March/April 1970
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Electronics Digest

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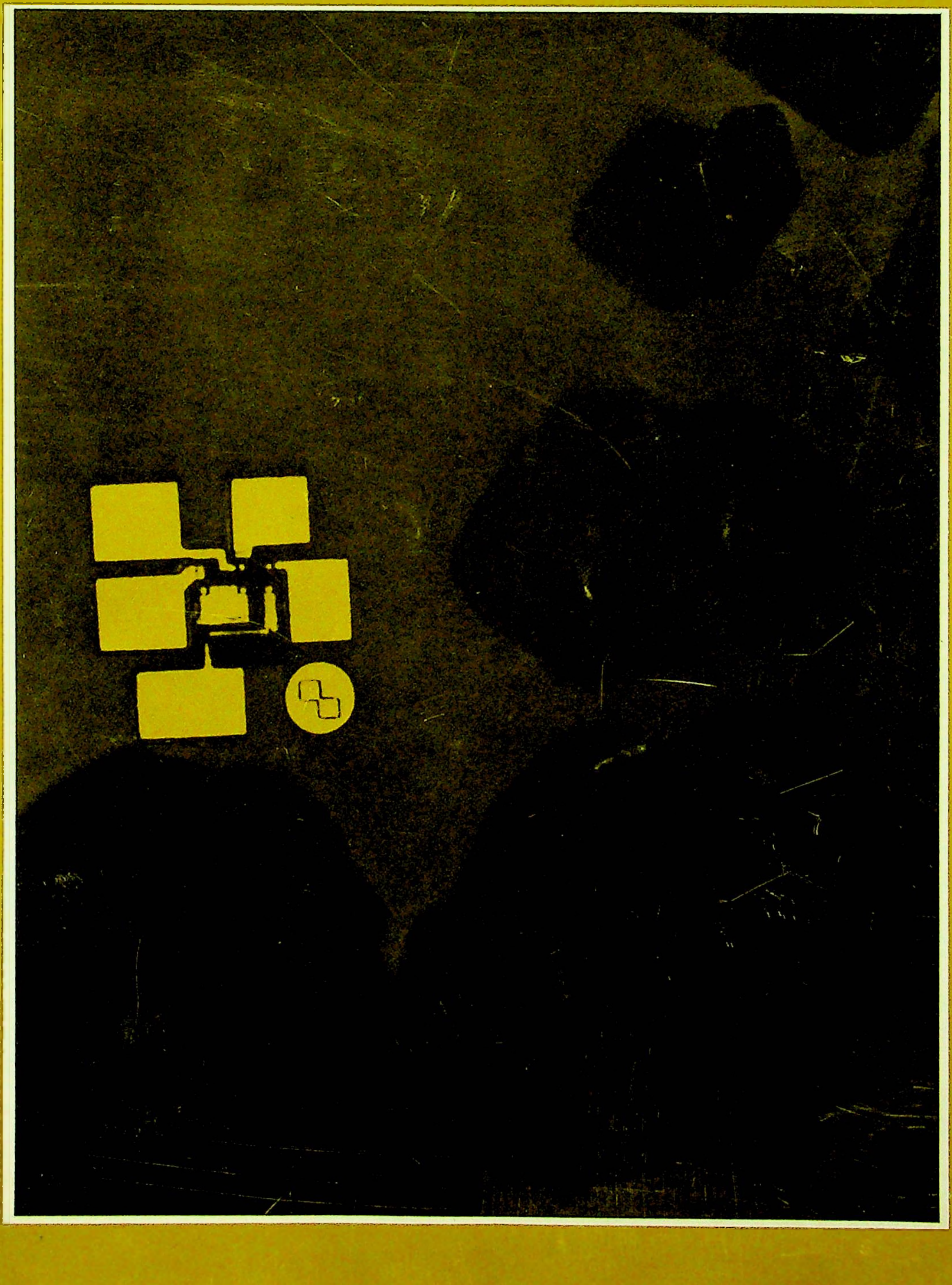


PROF. ELISHA GRAY A
Inventor of the Automatic Telegraph Printer

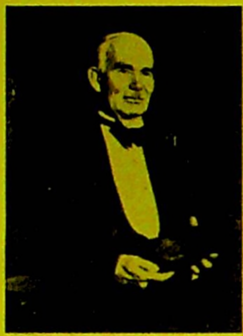
SAMUEL F. B. MORSE B
Inventor of the Telegraph

VLADIMIR K. ZWORYKIN C
Inventor of the Iconoscope

NIKOLA TESLA D
Inventor of AC Power Generators

LAURENS HAMMOND E
Inventor of the Electric Organ

KARL GUTHE JANSKY F
Discoverer of Radio Waves from Outer Space



LEE DEFOREST G
Inventor of the Radio Amplifier Tube

THOMAS A. EDISON H
Inventor of the Incandescent Lamp

GEN. DAVID SARNOFF I
Pioneer in Development of the Electronics Industry

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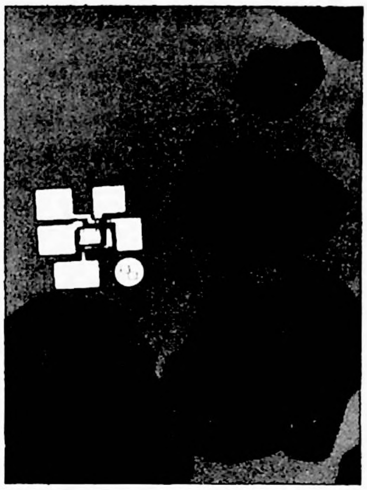
THE ELECTRONICS MAGAZINE FOR HOME AND SCHOOL

VOLUME THREE / NUMBER FIVE

March/April 1970

WILLIAM M. PALMER, W5SFE
Editor



COVER STORY

A Moon landing? No, the "rocks" are grains of table sugar used to demonstrate the small size of this new Bell Laboratories integrated circuit fabricating by using a new Tri Mask (TRIM) technology. The large rectangles are merely contact points surrounding the circuit, in this case a "logic gate" used in computers and in telephone switching equipment. This logic gate contains five components: three resistors and two transistors. A transistor in this circuit occupies less than 760 billionths of a square inch space.

Because of the small size of integrated circuits, minute features and connecting lines are formed by photolithographic techniques. Normally, integrated circuits that use conventional bipolar transistors require five to seven photolithographic masking steps before the contacts to the silicon are formed. The new circuit needs only three such steps. In both cases, additional processing is required to make contacts to other circuitry and to protect the circuit from the environment.

The new "Trim Mask" (three photographic masking steps) structure is based on using lateral transistors, that is, transistors in which injected carriers flow parallel to the surface rather than perpendicular to it.

See SCIENCE REPORTS in this issue

ARTICLES

REGULAR FEATURES

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SCIENCE REPORTS

Engineers Have Designed Oxygen Regeneration System for Spacecraft

PITTSBURGH, Mar. 16—Engineers at the Westinghouse Research Laboratories have designed and successfully life-tested major components of a system to reclaim oxygen from the breath of astronauts.

"It will be impractical to stow in a spacecraft all the fresh oxygen that will be needed for missions of several months. In search of a solution to this problem, the National Aeronautics and Space Administration is funding development of a reliable, light-weight oxygen regeneration system based on the Westinghouse solid electrolyte battery," said Leonard Elikan, leader of the project.

Both the battery and the other major component, a carbon deposition reactor, have completed more than 100 days of continuous testing.

The battery, basically a fuel cell unit that would normally combine gaseous fuel with oxygen to produce electricity, operates in reverse in this system: it uses electricity to "unburn" carbon dioxide and water vapor in the breath that comes from food burned up by the body, winding up with pure oxygen at one terminal of the battery and gases containing hydrogen and carbon atoms at the other.

Carbon is extracted by the carbon deposition reactor, and will be stowed in empty food storage space; hydrogen will pass into space through a membrane of palladium, a metal of the platinum group.

The project is being conducted by a team of engineers, headed by Mr. Elikan and Joseph Morris, who are now building a small system to test the components working together as a unit. Charles G. Saunders of NASA Langley Research Center is the program coordinator for NASA.

"We estimate that a system to provide oxygen for four men on a 100-day mission would weigh about 120 pounds and require about 1200 watts of power," Mr. Elikan said.

The battery is constructed of a number of thin-walled cylindrical electrolysis cells consisting mostly of zirconium oxide, which has the unusual property of permitting negatively charged oxygen atoms, or ions, to migrate through it easily.

Carbon dioxide and water vapor, taken from the air in the spacecraft, will pass through the cell. Electricity is used to break down carbon dioxide and water into carbon monoxide, hydrogen and oxygen ions on one side of the cylinders, and to pump the ions to the other side where they combine to form pure oxygen.

The carbon deposition reactor uses iron heated to 1400 degrees Fahrenheit as a catalyst to change the carbon monoxide into carbon dioxide, which is recycled through the battery, and solid carbon.

Photolithography Used to Make Grain-of-Sugar Size Computer Logic Gates

A new and greatly simplified integrated circuit, smaller than a grain of sugar, promises to be more economical to make than comparable circuits now in use.

Designed at Bell Telephone Laboratories, this circuit will be easier to produce because it involves fewer manufacturing steps.

Because of the small size of integrated circuits, minute features and connecting lines are formed by photolithographic techniques. Normally, integrated circuits that use conventional bipolar transistors require five to seven photolithographic masking steps before the contacts to the silicon are formed. The new circuit needs only three such steps. In both cases, additional processing is required to make contacts to other circuitry and to protect the circuit from the environment.

The new "Trim Mask" (three photographic masking steps) structure is based on using lateral transistors, that is, transistors in which injected carriers flow parallel to the surface rather than perpendicular to it. The collectors and emitters needed for the transistor are diffused simultaneously, and therefore need only one masking operation. Thus, all of the important transistor properties are determined by this one operation, leading to a high proportion of good circuits

The Tri Mask method has been used to build integrated circuit logic gates (circuits used in computers and telephone switching) with fewer masking steps than are now used in making individual transistors. A transistor in such a circuit occupies less than one-millionth of a square inch.

The Tri Mask structure gives integrated circuits whose performance compares favorably with the metal-oxide-silicon integrated circuits now in wide use, but is simpler to make.

The structure gives good isolation between transistors because the substrate has a high resistivity, and the emitter and base regions are encircled by a collector region.

A triple-mask transistor is made in the following way. The substrate is silicon lightly doped with boron (p-type substrate). Into this substrate is diffused a shallow p-type base layer.

Silicon oxide is grown over the entire surface, and is then etched away selectively where the emitter and collector regions are to be formed. The first photolithographic mask is used for this step. Phosphorous-doped emitter and collector regions (n-type) are diffused through the p-type base, and then all of the exposed silicon oxide is removed. A second silicon oxide layer is grown on the surface and the second mask defines the emitter, collector, base, and surface contact holes. Metal is evaporated over the entire surface and etched away except where the third mask defines the metal conductor paths. For Bell System use, the contacts to external circuitry are provided through beam leads while a layer of silicon nitride provides the protection.

Tri Mask devices are simpler to make than conventional metal-oxide-silicon devices. Yet Tri Mask devices give the low, sharp and stable threshold devices of conventional bipolar transistors.

The new technique was reported recently by Vincent J. Glinski of Bell Laboratories.

