the antenna coil) in the antenna coil counter clockwise until it is out as far as it will go. NOTE: (Be careful not to break the antenna by twisting too hard when the slug has been turned as far as it will go)

Continue by turning on your AM radio and turning the station selector dial as far to the right as it will go so that it is off of any station. Place the WWV Converter very close to the radio and slowly begin turning the slug back into the antenna coil (clockwise) until you reach maximum sound level (until the hissing noise in the radio is at its loudest level). Then very slowly turn the radio station selector to 1630 on your dial.

For best results, connect an outdoor antenna (Radio Shack Cat. No. 278-1373) to push-in terminal G1. This antenna can be as long as facilities permit. If this is impractical you can use a five or six foot piece of wire connected

(Continued on next page)

to G1. It is also possible to connect a wire from G1 to the metal dial stop on your telephone.

Time signals, audio frequencies, and a 36-digit lineary timing code are broadcast continuously day and night from WWV, except for a four-minute period beginning approximately 45 minutes after each hour.

WWV is operated by the National Bureau of Standards at Fort Collins, Colorado 80521. The WWV broadcast frequencies are 2.5, 5, 10, 15, 20 and 25 MHz, and its modualtion consists of 1-Hz pulses, and 440-and 600-Hz tones. Signals from WWV are coordinated with Stations GBR and MSF at Rugby, England, and Station NBA in the Canal Zone. This coordination provides a more uniform system of time and frequency transmissions throughout the world.

The audiofrequency signals are transmitted from WWV for precisely two minutes at the beginning of each five-minute period except at the beginning of each hour, when the transmission is for three minutes, and at 45 minutes after the hour when WWV is silent.

The WWV timing code (a 36-bit, 100-pulses-per-second code carried on 1,000-Hz modulation) is broadcast for one-minute intervals, 10 times per hour. This timing code is indicated by the shaded area in Fig. A, and immediately follows the 440- and 600-Hz modulation except at the beginning of each hour. It is a special computerized signal which can not be deciphered by the human ear.

A voice announcement of Eastern Standard Time and call letters is given each five minutes from station WWV. This is followed by a telegraph-code announcement of Universal Time and another voice announcement of Eastern Standard Time. During announcement intervals at the latter half of the fifth minute past each hour, propagation notices applying to transmission paths over the North Atlantic are transmitted from WWV. These notices, in telegraphic code, consist of a letter followed by a number. The letter signifies the propagation conditions at the time of the broadcast. The following designations are used:
N-Normal U-Unsettled W-Disturbance
The Number following the letter applies to expected propagation conditions during the subsequent 6 or more hours. The following designations are used:

1-Useless 4-Poor to Fair 7-Good
2-Very Poor 5-Fair 8-Very Good
3-Poor 6-Fair to Good 9-Excellent

During the first half of the 19th minute of each hour on WWV the IUWDS (International Urisigram and World Days Service) warning is broadcast. This message reveals to experimenters in radio, geophysical, and solar sciences the content of the warning message issued daily at 0400 UT (Universal Time, formerly Greenwich Mean Time) by the world warning agency on days when an outstanding geophysical (Geoalert) event has occurred during the preceding 24 hours. There are five types of Geoalert which are used, and thus there are five letter symbols to identify them, and a sixth type of Geoalert to signify there is no Geoalert. The six Geoalerts and the six symbols are as follows:

C-Cosmic event W-Statwarm
M-Magnetic storm N-Soflare flare
S-Soflare proton flare E-No Geoalert

Complete information on WWV transmissions can be found in Miscellaneous Publication 236, "Standard Frequencies and Time Services," for sale for 15 cents by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

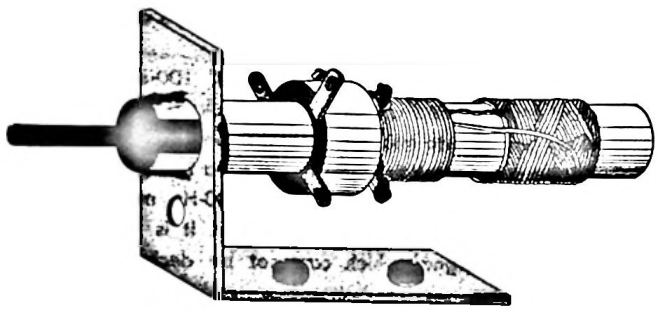


Fig. 3 Mounting Bracket For Antenna Coil

The antenna coil which is mounted on the perfboard by means of an "L" bracket, as illustrated above, may be purchased from a hardware store. It will be necessary to enlarge the hole for mounting the antenna coil. Exercise care in handling the coil in order to avoid damage to the fine wire windings.

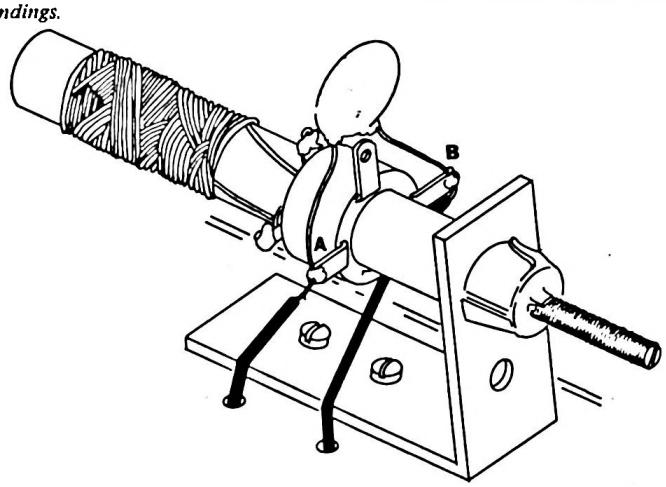


Fig. 4 Solder Connections To Antenna Coil

Mount a 100 pfd disk capacitor, C-5 from terminal "A" of the antenna coil, as illustrated above, to terminal "B" and the other circuit connections as shown in Fig. 1, Perfboard Layout. The wires should be inserted through the small holes in the terminal and crimped with needle-nosed pliers for a tight connection. Then heat the joints momentarily and apply solder, being careful to get an even flow over entire joint.

PARTS LIST

Q1, Q2, Q3, 2N5223 Transistors
R1, 33K Resistor
R2, R3, R6, R9, 47K Resistors
R4, 1K Resistor
R5, 10K Resistor
R7, 1.5K Resistor
R8, 560 Ohm Resistor
C1, 12 pfd Disc. Capacitor
C2, C4, C8, .001 MFD Capacitor
C3, C6, C10, .01 MFD Disc. Capacitor
C5, 100 pfd Disc. Capacitor
C9, 50 pfd Disc. Capacitor
L1, 10 mhy coil
L2, Ant. coil
X, 11.63 mc crystal
1 Battery Clip

Miscellaneous:

Three Push-in-terminals, two 4-40 x 3/8" Screws, two 4-40 Nuts, Hook-up wire.

Old Time Loose-Coupler Crystal Radio

This replica project illustrates basic principles of radio and also allows the student, teacher, and radio amateur to assemble a collection for a home or school museum

by Art Trauffer

If you were a wireless fan in the period from about 1910 to 1923 and thumbed through the wireless catalogs and magazine ads of the time, you would have seen a number of loose-coupler and crystal detector receivers similar to the one described in this article. Many of the sets used large loose couplers, having many turns of wire, for receiving the long-wave stations of that time, but our project uses a Junior-size loose coupler for receiving the standard AM broadcast stations of today, or you can simply place the receiver on the shelf as a conversation piece of radio history.

A loose coupler is simply a two-coil tuning instrument. The primary coil (larger stationary coil) has a sliding contact for fine adjustment, and is used to tune the Antenna-Ground circuit. The secondary coil (smaller movable coil) has a number of taps to vary the inductance, and it can be moved nearer or farther from the primary coil – in other words, it can be tightly-coupled or loosely-coupled to the primary coil – hence the name "loose coupler."

The variable condenser in this project is a replica of the famous Murdock or Chelsea glass-enclosed variable condensers of the old days.

The crystal detector is the old stand-by galena-and-cat-whisker detector used so much in the days before vacuum tubes became popular.

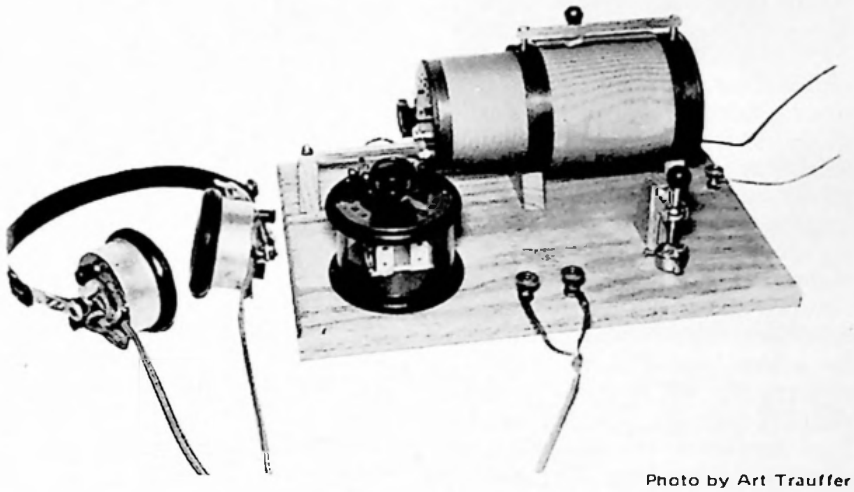


Photo by Art Trauffer

Shown above is the Loose-Coupler Crystal Radio Receiver complete with the old-time Murdock glass-enclosed variable condenser. Watch future issues of ELECTRONICS DIGEST for old-time radio projects that still illustrate many of the basic theories of radio while at the same time allowing the amateur radio enthusiast, student, teacher, or hobbyist, to assemble a collection of the devices for a school or home museum. Reprints of previous projects will be available soon.

Constructional Details

The hardwood baseboard (the writer used oak) is 11" x 7¼" x 5/8". Sand it smooth – bevel the top edges – and stain with oak or walnut stain, then hand-rub with facial tissues. Some of the old sets used stained and varnished mahogany. Nail or screw-fasten a ¼" x ½" rubber bumper under each corner.

Details for the entire loose coupler are shown in drawings Figs. 1,2, and photo Fig. 3. Using your imagination and ingenuity you should have no trouble.

Use non-metallic coil forms as close to the specified sizes as possible. Formica or other plastic is recommended, but if you must use pasteboard or cardboard tubes give the insides and outsides two coats of shellac to moistureproof them and reduce swelling or shrinking.

The writer used No.22 cotten-covered enameled copper magnet wire for the primary coil, and the same in No.24 for the secondary coil, but if you cannot find cotton-covered you may use the modern Nylon-covered or just plain enameled. Green silk-covered wire was popular in the old days but this is scarce now. If you can find white cotton-covered you can dye it green in RIT dye, as the writer did.

The primary form is given about 90 turns, closely and tightly wound, and the ends are anchored in small holes using Duco Cement.

The secondary form is given about 105 turns. See Fig. 2 for making the five taps. Drill small holes in the form so you can double the wire and pass the doubled leads through the holes, as shown. Use Duco Cement at the holes to keep the wire turns from loosening while you make the taps. Make the tap leads long enough so you can connect them to the switch points later.

Figs. 2 & 3 give all details for making the switch lever, the 5 switch points, the 2 switch lever stops, the 2 binding

(Continued on page 22)

Programmed Lesson on DC Circuits

In this lesson Ohm's law is applied to DC circuitry in order to find the current, voltage, and resistance operating in a particular circuit

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

An electrical circuit includes a potential difference, a path for electron movement and resistance that limits the amount of electron flow. In DC circuits the potential difference is constant with time and may be supplied by an ordinary battery.

In this lesson we shall apply Ohm's law to several DC circuits and find the current, voltage and power associated with each resistive branch. In lessons to follow, AC circuits will be discussed where the potential difference varies with time. Principles discussed in this lesson are essential for the analysis of AC circuits as well as other electronic circuits which contain diodes, tubes and transistors.

Start by reading frame 1 and answering the question at the end of the frame. Proceed to the next frame as the answer you select indicates. Then continue through the lesson as directed.

---

1 The simpliest schematic diagram of a DC circuit is shown in figure 1. The battery supplies the potential difference, wires provide a path for electron movement and a resistor represents the total resistance. The negative terminal of the battery provides electrons which are attracted to the positive end through the resistor. The rate of electron flow is called the current and can be found by using Ohm's law. Ohm's law relates the voltage, current and resistance of the circuit by the equation, E = IR. Figure 2 shows how Ohm's law is used to find an unknown current, voltage or resistance.