Line Voltage Variations Triggers Monitor Alarm Reduces Computer Errors

Data processing errors are often caused by power line voltage fluctuations. These rapid power fluctuations can cause computers to generate erroneous data wasting costly computer time. It has been reported that a new line monitor called PowerGuard ends this problem by providing a long term, permanent record of the amplitude, duration and time of occurrence of any power line fluctuation.

Western Union Computer Utilities, Inc.'s PowerGuard is a low cost recording system connected directly to input power lines for monitoring and recording high speed transients. The unique design allows weeks of continuous information to be written on a slow-speed recorder without the loss of high-speed transient response normally associated with low-speed devices. It provides a continuous monitoring system that sounds an alarm when transients occur and permanently records the amplitude, duration and time of occurrence.

WUCU further reports that system data reliability is increased with PowerGuard by assuring the user that proper voltage level, affects data reliability, being supplied to the EDP installation at all times. PowerGuard is a complete transient detection system including strip chart recorder, transient detection electronics, automatic reset, continuous panel display, and an internal digital clock to record the precise moment of the power fluctuation. No other equipment is necessary in order to obtain a full and accurate diagnosis of transient occurrences.

PowerGuard is available for 115, 208 and 230 volt EDP installations. Transient durations detected are 0.1, 1.0 and 8 milliseconds and voltage transients are detected and recorded at levels of $\pm$ 10% and $\pm$ 20% of the nominal voltage. It is a product of Western Union Computer Utilities, Inc., 2455 East Sunrise Boulevard, Fort Lauderdale, Florida 33304.

"Lightguides" Promise Miniature Circuits For Laser Communications

Newly developed "lightguides" — hair-like, transparent pipes formed on glass plates—will enable scientists to manipulate laser light as though it were a current in an electronic circuit.

These lightguides, being investigated at Bell Telephone Laboratories, can be interconnected to form complex optical circuits that perform functions similar to those of electronic circuits in computers and communications equipment. The lightguides could form important circuits in a laser communications system that may someday carry telephone, PICTUREPHONE®, data, and TV signals. The guides might also be used to process signals in other high capacity communications systems and computers.

The lightguide itself is a thin glass or crystal strip—about 100 times thinner than human hair—deposited as a film on a glass plate. Because the width of these films is only about ten times their thickness, an entire laser circuit would fit on a plate the size of a nickel. Such a circuit would be relatively unaffected by heat, noise, or vibrations, which might affect larger apparatus presently used for the same functions.

The thin film strips guide laser beams around relatively sharp bends because they behave like tunnels with mirrors for walls. Glass or crystal films must be used to achieve this "mirror" effect because conventional silvered mirrors would dissipate too much laser light.

J. E. Goell and R. D. Standley describe the new lightguide experiments in a recent issue of the BELL SYSTEM TECHNICAL JOURNAL. The experiments are part of a continuing research program to investigate the possibility of using lasers for communications.

For long distance transmission, the capacity of a laser system could exceed 100 times that of microwave systems presently in use commercially. Although this enormous capacity would probably not be needed until the 1980's, Bell Labs is proceeding with an active optical research program.

Additional Technical Information

OPTICAL CIRCUITS NEEDED FOR A LASER COMMUNICATIONS SYSTEM—For a laser communications system, optical circuits could be used in a device called a "repeater," periodically spaced along the transmission route. Such a device would "amplify," or regenerate, signals carried by a laser beam. These signals—voice, video, data—would probably travel as a series of light pulses.

HOW LASER LIGHTGUIDES ARE MADE—Suitable glasses or crystals are deposited on a glass substrate by a technique known as "sputtering." A lightguide is then made by a masking and etching process similar to that used in making many conventional integrated circuits. For complicated optical circuits, methods similar to photolithographic processes could simplify reproduction once an original had been developed.

Solder Mask for Hybrid Microcircuit Substrates

A new, flexible material designed to mask the application of solder on undesired areas of ceramic and plastic circuit boards has been announced by Starnetics Company, who says their product is superior to previously available materials which were difficult to remove and sometimes caused discoloration of gold, silver and copper surfaces.

SC-300 is easily peeled from the masked surface and will withstand short exposures to solder temperatures of 500 Deg. F. The mask also functions as a protective coating during assembly operations.

Supplied with a special applicator tip, the mask can be placed on the material directly or it can be brushed, dipped or screened. Thin coats cure in 30 minutes at 72 Deg. F. and in 10 minutes at 150 Deg. F. Curing can be accomplished in several minutes at 250 Deg. F, according to the manufacturer.

Man Probes the Mysterious Wilderness of Outer Space

by William M. Palmer

A sensitive early day radio receiver and a 100-foot long antenna array—which could be rotated by means of four wheels salvaged from a Model "T" Ford—and a young physicist, Karl Guthe Jansky, played leading roles in an amazing science drama less than four decades ago. Jansky had begun his observations in August, 1931, as a project to track down the high-frequency static and noises that continually plagued transatlantic communication of that era.

During these observations, Jansky was able to identify the sources of two types of static: lightning in nearby thunderstorms, and from the distant storms whose radio emissions may have been reflected back to earth by ionized layers of the upper atmosphere. The third type was quite different . . . and they were later identified as radio waves from outer space.

Jansky announced his momentous discovery at a meeting of the International Scientific Radio Union on April 27, 1933—thirty-seven years ago this year—thus marking the real beginning of radio astronomy.

Today NASA's Orbiting Astronomical Observatory (OAO) with its Project Celescope equipment—a television/telescope system planned by the Smithsonian Astrophysical Observatory—is mapping vast areas of space never before visible to man. The project is producing new data on pulsars, quarsars, novae, Scorpio-Centaur and Orion star clusters, and the planets.

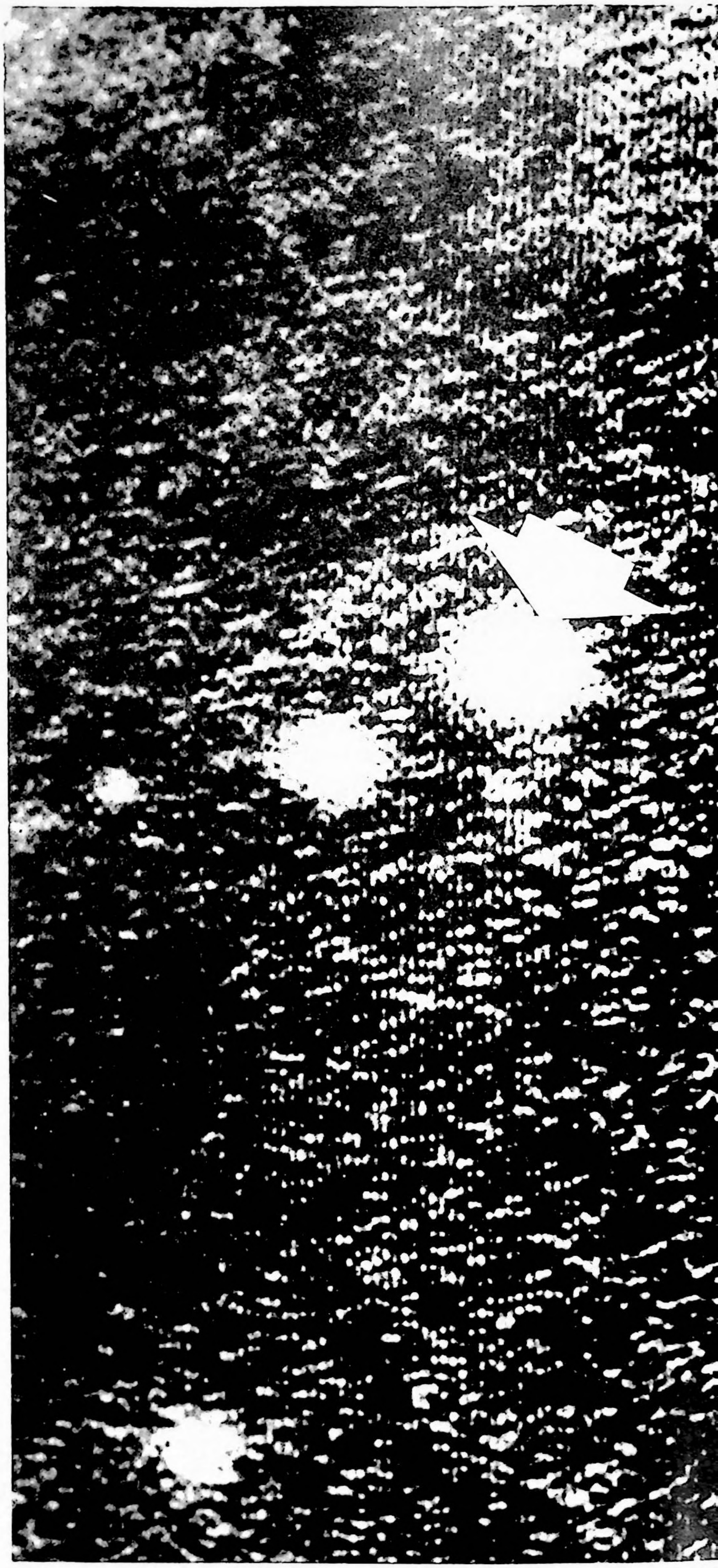
New knowledge is also being accumulated through deep-space studies making use of huge radio telescopes such as the instrument on the grounds of the National Radio Astronomy Observatory at Green Bank West Virginia. This telescope, which was completed in 1965, weighs about 10,000 tons and cost the U. S. Government nearly $13,000,000 to build.

In addition to these studies, the revolutionary Westinghouse SEC (Secondary Electron Conduction) tubes are playing a major role in today's astrophysics.