Power is required in electrical circuits to pass current through a resistor. The unit of power is the watt and can be found using the formula, P = EI. This formula states that one watt of power is required to pass one ampere of current through a potential difference of one volt. Batteries generally supply power while resistors dissipate power in the form of heat.

QUESTION: In the circuit of figure 2a, how much power is dissipated by the resistor?

1) 48 watts . . . See frame 7
2) 36 watts . . . See frame 4
3) 12 watts . . . See frame 10

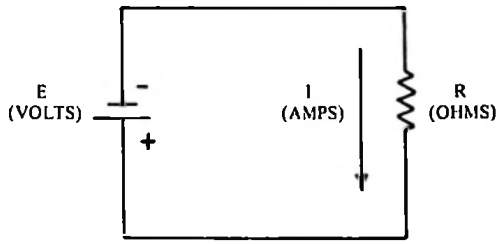


FIGURE 1
A SIMPLE DC CIRCUIT
THE BATTERY VOLTAGE EXISTS ACROSS THE RESISTOR WHILE CURRENT IS SAID TO FLOW THROUGH THE RESISTOR

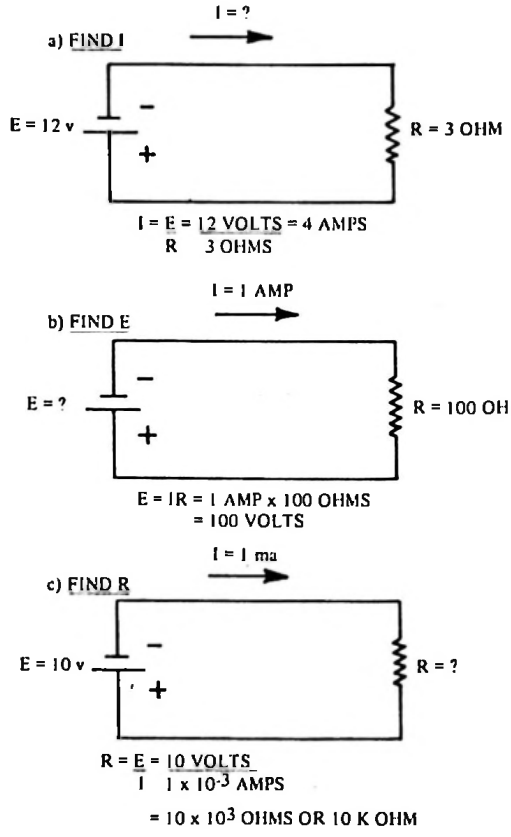
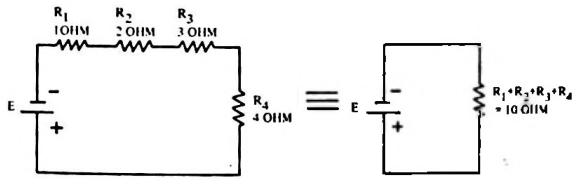


FIGURE 2
EXAMPLES USING THE THREE FORMS OF OHM'S LAW

2 Your answer is incorrect Ohm's law can be applied to each resistor branch of the circuit. To find the voltage across the 4 Ohm resistor, the series current is multiplied by 4 Ohms. Return to frame 11 and choose another answer.

3 Your answer is incorrect. In a series circuit the series current is found by dividing the battery voltage by the total series resistance. In effect, the series resistors are lumped into one resistor to form an equivalent circuit as shown below;



Apply Ohm's law to the equivalent series circuit and choose another answer to frame 7.

4 Your answer is incorrect. Power dissipated by the resistor is not equal to the battery voltage times the resistance. Use the power formula, P = EI to find the power and choose another answer to frame 1.

5 Your answer is correct. The potential difference across the resistor is called the "IR drop" or "voltage drop" since less voltage is available to the remainder of the circuit.

By using the voltage divider principle, the IR drop across any series resistor can be found without first finding the series current. In figure 3 the series current from Ohm's law is $I_S = \frac{E}{R_1+R_2+R_3+R_4}$.

The IR drop across R_4 is equal to $I_S R_4$ or $\frac{ER_4}{R_1+R_2+R_3+R_4}$.

Thus the IR drop for R_4 equals the battery voltage times R_4 divided by the total series resistance. IR drops for other resistors in series can be found using the voltage divider in a similar manner.

QUESTION: By using the voltage divider, what is the IR drop across the 3 Ohm resistor in figure 3.

1) 3 volts . . . See frame 9
2) 14 volts . . . See frame 19
3) 6 volts . . . See frame 12

6 You forgot about the units! Remember that 1.5K Ohms is equal to 1500 Ohms. Return to frame 12 and choose another answer.

7 Your answer is correct. Using Ohm's law and the basic formula for power, additional equations may be written for power. Since E = IR we can substitute IR for E. Thus, P = IRxI or I^2R. Also, since I = E/R, E/R can be substituted in a similar manner to obtain, P = E^2/R. All three expressions for power give the same results and any one may be used to reduce calculations. Note in figure 2a that the power dissipated by the 3 Ohm resistor could have been found without finding the current by using, P = E^2/R. As a check, find the power using this formula.

The circuit shown in figure 3 is called a series circuit since each resistor is in series with the other. In a series circuit the current through each resistor is the same.

QUESTION: For the circuit in figure 3, how much current flows through the 2 Ohm resistor?

1) I = 10 amps . . . See frame 15
2) I = 40 amps . . . See frame 3
3) I = 2 amps . . . See frame 11

8 Your answer is incorrect. In general the equivalent parallel resistor will be less than any of the parallel resistors. This fact is useful as a check on the calculated equivalent resistor. For figure 5c, R_P is calculated as shown below:

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_P} = \frac{1}{1.5\times10^3\,\text{Ohm}} + \frac{1}{1\times10^3\,\text{Ohm}}$$

$$\frac{1}{R_P} = \frac{.67\times10^{-3}}{\text{Ohm}} + \frac{1\times10^{-3}}{\text{Ohm}} = \frac{1.67\times10^{-3}}{\text{Ohm}}$$

$$R_P = \frac{1\ \text{Ohm}}{1.67\times10^{-3}} = 0.6\times10^3\,\text{Ohm}$$

$$R_P = 600\ \text{Ohm}$$

Begin reading with the second sentence of frame 13.

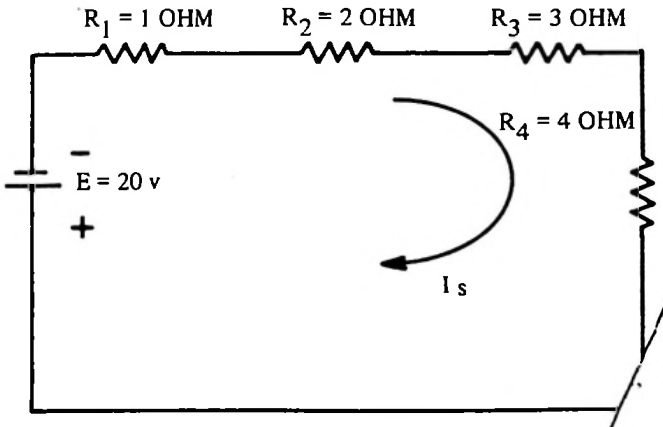


FIGURE 3
THE CURRENT THROUGH EACH RESISTOR AND IN A SERIES CIRCUIT IS THE SAME

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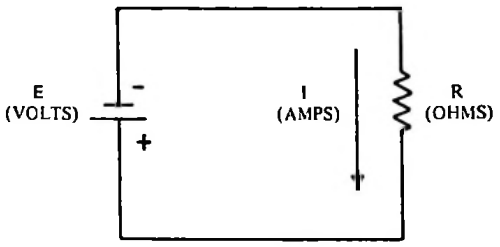

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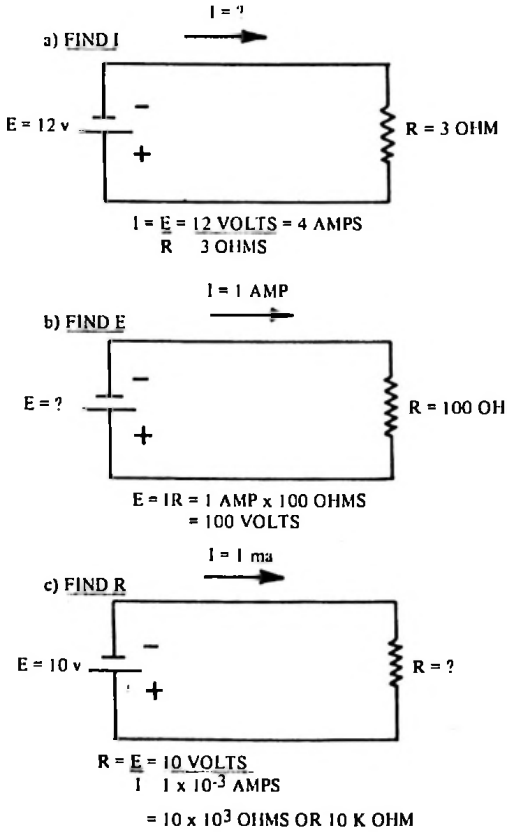

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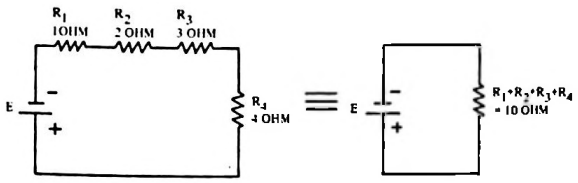

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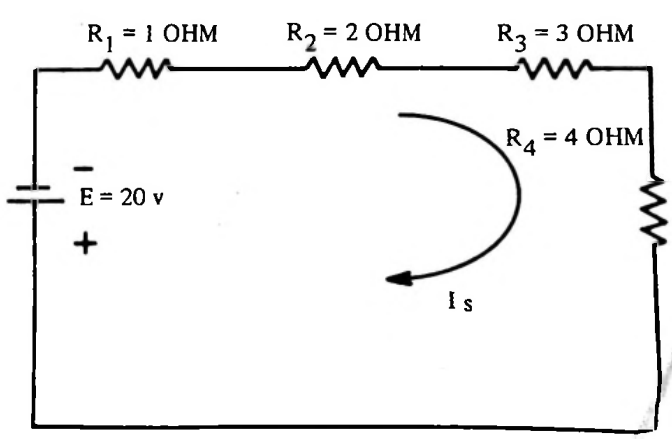


FIGURE 3
THE CURRENT THROUGH EACH RESISTOR IN A SERIES CIRCUIT IS THE SAME

9 Your answer is incorrect. Using the voltage divider, the voltage across R_3 is, $E_3 = \frac{ER_3}{R_1+R_2+R_3+R_4}$

Return to frame 5 and choose another answer.

10 Your answer is incorrect. Power dissipated by the resistor is not found by multiplying the current times the resistor. Use the power formula, P = EI to find the power and choose another answer to frame 1.

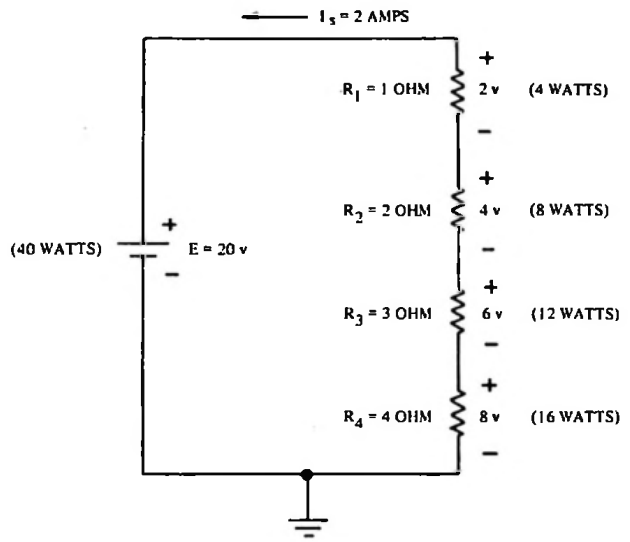


FIGURE 4
IF THE NEGATIVE BATTERY TERMINAL IS TAKEN AS THE O REFERENCE, THE VOLTAGE RISE OF THE BATTERY EQUALS THE VOLTAGE DROPS OF THE RESISTORS