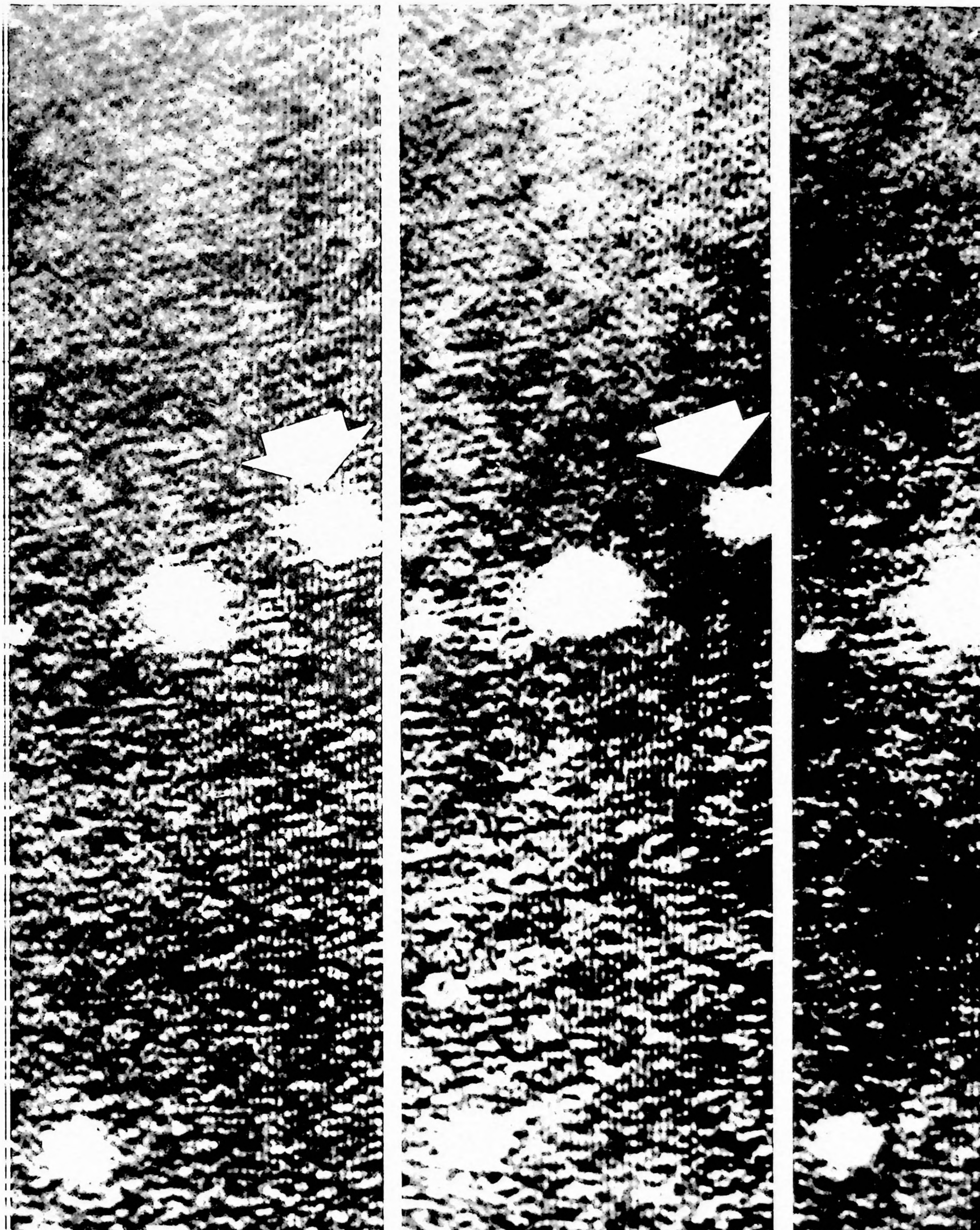
In 1969, the Lick Observatory of the University of California turned its SEC-equipped 120-inch telescope on the famous pulsar in the Crab Nebula. The results were dramatic! The Lick experiment proved that the Crab Nebula pulsar emits visible light in bursts exactly timed to radio pulses . . . 30 times per second.

The experiment was built around a slotted spinning disk which was synchronized to the pulsar's blinking light. The pulsar then became visible by means of the SEC tube which integrated the signal over several seconds.

Thus, man continues to increase his knowledge about the far reaches of interstellar space which had been hidden from his view since the beginning of time.



Pulsar Blink . . .



Lick Obse

Going . . . Going . . . Gone!

Robot Gas-Electric-Water Meter Reader

In the future, a computor may read utility meters automatically through your telephone line without ringing the phone

A computer could read your electric, water, or gas meter automatically through your telephone line without ringing the phone or perceptibly tying up the line.

To test such a system, trials involving up to 150 homes at Holmdel, N. J., will be started in month or two by Bell Telephone Laboratories. More extensive trials will be held in other locations during 1970.

Automatic meter reading requires some special equipment in the home, telephone central office, and utility company office. Whether new equipment and techniques will permit this to be done on a broad scale with sufficient economy is being studied by Bell Labs, research and development unit of the Bell System, in cooperation with Bell System phone companies, public utilities, and meter manufacturers. American Telephone and Telegraph Company is coordinating the trials and studying economic factors involved.

In use, an attendant at the utility company establishes a connection between the utility company's computer and special equipment in the telephone company central office. The computer calls the subscriber's phone number, and telephone equipment connects the call to the meter on the subscriber's telephone line. To keep the phone from ringing, this connection is made using different electrical currents and circuits than those normally used. An encoder and a modulator attached to the meter convert mechanical dial readings into electrical pulses or tones which are transmitted, through a coupler and telephone lines, back to the utility's information collection center. There a data communications terminal, which controls the entire process, receives the meter signals and directs them to the computer. The utility's data processor then handles the information for record and billing purposes.

The full procedure, from connection to recording, takes only a few seconds —about the time that it takes to read this sentence aloud. The part of the process involving the subscriber's line is even faster. So fast, in fact, that someone starting to make a call would be unaware that a reading had just been taken. The automatic system will not interrupt a regular call already in progress.

Bell Telephone Labs

METER MAID—Charleen Bruckmann of Bell Telephone Laboratories demonstrates a data communications terminal, part of an experimental system for reading residential gas, water or electric meters automatically over telephone lines. A utility company computer connected to this terminal can record the meter reading without ringing the home telephone or perceptibly tying up the line. The system also requires special equipment at the meter location and in the phone company central office.

In such a meter reading system, the Bell System would provide the communications connections to and within the telephone network. The utility companies would be responsible for providing the terminal equipment — the computer or recording unit at one end and the meter and certain attachments at the other.

Equipment required at the home, in addition to the meter itself, includes: an encoder to convert mechanical dial readings into electrical form; a modulator or modem to translate electrical pulses into a series of tones suitable for transmission; and a coupler to connect the modulator to telephone lines. *Encoding* would be a function of utility company equipment. *Modulation* could be handled by utility company equipment or by a telephone company data set. The coupler, supplied by the phone company could be either part of the data set or a separate unit if the utility company provides the modulation equipment.

The Holmdel Laboratory of Bell Labs devised some of the special experimental equipment for use in the trials. This included a data set, (including the coupler), a separate coupler, access circuit equipment in the telephone central office, and the data communications terminal at the collection center.

In the past a number of meter reading systems have been proposed or tried, but thusfar, for economic or technical reasons, none have proven practical for mass residential use. There has been limited industrial use of more elaborate, more costly systems. Some utility companies have used "remote" systems which transmit a reading from the meter to a more accessible location but still require a meter reading man.

About three years ago Bell Labs made experimental equipment available to meter manufacturers so they could develop compatible meters and encoders for the automatic system. Later meter reading access equipment was added to New Jersey Bell Telephone Company's central office at Holmdel, N. J. This permitted manufacturers to connect and test meters and control equipment in their laboratories via regular telephone lines. Utility subscribers were not involved.

Now automatic reading will be tested under everyday conditions using residential meters in the Holmdel area. A water company, a gas company, and a power company, as well as their designated meter manufacturers, will participate. Other utilities and Bell Telephone Companies will take part in trials later in the year in other parts of the country. In addition to the Bell System equipment, the utilities will use meter and encoder brands of their own choosing at test installations in their service areas.

Opportunities in Electronics

Guest Writer,
Carl W. Costeel,
U.S.A.F. Retired

Today's young men who would like a career in electronics but who lack the education or the experience to step right into the field, might find this ad of interest: "Wanted. High School Graduate. No experience necessary. Employer will furnish room, meals and generous spending allowance, while training in one of the nations foremost electronics schools with the latest in electronic training equipment and one of the finest staffs in the world. After completing school, students will be given a raise in pay for an additional year of expert supervised on-the-job training. Advancement after this training period will be based upon merit and proficiency, with almost unlimited horizons. Free hospitalization. Low cost insurance. Many other benefits."

Although written up in this form as an illustration . . . the ad tells it like it is . . . And if you have not guessed by now the employer's name, it's the United States Air Force.

Generally speaking, this is the way the story takes shape. First of all, before you go to that school, it will be necessary to complete eight weeks of what the Air Force calls "Basic Training." BT is really no more than a series of mental and physical fitness tests plus an indoctrination into military routine. Naturally, your employer wants to select mature, healthy candidates for the costly technical training, which amounts to perhaps several thousand dollars. The exceptional physical fitness program, in addition to the technical training, provides regular exercise and instills good health habits that will benefit most men throughout their life.

The first few weeks of school are usually devoted to basic electronic theory and the classes are small for more effective teaching. Even though you may have some background in "experimenting" and hobby electronics, you will still find it very interesting to have these studies presented again in a dynamic manner that will whet your appetite for more knowledge.

Students are taught solid state electronics theory and perform many interesting experiments in both solid states and the vacuum tube applications which will dramatically illustrate these theories as they move from basic to more advanced study. Finally, the students will be permitted to operate the various types of electronic equipment associated with the type of work to which they will be assigned.

The schools usually schedule their classes for periods of six hours a day, five days a week. In some instances, depending upon individual ability, it may be necessary to do a little "homework" in order to keep pace with the course requirements. Even so, a student should have plenty of time to enjoy the recreational facilities near the school, as well as the wide range of recreational facilities on the base.

After completion of studies at the school an additional year may be spent in well supervised on-the-job training. Regardless of the location of your first assignment—a space center, small radar site, or other installation—a young man will find his supervisor eager to speed him on the way to becoming a first class technician who can be justly proud of the work he turns out.

So, if you do not plan to attend college but would like to become an electronics technician, this may be for you. It may mean signing a four-year contract for some types of training, but a part of that time is spent in school with the remaining time providing experience in some of the best equipped electronics shops in the world. And even though you may not decide to "make it a career," the training and experience is invaluable. For those young career men in the Air Force it can mean helping to launch men into space or other equally interesting work in the broad field of electronics in the service of their country.

Charles Proteus Steinmetz

Mathematician and Electrical Engineer

April 9, 1865 • October 26, 1923

by William M. Palmer

There was a traditional aura of excitement attending the birth of a son—the first born for the young parents. There had been the typical plans and dreams that parents weave for the important childhood years ahead. But one glance at the newborn baby told them that he was hopelessly different—the agonizing realization that cannot be imagined by anyone who has not passed through this traumatic experience. His frail body was misshapen by a humped back, a left leg shorter than the right, and a head that was much too large for the rest of his body. And, although they did not know it at the time, he was going to be a dwarfish four feet three inches in height. The irreversible forces of nature had given their infant an unequal beginning in life. Yet, he was destined to become a genius in the world of mathematics and electrical engineering. As a tribute to his indomitable *will to achieve*, as well as his scientific contributions for the benefit of mankind, we place in History's Hall of Honor the name of Charles Proteus Steinmetz.

Steinmetz, who was born in Breslau, Germany (now Wroclaw, Poland) on April 9, 1865, was given the name of Karl August Rudolph by his parents, Karl Heinrich and Caroline (Neubert) Steinmetz. His mother died a year later.

The next few years of Steinmetz's life were spent with his grandmother who, from all accounts, cared for him tenderly during his fragile early youth. He was an unusually shy child outside of the household, and his physical handicap prevented him from participating in games and other activities with other children of the neighborhood. These circumstances were possibly responsible for his failure to adjust to school attendance, the first few years of which were most unhappy. Various accounts of these early years indicate a lack of interest and inability to bring his latent mental power into focus for satisfactory schoolwork.

In spite of these early psychological and physical hindrances, Steinmetz later developed an increasing zest for study. Perhaps he saw in academic knowledge an opportunity to gain the respect and admiration of his classmates—a kind of psychological compensation for his lack of physical ability to participate in sports and other activities. Intense devotion to study gained the results he desired . . . graduation from the gymnasium (the German high school) at the head of his class.

After entering the University of Breslau in 1883, Steinmetz's insatiable thirst for knowledge prompted him to expand the scope of his studies to include theoretical physics, chemistry, electrical engineering, economics, and special work in advanced mathematics and medicine. His other interests at that time included reading of the classics and journalism.