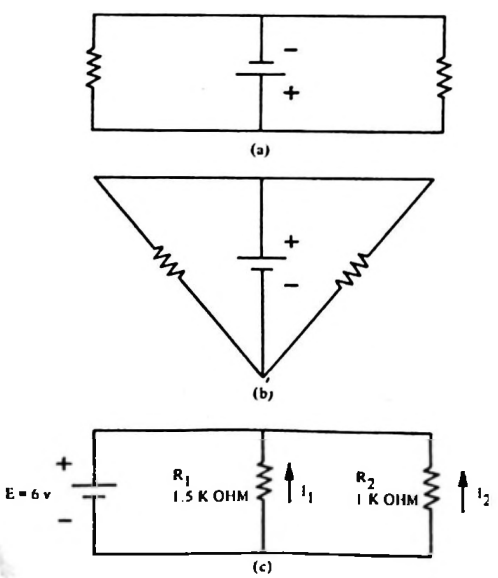


FIGURE 5
EXAMPLES OF PARALLEL CIRCUITS

11 Your answer is correct. The series current of 2 amps is also the same current through all the other resistors.

QUESTION: For the series circuit in figure 3 what is the potential difference (or voltage) across the 4 Ohm resistor?

1) 4 volts . . . See frame 2
2) 8 volts . . . See frame 5
3) 12 volts . . . See frame 16

12 Your answer is correct. By using the voltage divider, the IR drops across the remaining series resistors can quickly be found. The circuit of figure 3 is shown in figure 4 with the IR drops and power calculated for each resistor. In figure 4 the negative terminal of the battery has been selected as the ground reference of 0 volts. The battery produces a voltage rise which is equal to the sum of the IR drops of the series resistors. The ground reference position is arbitrary, but the IR drop of each resistor has a polarity associated with the direction of current flow. Note from figure 4 that the power dissipated by the sum of the resistors is equal to the power supplied by the battery.

The circuits shown in figure 5 are all called parallel circuits. In a parallel circuit, there are many paths for current but the same voltage exists across all resistors.

QUESTION: In figure 5c what is the value of I_1, the current through the 1.5K Ohm resistor?

1) I_1 = 4 amps . . . See frame 6
2) I_1 = 10 ma . . . . See frame 21
3) I_1 = 4 ma . . . . See frame 18

13 Your answer is correct. The equivalent resistor for the two parallel resistors can also be found using the formula $\frac{R_1R_2}{R_1R_2}$, and is easily remembered as the product over the sum. This formula is sometimes easier to use but applies only for two parallel resistors. For practice, find the equivalent resistance of figure 5c using this formula. Power dissipated by each parallel resistor is determined using the same basic power relationships ($P = EI = I^2R = E^2/R$), as for series circuits. Ohm's law is applied to each parallel branch in order to find either the unknown current or voltage.

QUESTION: For the parallel circuit in figure 5c how much power do both parallel resistors dissipate?

1) 2.6 watts . . . See frame 20
2) 60 mw . . . . See frame 17
3) 24 mw . . . . See frame 23

14 Your answer is incorrect. To reduce this circuit, start by adding the series resistors R_2 and R_3 as shown in figure 7. Next find the parallel combination of R_2 and R_3 with R_4, and replace with a single equivalent resistor as

(Continued on page 27)

shown in the figure. Now, the circuit is reduced to a series circuit where the resistors can be summed together to find one resistor.

Use this procedure to reduce the network in figure 6 and choose another answer to frame 17.

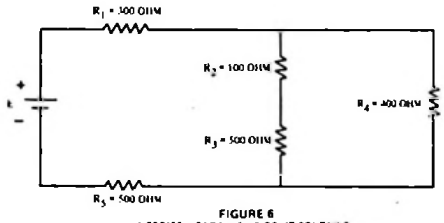


FIGURE 6
A SERIES - PARALLEL CIRCUIT CONTAINS RESISTORS IN BOTH SERIES AND PARALLEL

---

15 Your answer is incorrect. The potential difference of the battery exists across the sum of the resistors, not just the 2 Ohm resistor. In a series circuit the series current is determined by adding the resistors together and dividing the battery voltage by their sum. Re-calculate the series current for the circuit in figure 3, and choose another answer to frame 7.

---

16 Your answer is incorrect. The voltage across a resistor in a series circuit is found by multiplying the series current times the resistor. Apply Ohm's law to the 4 Ohm branch and choose another answer to frame 11.

---

17 Your answer is correct and could have been found by three different approaches. First, the power dissipated by each resistor could have been added together to find the total power dissipated. Or, the power dissipated by the parallel equivalent resistor could have been found since its power is equal to the sum of the powers dissipated by each parallel resistor. The third method involves finding the power supplied by the battery. For parallel circuits similar to figure 5c the sum of currents through the parallel resistors equals the total current supplied by the battery. The power the battery supplies is then found from $P = EI_T$ where, $I_T = I_1 + I_2$.

Table I summarizes the basic relationships and properties for series and parallel circuits that we have discussed so far. Note the similarities and differences for each type of circuit.

The circuit in figure 6 is called a series-parallel circuit since some resistors are in series and others in parallel. This type of network can be reduced to a single equivalent resistor by reducing and combining series and parallel sections, until one resistor remains.

QUESTION: What is the value of the equivalent resistor that can replace the resistors in figure 6?

1) 1K Ohm . . . See frame 25
2) 1200 Ohm . . . See frame 22
3) 1400 Ohm . . . See frame 14

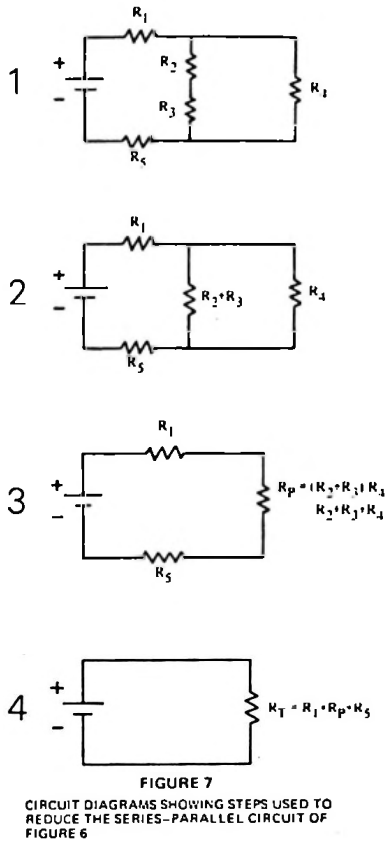


FIGURE 7
CIRCUIT DIAGRAMS SHOWING STEPS USED TO REDUCE THE SERIES-PARALLEL CIRCUIT OF FIGURE 6

---

18 Your answer is correct. Note that the current through R_1 is the same whether or not R_2 is connected to the circuit. Additional parallel resistors would not change the value of I_1 either. For this reason parallel circuits are used in house wiring to prevent "loading" or interaction between lights, radio, TV, appliances, etc.

The parallel resistors R_1 and R_2, in figure 5c may be represented by a single resistor which is said to be equivalent since it draws the same current from the battery as do the parallel resistors. This equivalent resistor is calculated using the formula, $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$, where R_P is the equivalent resistor that replaces the parallel resistors.

QUESTION: What is the value of an equivalent resistor which replaces the parallel resistors in figure 5c?

1) Req = 600 Ohm . See frame 13
2) Req = 6K Ohm . . See frame 8
3) Req = 2.5K Ohm . . See frame 24

---

19 Your answer is incorrect. The voltage across R_3 using the voltage divider, is found from the expression, $E_3 = \frac{ER_3}{R_1+R_2+R_3+R_4}$

Substitute the resistor values in the above formula and choose another answer to frame 5.

OHM'S LAW	$E = IR \quad , \quad I = \frac{E}{R} \quad , \quad R = \frac{E}{I}$
POWER	$P = EI = \frac{E^2}{R} = I^2R$

SERIES CIRCUITS	PARALLEL CIRCUITS
$R_S = R_1 + R_2 + R_3 + \ldots$	$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$
	FOR TWO PARALLEL RESISTORS
	$R_P = \frac{R_1 R_2}{R_1 + R_2}$
$I_S = I_1 = I_2 = I_3 = \ldots$	$I_T = I_1 + I_2 + I_3 + \ldots$
$E = E_1 + E_2 + E_3 + \ldots$	$E = E_1 = E_2 = E_3 = \ldots$
$P_T = P_1 + P_2 + P_3 + \ldots$	$P_T = P_1 + P_2 + P_3 + \ldots$

TABLE I
REFERENCE TABLE FOR SERIES AND PARALLEL CIRCUITS

20 Your answer is incorrect. Use any one of the three expressions for power as discussed in frame 7, to find the power dissipated by each resistor. Keep in mind for a parallel circuit, that the voltage across each resistor is the same but that the current through each resistor may be different.

Re-calculate the total power dissipated and choose another answer to frame 13.

21 Your answer is incorrect. The voltage across R_1 is the same as the battery voltage. Apply Ohm's law and find the current through R_1. Return to frame 12 and choose the correct answer.

22 See frame 14

23 Your answer is incorrect. This is the power dissipated by R_1 only. Calculate the power dissipated by R_2 and add the results to find the total power dissipated by both R_1 and R_2. Return to frame 13 and choose the correct answer.

24 Your answer is incorrect. The resistors are not added as are resistors in a series circuit. Return to frame 18 and find R_P, using the formula for parallel resistors.

25 Your answer is correct. To find the voltage, current and power associated with each resistor, the relationships from table I are used for the various series and parallel sub-sections of the circuit. Figure 8 illustrates the rebuilding of the series-parallel circuit of figure 6, to find all resistor currents and voltages. Any formula for power can be used to find the power dissipated by each resistor. The total power dissipated by the resistors, equals the power supplied by the battery (100 mw). As a check, find the power for each resistor and add their total.

In this lesson Ohm's law has been used to analyze series, parallel and series-parallel combinations. For more complicated circuits additional network analysis methods are available. Often times however, complicated networks are reduced to sub-sections, where they can be analyzed by series, parallel and series-parallel combinations.

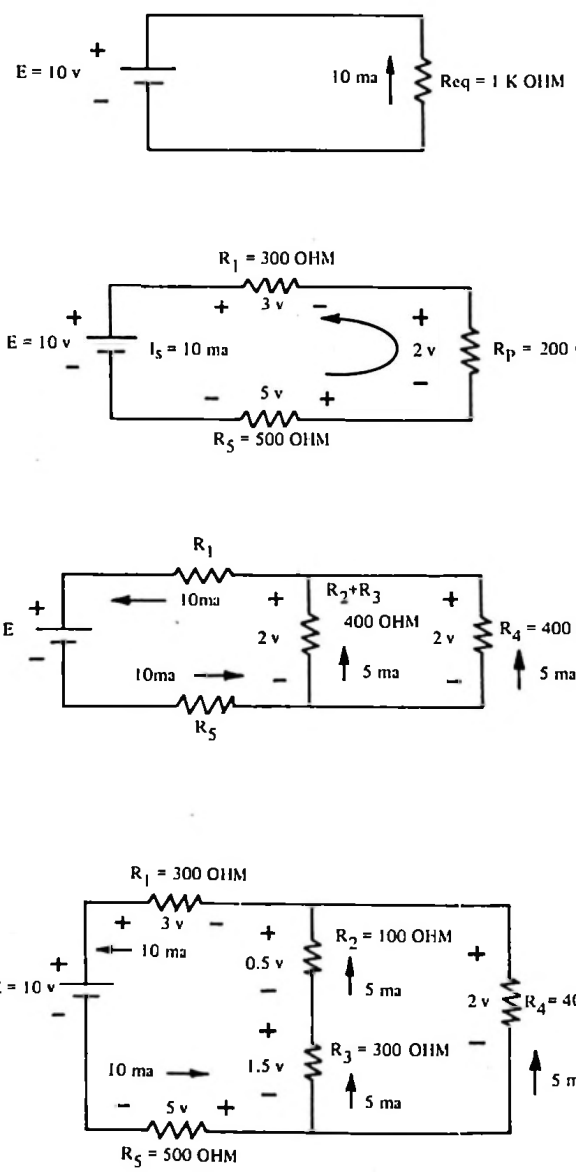
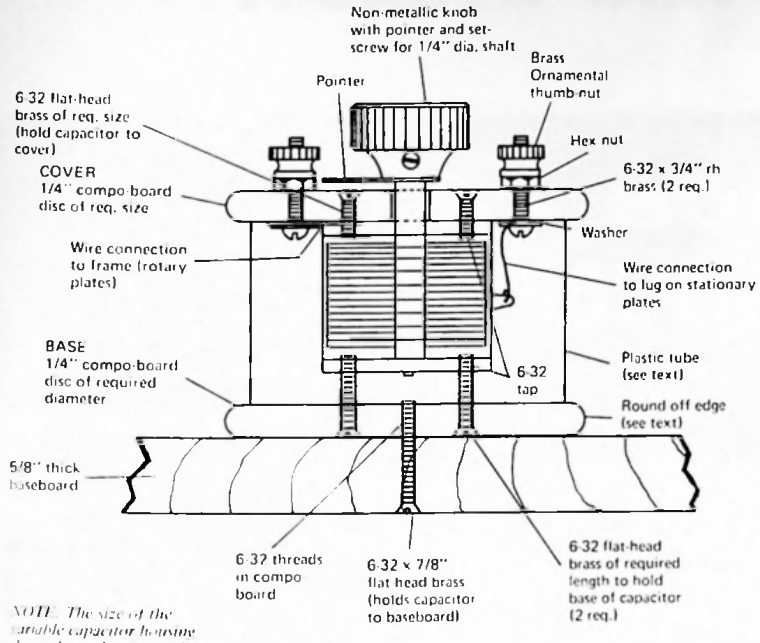