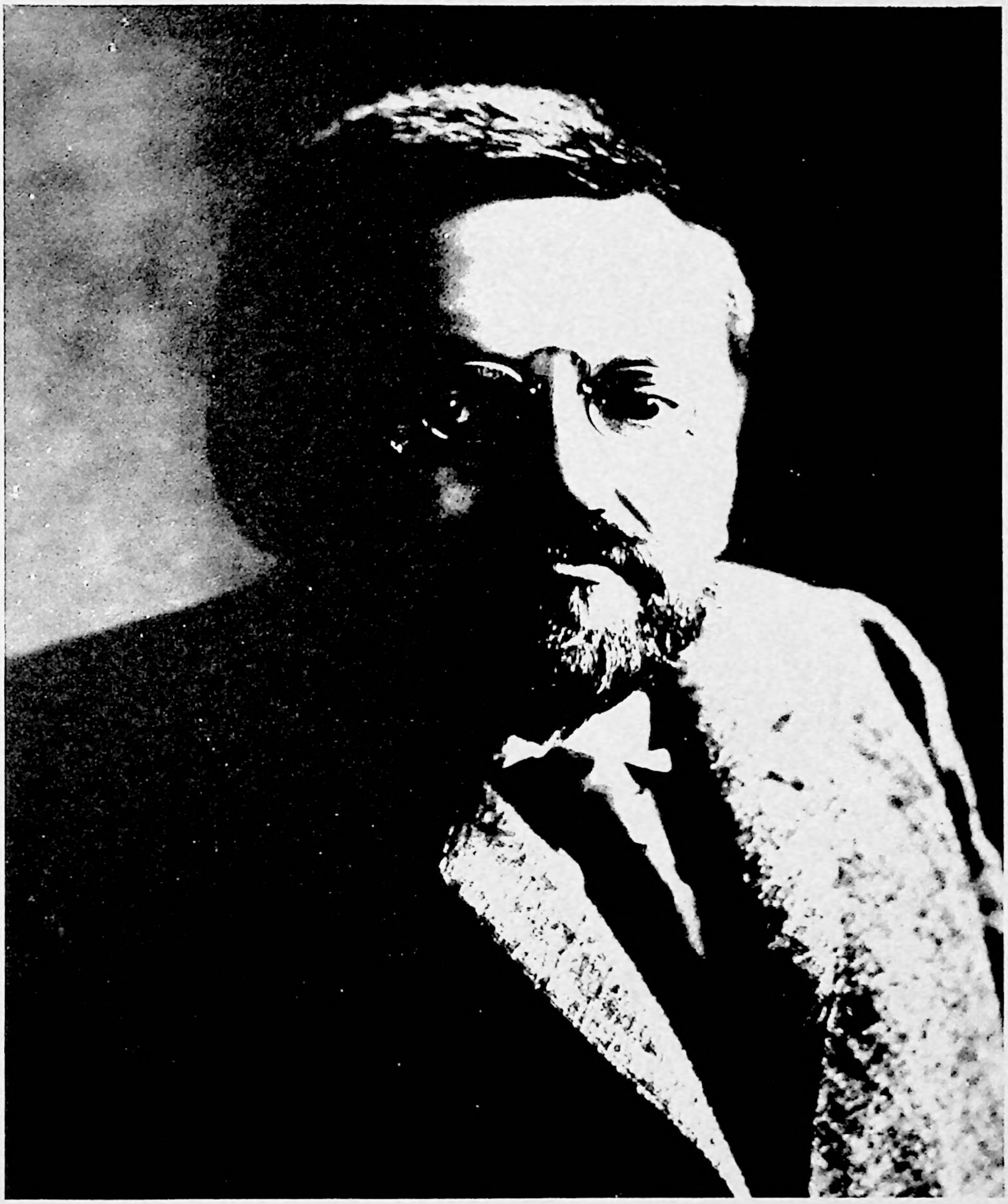
It was during his years at Breslau that one of the members of the mathematics club, of which he was a member, tagged him with the nickname *Proteus*, a name he combined with Charles (the American equivalent of Karl) some years later in an application for United States citizenship. The name comes from Greek mythology woven about a sea god on the island of Pharos, near the mouth of the Nile, who possessed the knowledge of all things, past, present and future. This old man of the sea if caught would try to escape by assuming all sorts of shapes. But if his captor held him fast he would at last return to his proper shape — a dwarfish hunchback — and reveal all the secrets of the world. It must have been a somewhat stinging appraisal for young Steinmetz, even though it was spoken in jest. But he accepted it in good grace, and not without a measure of fascination, since he chose to become Charles Proteus Steinmetz in America — representing perhaps his transition from the Old World to the New.

Steinmetz also became involved in unpopular political activities while at the University, and was finally forced to flee his native land. First he travelled to Austria, then to Zurich, Switzerland. There he met a young man from Denmark, and the two became fast friends. They later decided to come to America in search of greater freedom and opportunity for individual achievement. Steinmetz was virtually penniless, so his new friend financed his passage to this country—the year was 1889.

Like most immigrants, Steinmetz had a scant knowledge of the English language. Consequently, it was necessary for him to spend a brief interval of time after arrival in New York acquiring sufficient vocabulary with which to communicate his thoughts—not only concerning the day to day necessities of life, but also to enable him to qualify for a job that would provide the money with which to purchase them. There were no subsidies in the New World . . . only opportunities.

The little immigrant's first job in America was with Rudolph Eckemeyer, a manufacturer of electrical equipment in Yonkers, New York. The pay was small—only $12 a week—and the work

(Continued on page 12)



Courtesy General Electric Company

Charles Proteus Steinmetz

Mathematician and Electrical Engineer

April 9, 1865 • October 26, 1923

Steinmetz *(Continued from page 10)*

was as a draftsman not an electrical engineer. Nevertheless, it was a step toward eventual success, and he considered himself indeed fortunate to have found this golden opportunity.

Soon, he was promoted to a job in electrical research where he was assigned the task of designing a electric streetcar motor. His success was the beginning of the end for the horse-drawn streetcars of that era. Further, his brilliant work at the Eckemeyer factory pushed him into the spotlight of electrical engineering in this country.

In 1892, the young electrical engineer accepted employment with the General Electric Company at its plant in Lynn, Massachusetts. When it was discovered, after several weeks had passed, that a clerk had inadvertently left Steinmetz's name off the payroll he is said to have remarked, after a query as to why he had not complained, "Do not many men work gladly without pay—just for the experience?"

In January, 1894, Steinmetz was transferred to the plant in Schenectady, New York, where he earned the affectionate title of "Mathematical Wizard" of the General Electric Company. It marked the beginning of *the good life* for Steinmetz—the reward for his incredible strength of purpose, and devotion to study maintained throughout the lean years of his life.

Since his personal wants in life were few, he endeavored to use his money to bring happiness to others. He possessed an understanding sympathy for the unfortunates of society which he extended even to the outcasts of the animal kingdom included in his collection of pets.

Perhaps one of Steinmetz's greatest accomplishments during his many years with General Electric was his mathematical work in alternating electric current phenomena. Out of these studies came a mathematical method of reducing the theory of alternating current to a basis of practical calculation, a complex outline of which was presented before the International Electrical Congress in Chicago, Illinois, in 1893. He later published a textbook dealing with the practical aspects of his symbolic method under the title, *Theory and Calculation of Alternating Current Phenomena* (1897), which was expanded into three volumes in 1917. His symbolic method is now widely used in alternating current calculations. Steinmetz also published a number of other textbooks on electrical engineering.

One of these textbooks came to the attention of a young Swedish electrical engineer who was just completing a year of post-graduate study at the Royal Institute in Berlin — his name was Ernst F. W. Alexanderson. The book influenced his decision to come to America. Dr. Alexanderson remarked in later years, ". . . when I read the first English language edition of Dr. Steinmetz's book on alternating current phenomena, I knew I had to see him." Alexanderson obtained an appointment with the G. E. Wizard who was so impressed with the young Swedish engineer that he offered him immediate employment—a job with General Electric that spanned more than 40 years. Alexanderson later gained fame through his powerful Alexanderson Alternators used in the early days of wireless telegraphy, and his later experimental work with television and radio-echo altimeters.

Other notable accomplishments of Steinmetz included his discovery of the law of hysteresis (loss of efficiency in electrical apparatus due to alternating current magnetism) derived mathematically from existing data.

He is credited with having been granted more than 200 patents relating to the broad field of electricity during his long career.

In addition to his consulting work at General Electric, Steinmetz served as professor of electrical engineering and professor of electrophysics from 1902 to 1923 at Union University, Schenectady, New York, and gave many lectures on these subjects throughout the U. S. He also served as president of the American Institute of Electrical Engineers (1901-02), and held membership in the American Academy of Arts and Sciences and the American Philosophical Society. He was the recipient of many awards and honors during his lifetime.

Although Steinmetz never married, he legally adopted as his son and heir a young engineer whose name was Joseph Leroy Hayden. In 1903 his adopted son was married to Corinne Rost, and, shortly thereafter, Steinmetz persuaded the young couple to live with him in his spacious Elizabethan home which he had ordered to be built at about the same time—an unlikely coincidence, since he yearned for family surroundings in his later years.

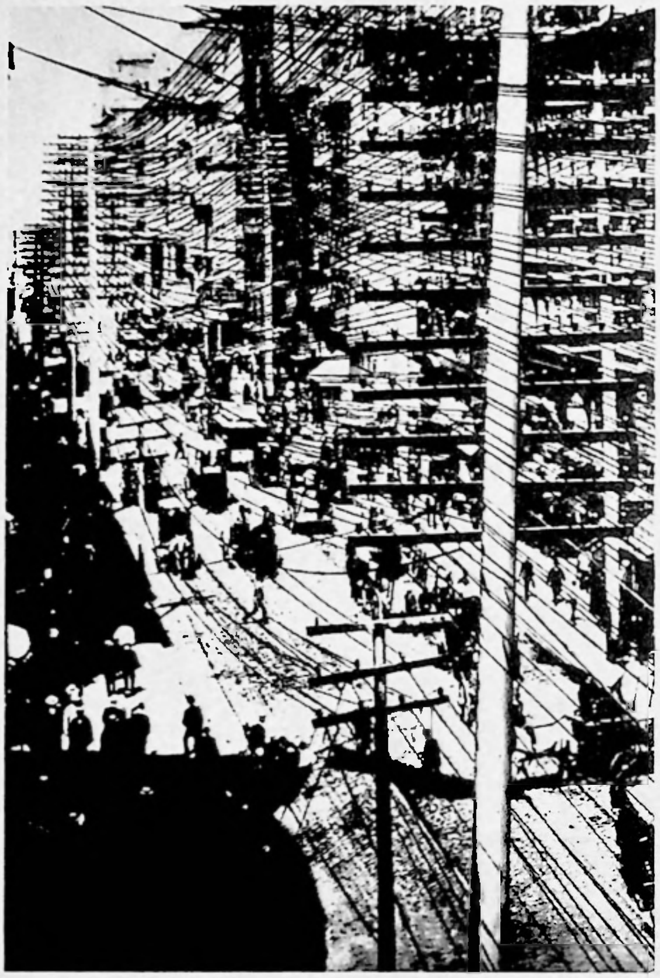
It was at home, with his adopted family, that Charles Proteus Steinmetz died peacefully the morning of October 26, 1923—the final chapter in a lifetime of scientific accomplishment for the benefit of mankind. His name will echo through the marbled halls of history so long as man can remember, and his life will serve as a lasting inspiration to those who struggle against the inequalities of nature to reach a place in the sun of achievement—a worthy contribution toward a nobler way of life.