FIGURE 8
REBUILDING THE SERIES – PARALLEL CIRCUIT OF FIGURE 6 TO FIND ALL VOLTAGES AND CURRENTS

OLD TIME LOOSE-COUPLER RADIO

(Continued from page 23)



NOTE: The size of the variable capacitor housing depends on the size of the capacitor used. The writer used an Allied midget 365 pf capacitor such as the No.61009.

Figure 4

REPLICA OF OLD-TIME MURDOCK GLASS-ENCLOSED VARIABLE CONDENSER

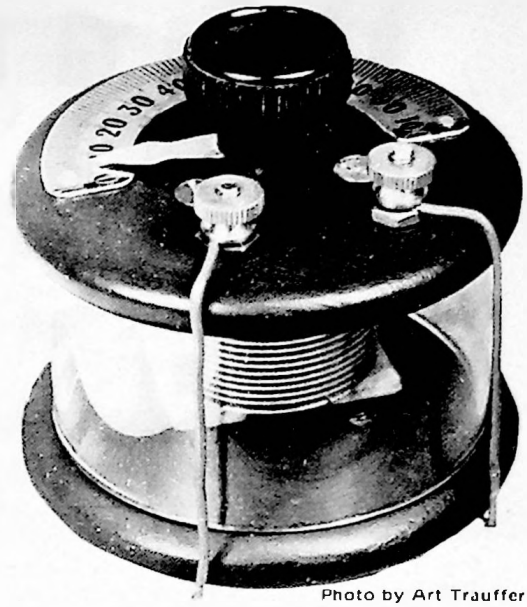
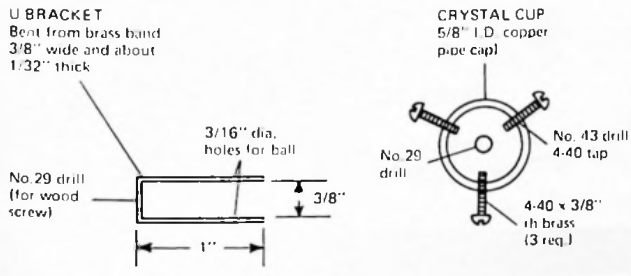


Photo by Art Trauffer

Figure 5

Photo above shows the completed old time Murdock glass-enclosed variable condenser.



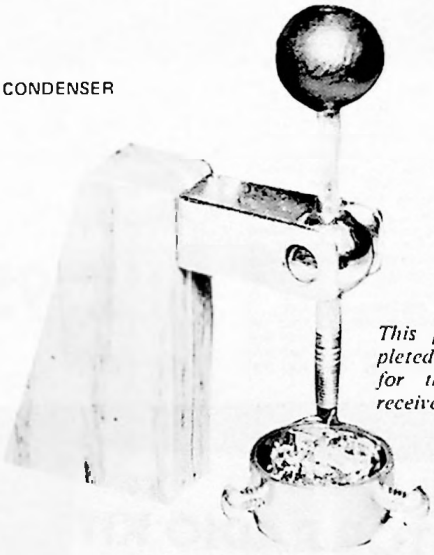


Figure 7

This photo shows the completed crystal detector stand for the loose-coupler radio receiver.

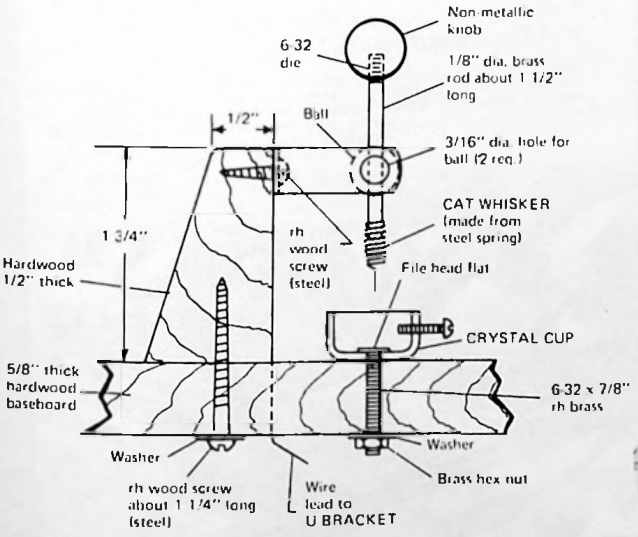


Figure 6

CRYSTAL DETECTOR STAND

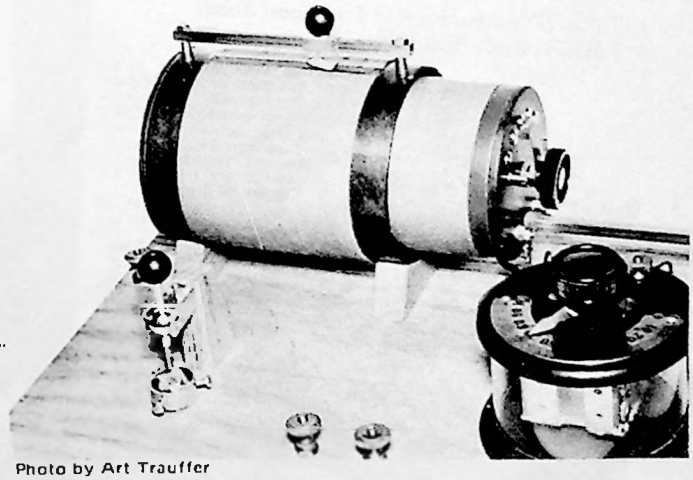


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Figure 8

Photo above shows the completed receiver with the secondary coil pulled almost all the way out (loosely coupled).

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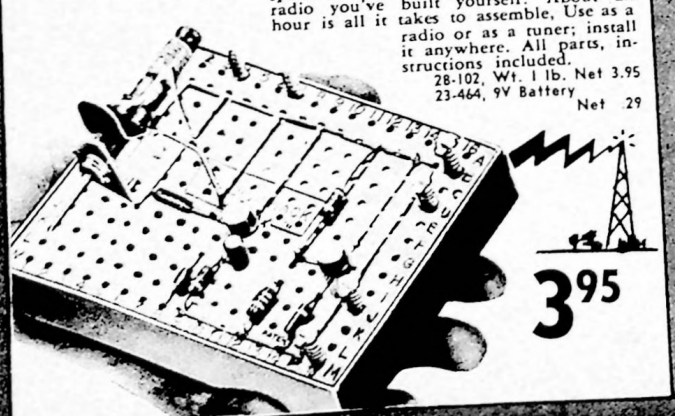

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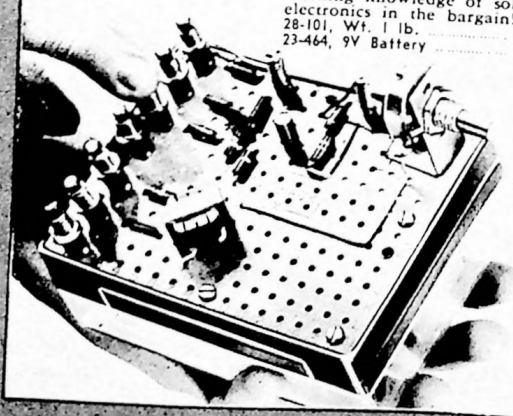

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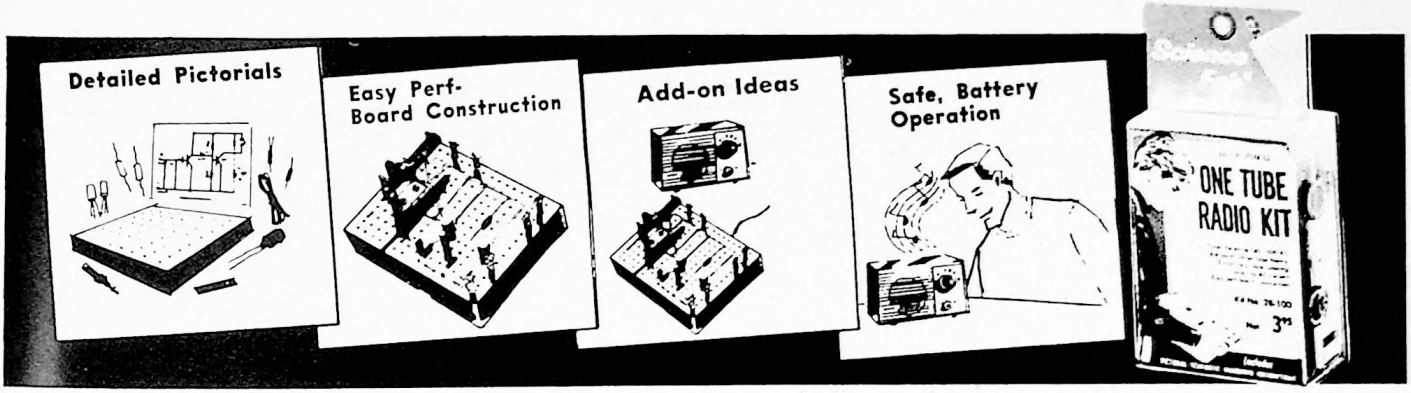

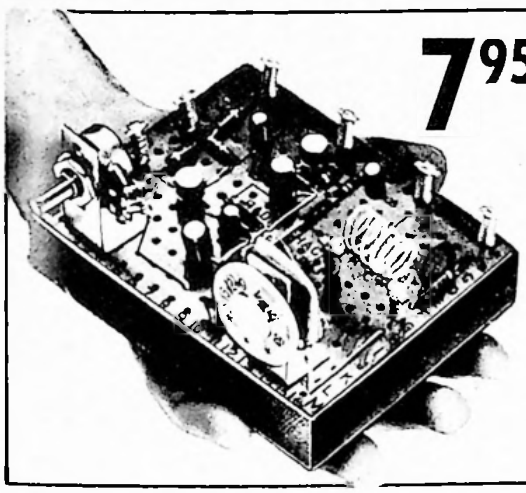

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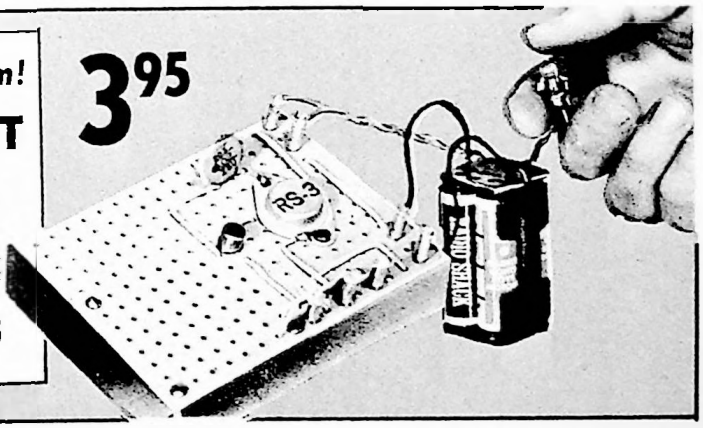

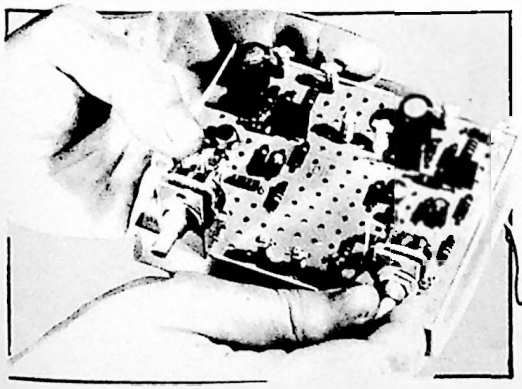

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