Courtesy General Electric Company

In addition to his consulting work at General Electric, Steinmetz served as professor of electrical engineering and professor of electrophysics from 1902 to 1923 at Union University, Schenectady, New York, and gave many lectures on these subjects throughout the U. S. He also served as president of the American Institute of Electrical Engineers (1901-1902), and held membership in the American Academy of Arts and Sciences and the American Philosophical Society. He was the recipient of many awards and honors during his lifetime.

The idealism of equal opportunity often disappears in the reality of nature; but the man with a "will to achieve" accepts the challenge without complaint. —William M. Palmer

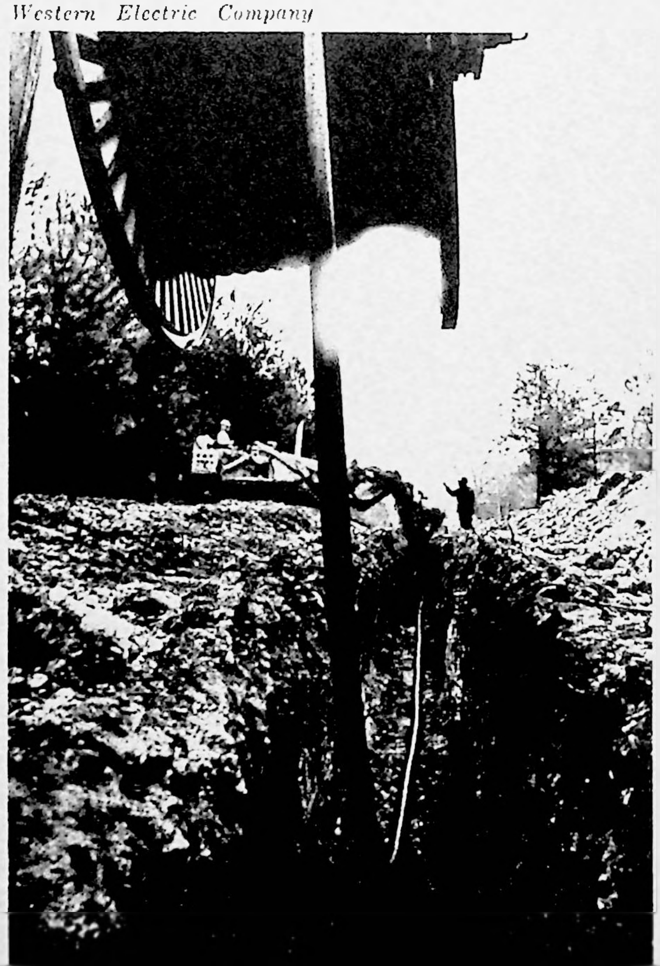
Telephone Lines Above and Under Ground



Yesterday

One catches a glimpse of the past through the window of history in this photograph of New York City's lower Broadway in the 1880's which shows a bewildering maze of wires supported by wooden cross-arms and poles. It was an impressive sight to the New Yorker's of that day, and a proud achievement of the infant telephone industry. In addition, it was hailed throughout the world as a giant step in communications offering the undreamed of capability of 200 simultaneous conversations.

Western Electric Company



and Today . . .

A study in contrast is this photo which shows a modern-day cable, manufactured by the Western Electric Company, being dropped into a deep trench where it will be protected from severe weather. This method also leaves the space above open for more attractive urban and rural areas. Not only that, a cable can carry over 32,000 simultaneous conversations — a miraculous accomplishment made possible by people in America who had faith in the future.

TVA's Browns Ferry Nuclear Plant Will Be World's Largest Steam Electric System

by William M. Palmer

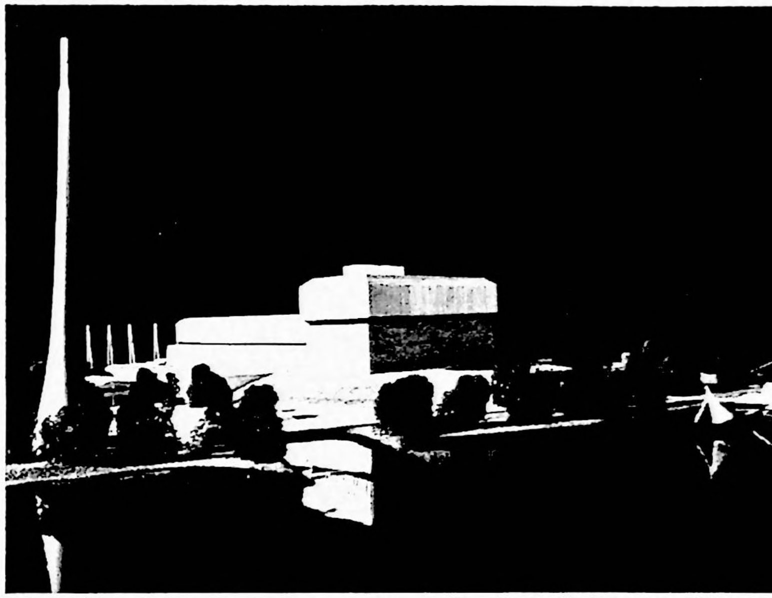
The earth may be likened to a gigantic spacecraft in orbit with a passenger list of nearly 3.5 billion people. Out of the available natural resources of this great voyager all of these people must work together to find, develop, and protect their basic survival needs: the air they breathe, water, and food. These basic survival requirements are actually similar to those of the American astronauts who became the first human beings to walk upon the surface of the moon more than 240,000 miles from the earth.

During this decade mankind must establish priority programs to deal with the hazardous pollution of two of these vital necessities, air and water. Today's technological advances can offer not only a means of control of present air pollution sources, but can in many instances replace them with pollution-free substitutes such as electric heating from power produced by nuclear steam electric plants.

The peaceful uses of atomic energy to solve many of man's environmental problems are gaining impetus with each passing year. A prime example is the nuclear steam electric plant which operates quietly, cleanly, and efficiently in the production of electric power needs. In twenty-eight states of the United States nuclear steam electric plants are either in operation or are scheduled to begin operation by 1974, at which time a total of 87 plants will have been constructed. One of the oldest in operation, the Shippingport, Pennsylvania, nuclear plant, which began operation in 1957, is operated by Duquesne Light Company.

Although most of the nuclear steam electric plants are investor-owned, the TVA (Tennessee Valley Authority), a corporation wholly owned by the United States, is building several units on the Tennessee River. When completed, TVA's Browns Ferry Nuclear Plant will be the world's largest steam electric plant—3,456,000 kilowatts in three units of 1,152,000 kw each. The first unit is expected to be ready for commercial operation late next year. The site of the plant is in Limestone County, Alabama, on the north shore of Wheeler Reservoir.

The TVA system, the largest producer of electric power in the United States, has established the Tennessee Valley region of the South as the national center for all-electric homes. Nashville, Tennessee, which has a population of 170,000 has more electrically-heated homes than any city in the world; and the region has more than half a million homes using electricity for heating. No smoke! No soot! No residues!



Tennessee Valley Authority

This is an architectural drawing of TVA's Browns Ferry Nuclear Plant for steam-electric production of electrical power. Scheduled for completion next year, it will be the world's largest electric plant—3,456,000 kilowatts in three units of 1,152,000 kw each. The plant is located in Limestone County, Alabama.

Further, many of the Tennessee Valley region's buildings, apartments and shopping centers are all-electric. Notable examples are the Post Office and Federal building and three high-rise apartment buildings in Memphis, Tennessee; a high-rise senior citizens' apartment building and a department store (using the hear-with-light principle) in Chattanooga; and the all-electric shopping centers at Guntersville, Scottsboro, Russellville, Hartselle, Cullman, Grant, Arab, and Centre, and Muscle Shoals, Alabama; in Cleveland and Chattanooga, Tennessee; in Hopkinsville and Glasgow, Kentucky; and in Fort Oglethorpe, Georgia.

The region now has 197 electrically-heated schools, more than three times the number in use only five years ago. In addition, 600 portable all-electric classrooms are in temporary use to meet over-crowded conditions in various localities.

In 1969, TVA paid $14.5 million in lieu of taxes to state and local governments in the region, while distributors of TVA power paid $22.9 million in taxes, or tax equivalents, to state and local governments—a fringe benefit of the TVA system.

NEWS DIGEST

(Continued from previous page)

Secretary Stans Awards 3.5 Millionth United States Patent

Secretary of Commerce Maurice H. Stans marked a milestone in American technology March 10 when he presented the 3½ millionth U. S. patent to a Bell Laboratories inventor and the widow of the co-inventor.

In a ceremony at the Department of Commerce building at 2:00 p.m., Benjamin F. Logan, Jr., and Myldred Kelly, widow of John L. Kelly, Jr., received Patent No. 3,500,000 from Secretary Stans for the Kelly-Logan invention, "Self-Adapted Echo Canceller."

Also present for the ceremony were W. O. Baker, Vice-President-Research, and other officials of Bell Laboratories.

Secretary Stans stated that the issuance of patents is an accurate measure of American technological development. He cited the period of roughly 75 years between Patent No. 1 in 1836 and the 1 millionth patent in 1911, 24 years between the 1 millionth and the 2 millionth, and 26 years between the 2 millionth and 3 millionth. Now, in less than 9 years, 500,000 have been issued and a projection of the time period between the 3 millionth and 4 millionth patents indicates a maximum of 16 years.

Projections into the future are that this technological development will continue to accelerate in order to meet the increasing needs and problems of an expanding, industralized society.

The Kelly-Logan echo cancelling scheme covered by the patent was invented as a possible means of controlling echos in satellite and long-distance terrestrial communications paths. The nature of two-way long distance telephone lines is such that each speaker might hear an echo of his own voice if it were not prevented by an echo control device. The echo canceller using the Kelly-Logan scheme creates signals that approximate echos in a transmission path which, injected into the path, cancel the echos by combining with them.

Benjamin F. Logan, Jr., a native of Coahoma, Texas, is currently in the Mathematical Research Department of Bell Labs. He received the B.S. degree in electrical engineering from Texas Technological College in 1946, the M.S. from Massachusetts Institute of Technology in 1951, and the Eng. D.Sc. degree from Columbia University in 1965. Before joining Bell Labs at Murray Hill, N. J., in 1956, he had done research work at Columbia University, M.I.T., and Hycon-Eastern, Inc.

John L. Kelly, Jr., was head of the Information Coding and Programming Department at Bell Laboratories at Murray Hill, N. J. at the time of his death in 1965 at the age of 41. He joined Bell Labs in 1953 as a member of the Television Research Department. A native of Corsicana, Texas,, Mr. Kelly received the B.A. degree in 1950, M.A. in 1952, and Ph.D. in physics in 1953 from the University of Texas. He served as a U. S. Navy aviator from 1944 until 1947.

Bell Telephone Laboratories is one of the world's largest industrial research organizations. As research and development unit for the Bell System, its main function is to conceive the technology that will enable the Bell System to meet its present and future service objectives. The company has over 16,000 employees at four main locations and 10 BTL-Western Electric facilities.

Since its incorporation in 1925, Bell Labs has received an average of over one patent per day, including weekends and holidays. To date, this amounts to over 17,000 patents.

The Kelly-Logan patent represents one aspect of a broad Bell Labs program of communications research. In addition to this patent, Bell Labs inventors have received numerous patents in the area of echo control. These patents date back to the late 1920's when echo suppressing devices were first introduced into the Bell System's long distance network.

Scientists Commute In New Lab-on-Wheels

Scientists driving a blue van outfitted as a laboratory periodically commute between Pittsburgh and Wright-Patterson Air Force Base in Dayton, Ohio.

Working under an Air Force contract, Westinghouse uses the mobile lab to carry out experiments with the large nuclear reactor at Wright-Patterson.

The Air Force wants to know how neutron radiation affects the performance of solar cells, often used on spacecraft to convert sunlight directly into electricity.

In addition to the usual laboratory equipment, the lab-on-wheels is equipped with a high intensity carbon arc lamp to provide artificial sunlight for the experiments.

The truck is operated by the Westinghouse Research Laboratories' radiation and nucleonics section, headed by Dr. Kuan Sun.

It's Back-to-School For Scientists-Engineers At Bell Laboratories

Through its "Continuing Education Program," Bell Labs offers courses during normal working hours to encourage its professionals to keep pace with rapid technological advances. The new program makes it possible for scientists and engineers to continue their technical education, on a strictly voluntary basis, throughout their careers. Bell Labs sponsors the program in addition to its financial support of university study by employees.

Most of the courses are being taught by Bell Labs specialists, but professors from near-by universities are also teaching a few of them. An average class section, consisting of from 15 to 35 participants, meets for a two-hour session each week for 16 weeks.

To make the best lecturers in various subjects available to students at all locations, closed circuit TV and video tapes are used.

For the 1969-70 program, about 100 different courses are offered in six major disciplines: materials and devices; systems engineering and mathematics; computer science; physical design; switching; and transmission. Three types of courses are offered in each discipline—in-depth, interdisciplinary, and preparatory, or refresher, courses.

In-depth courses, taught at an advanced graduate school level, deal with subject matter at the forefront of technology. They are intended to deepen the specialization of participants. Interdisciplinary courses, taught at a first-year graduate level, acquaint students with fields bordering on their own and help them see their own work in a broader context. Preparatory, or refresher, courses, equivalent to senior or first-year graduate level courses, are designed to strengthen the student's academic background to prepare him for in-depth courses.

Replica of Old Time Variocoupler

A popular device with radio "hams" and broadcast listeners between 1918 and 1926; and three projects illustrating its use with today's radio parts, circuitry and techniques

by Art Trauffer

The variocoupler, a two-coil variable inductance, was very popular with radio "hams" and broadcast listeners between about 1918 and 1926, and it was used in many factory-made and home-made receivers. Many built their own variocouplers — either from scratch, or from kits supplied by manufacturers. As shown in the illustrations, a variocoupler is simply a stationary coil having a number of taps, and a rotating coil placed close to the stationary coil. When the rotary coil is placed so that its turns of wire are in the same relative position as the turns of wire on the stationary coil, the instrument is said to be "tightly coupled"; but when the rotary coil of the variocoupler is revolved 90 degrees so that its turns of wire are at right angles to those of the stationary coil, it is said to be "loosely coupled." This article shows how to build a typical old-time variocoupler, and three of the many ways you can use it.

As shown in photos Figs. 1 & 2, the stationary coil is simply 66-turns of #26 nylon-covered enameled magnet wire around a red plastic thermos bottle cup 3¾" O.D. at the top, and 2½" high. Start the winding at the smallest diameter end of the cup, and twist a small loop (tap) at every 11th turn — this gives you 5 taps (6 including the start end of the winding). The ends of the wires are secured in small holes drilled in the plastic, and the twisted taps are secured with small dabs of Duco cement. The high end of the winding is connected to a small binding post consisting of a 6-32 by ½" machine screw with hex nut and thumb nut to fit.

Drawing Fig. 3 gives the specs for turning the hardwood rotor ball. If you don't have a wood-turning lathe you can have the rotor ball turned at a wood-working shop, or this would make a nice project to do in your school shop. Bore the two ¼" holes for the shafts, and give the rotor ball two coats of shellac to moisture-proof it. Both halves of the rotor are wound full of #26 nylon-covered enameled magnet wire (about 25 turns each half). Wind the two rotor coils in the same direction as the stationary coil, and pass the four ends of the wires through small holes drilled in the rotor ball, using wood glue or Duco cement to secure the wires. The two inner ends of the windings are soldered together inside the openings of the ball. Solder two flexible insulated wire leads to the two outside ends of the windings, and pass the two leads out through the rear ¼" hole. The two shafts are then pushed into the ¼" holes, using Duco cement, if necessary, to hold them secure. The two plastic brackets (or bearings) for the rotor are simply two pieces of plastic 1½" x ½" x ⅛", each having a ¼" dia. hole for the shafts, and a small hole for the mounting screws. It isn't necessary to use nuts when mounting the plastic brackets to the plastic cup—simply let the short 6-32 machine screws tap themselves into the slightly under-size holes. The two rotor pigtails are connected to two small binding posts on the rear of the cup, as shown in photo Fig. 2.

To mount the completed variocoupler on the wood base, simply drill a ⅛" dia. hole through the center of the closed end of the cup, and use a ⅝" long rh wood screw.

Drawing Fig. 4, and photo Fig. 1, give all the specs for making the switch lever and switch points. The only bottleneck for you might be the bearing for the lever shaft. The writer solved the problem easily by using the threaded sleeve of a jack (or socket) made for a banana plug — this was just right for the purpose. If desired, you can use a factory-made tap switch, but this doesn't have the old-time look of the switch of Fig. 4.

After assembly is completed, solder the six taps on the stationary coil to the six points on the switch, using short lengths of copper wire, as shown in Fig. 2. The medium-size Fahnestock clip, screw-fastened near the corner of the wood base, is connected to the lug on the lever bearing, as shown.

Drawing Fig. 5 shows how to use the variocoupler in a crystal receiver.

Drawing Fig. 6 is an experimental hookup using the variocoupler, with a field effect transistor serving as a regenerative detector.

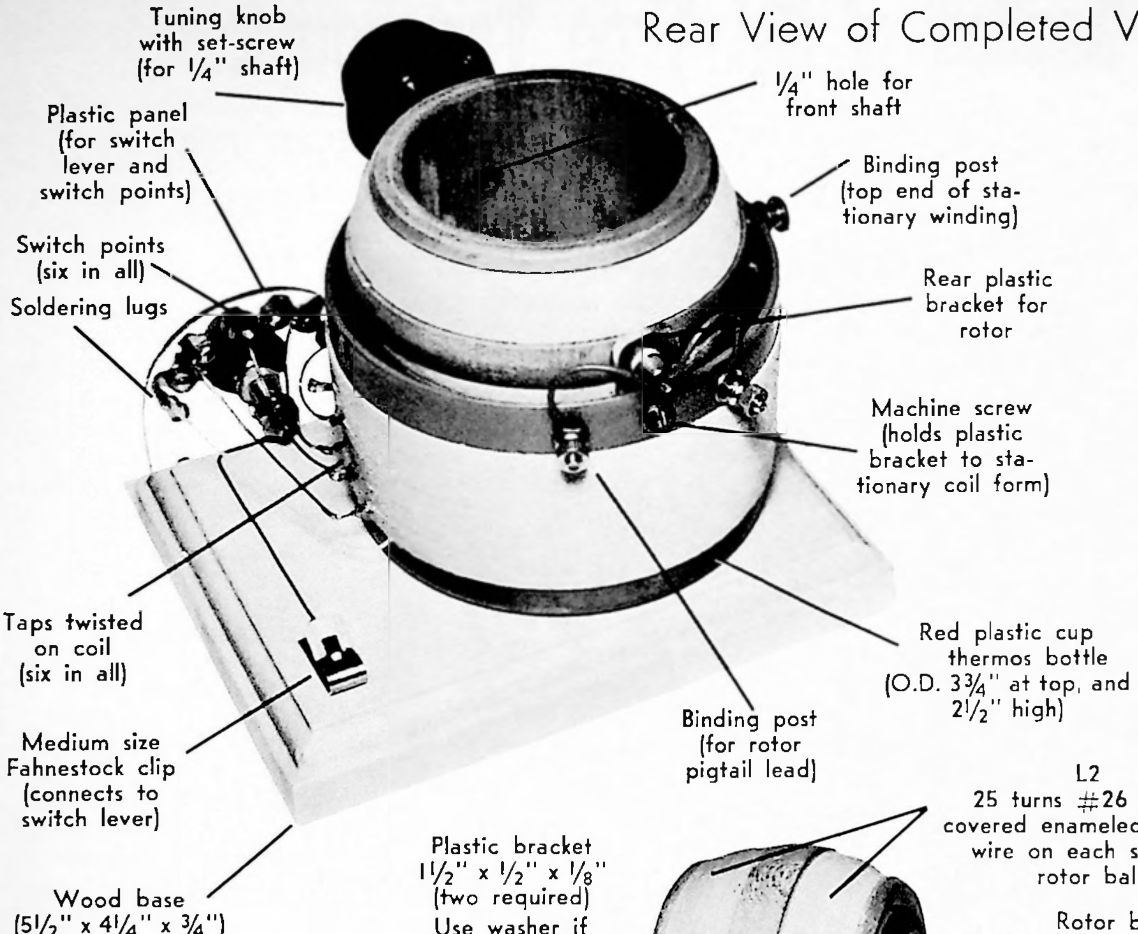
Drawing Fig. 7 shows how to use the variocoupler, with a triode vacuum tube serving as a regenerative detector. This circuit was very

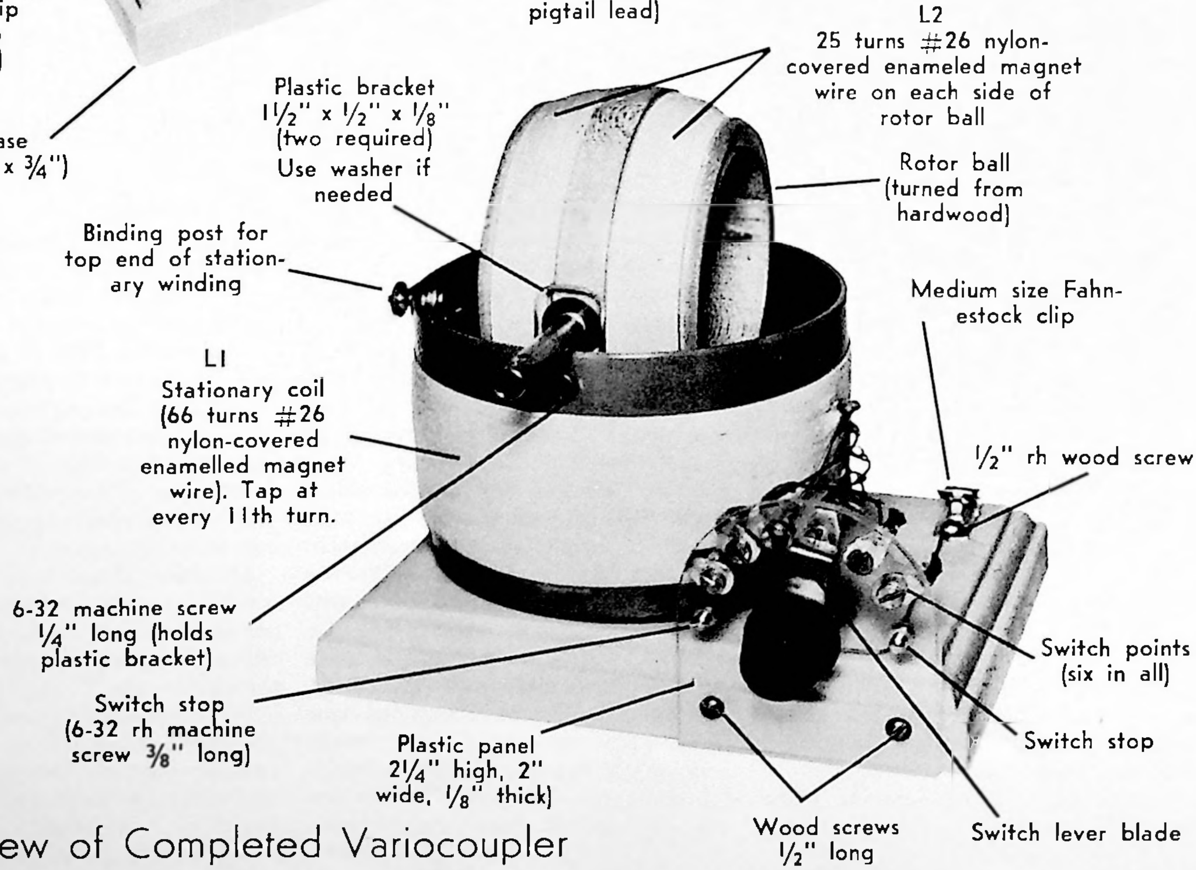
(Continued on page 19)

Electronics Jr. EXPERIMENTER

Rear View of Completed Variocoupler

2





1

Front View of Completed Variocoupler

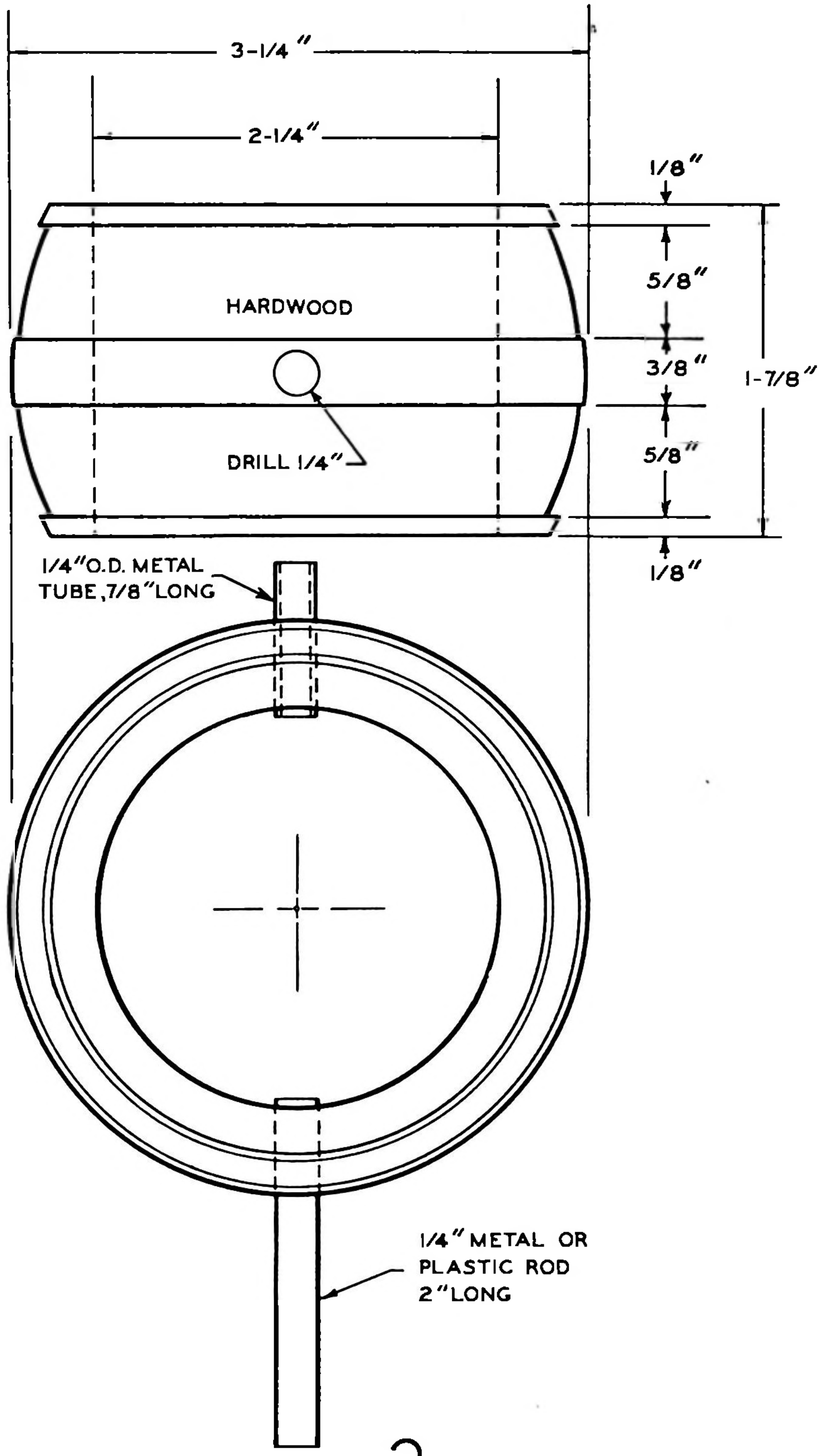
(Continued from page 17)

popular in the early 1920's. Use any triode you can find that has a filament of low voltage and low amperage. The writer uses a type 30 triode (filament volts DC 2.0; amperes 0.06). The type 30 triode is no longer being made, but some mail-order tube houses still stock it at a low price. The proper socket, rheostat, and "A" battery, will depend on the type of triode tube you use. For the 22½ volt "B" battery, see the article: "Replica of Old-Time "B" Battery."

Variocoupler

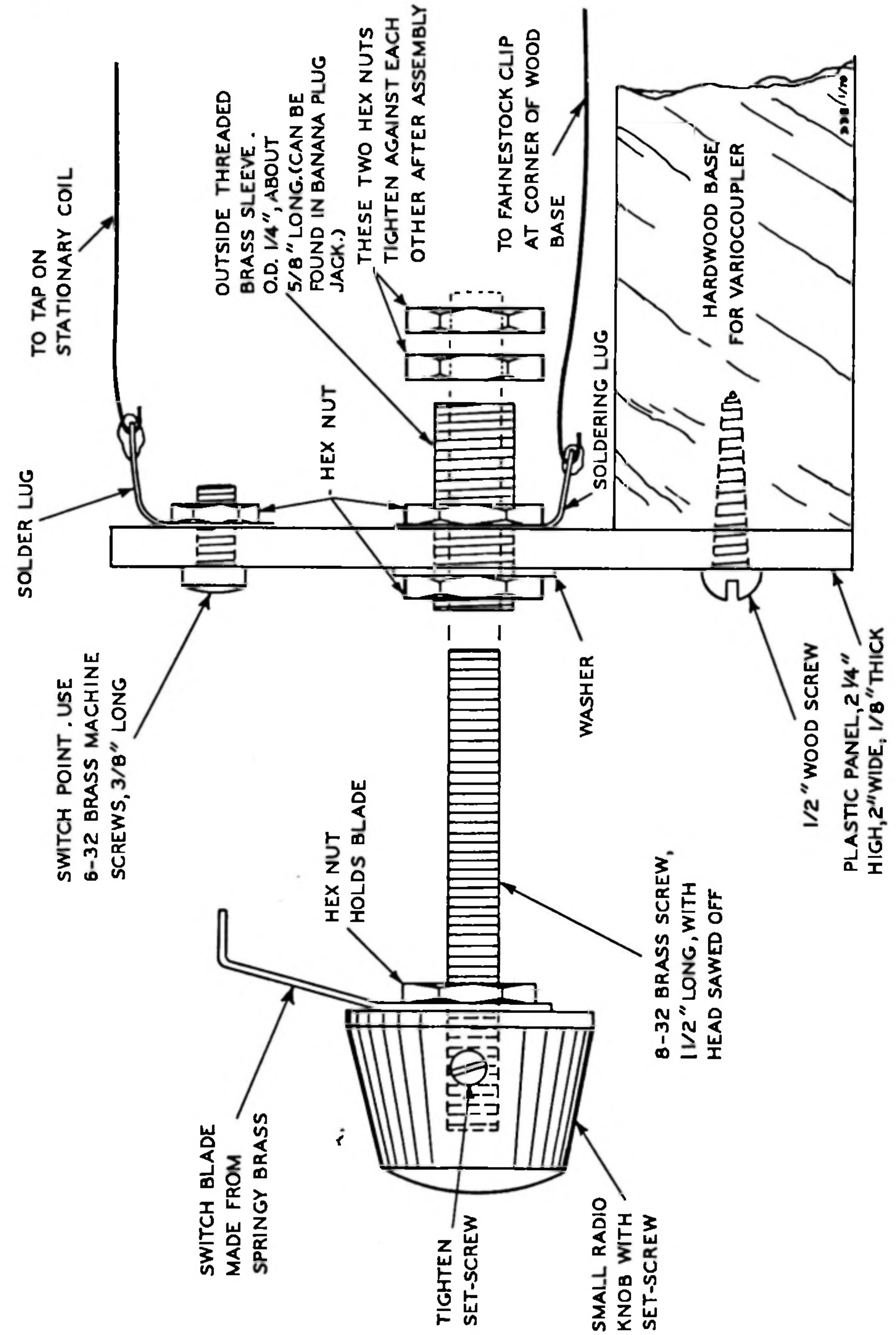
PARTS LIST

1 hardwood rotor ball for L2 (see text and illustrations).
1 red plastic thermos bottle cup, 3¾" O.D. at top, and 2½" deep. For stationary coil L1.
½ pound #26 nylon-covered enameled magnet wire, for L1 and L2.
One ¼" dia. metal or plastic rod 2" long. One ¼" O.D. metal tube ⅞" long. (Shafts for rotor ball.)
Two pieces plastic, 1½" by ⅛". (Brackets to hold rotor.)
Two 6-32 rh machine screws ¼" long (hold above plastic brackets).
Three binding posts, for mounting on L1 coil form.
One pointer knob with set-screw for ¼" dia. shaft. For rotor coil L2.
One piece plastic, 2¼" by 2" by ⅛". (Panel for switch lever and points.)
Six 6-32 rh machine screws ⅜" long, with hex nuts and soldering lugs to fit. (For making switch points).
Two 6-32 rh machine screws ⅜" long. (Switch stops for lever.)
One outside-threaded brass sleeve, ¼" O.D., about ⅝" long, with four hex nuts, one washer, and one soldering lug to fit. (Bearing for switch lever shaft.)
One 8-32 brass machine screw 1½" long. (Shaft for switch lever blade.)
One hex nut to fit above 8-32 screw.
Small piece thin spring brass (for making switch lever blade).
Small radio knob with set-screw, to fit switch lever 8-32 shaft.
Hardwood base, 5½" by 4¼" by ¾".
One medium-size Fahnestock clip, and one round-head wood screw ½" long.
Two rh wood screws ½" long, for mounting plastic panel to wood base.



3

Details for Hardwood Rotor and Shafts

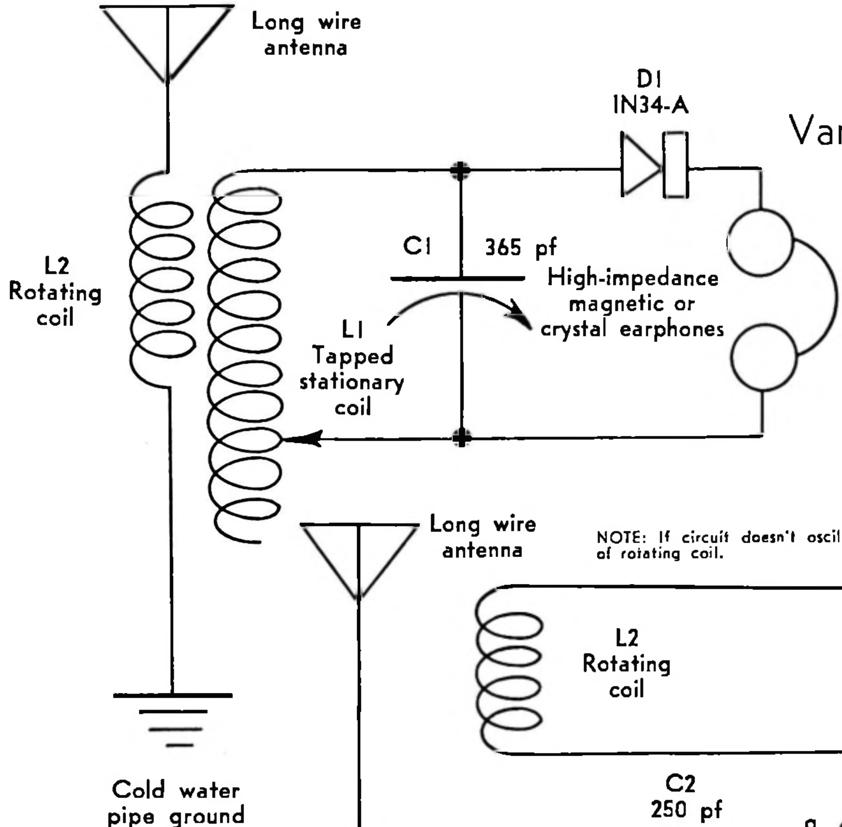


4

How to Make the Switch Lever and Switch Points

5

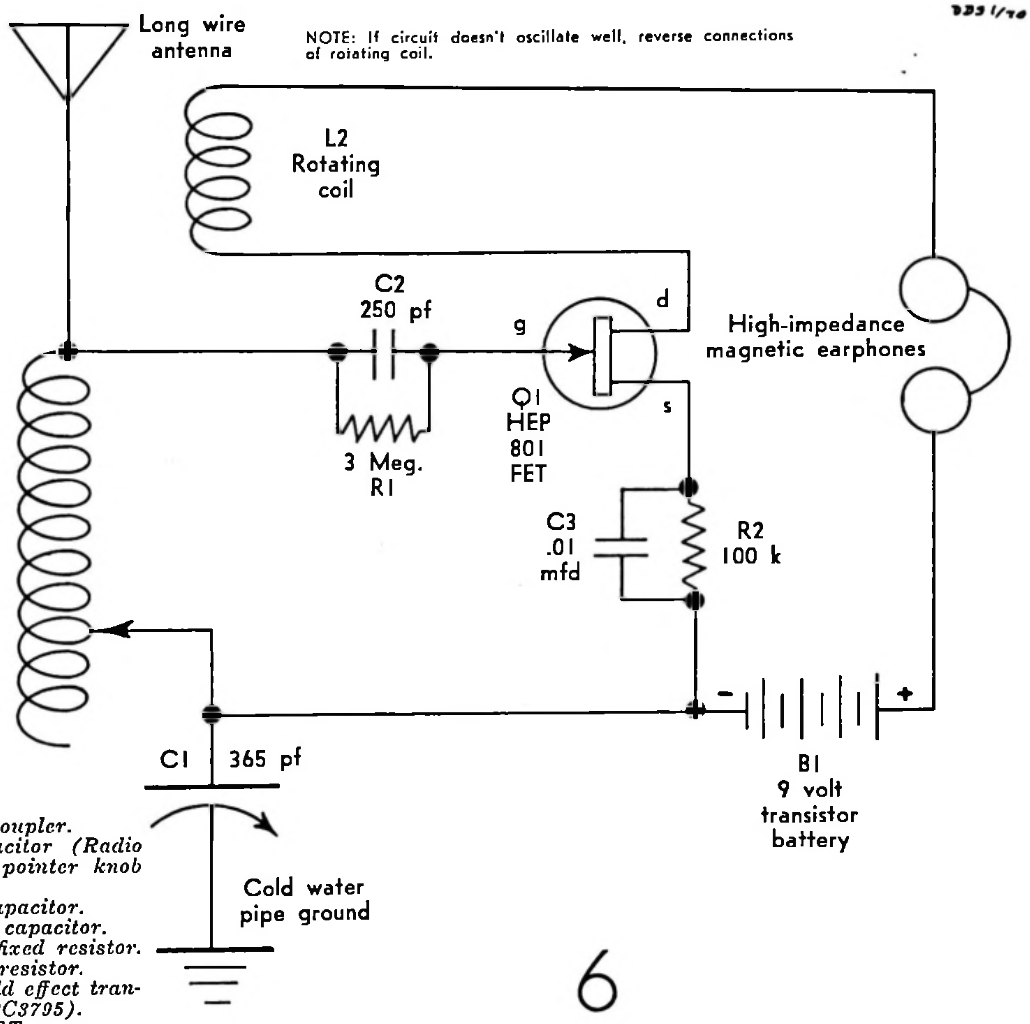
Variocoupler Crystal Receiver



PARTS LIST

L1-L2 Home made variocoupler.
C1 365-pf variable capacitor (Radio Shack 272-1343).
D1 1N34-A germanium crystal diode (Allied Radio 49C12 IN34A-SYL, or equiv.) One pointer knob with set-screw for ¼" dia. shaft (for C1). Two medium-size Fahnestock clips (for earphones).

NOTE: If circuit doesn't oscillate well, reverse connections of rotating coil.



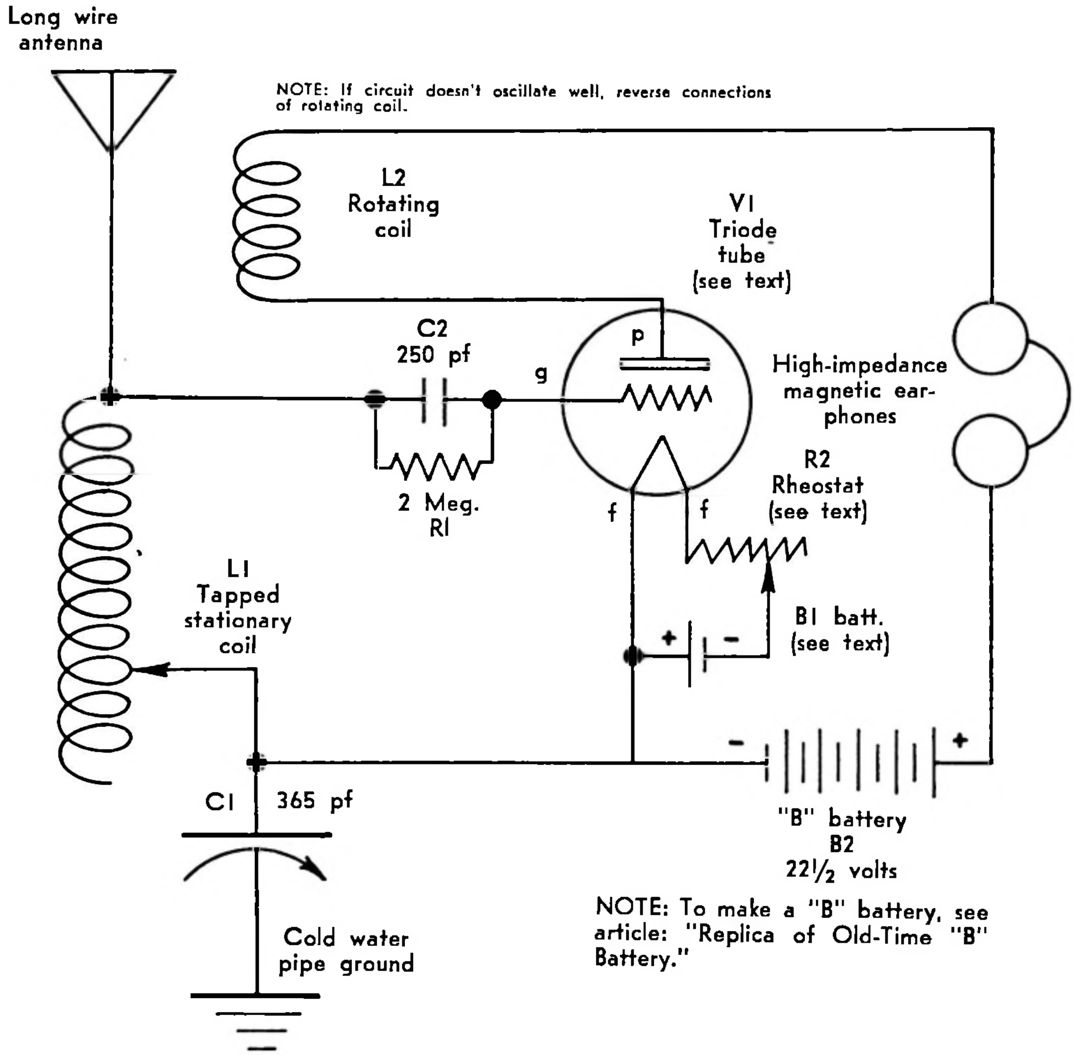
PARTS LIST

L1-L2 Home made variocoupler.
C1 365-pf variable capacitor (Radio Shack 272-1343). One pointer knob to fit shaft.
C2 250-pf ceramic disc capacitor.
C3 .01 mfd. ceramic disc capacitor.
R1 3 Megohm, ½ watt, fixed resistor.
R2 100 k, ½ watt, fixed resistor.
Q1 Motorola HEP 801 field effect transistor (Allied Radio 22C3795). One socket for above FET.
B1 9 volt transistor battery. Two medium-size Fahnestock clips for earphones.

6

Regenerative FET Receiver Using Vario-coupler

EXPERIMENTER



NOTE: To make a "B" battery, see article: "Replica of Old-Time "B" Battery."

PARTS LIST

L1-L2 Home made variocoupler.
C1 365-pf variable capacitor (Radio Shack 272-1343).
C2 250-pf ceramic disc capacitor.
R1 2 Megohm, ½ watt, fixed resistor.
R2 Variable resistor (see text).
V1 Triode vacuum tube (see text). Socket for tube (see text).
B1 "A" battery for tube (see text).
B2 22½ volt "B" battery (see text). Two medium-size Fahnestock clips for earphones.

7

Vario-coupler Regenerative Triode Vacuum Tube Detector Receiver

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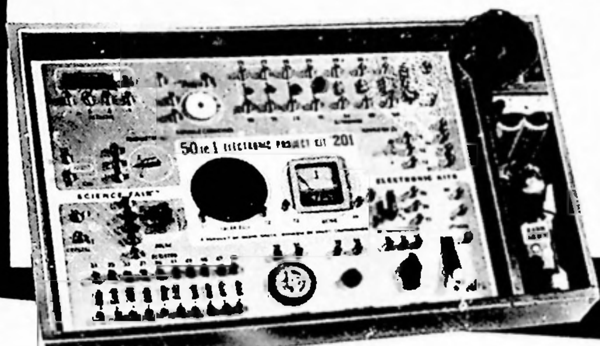

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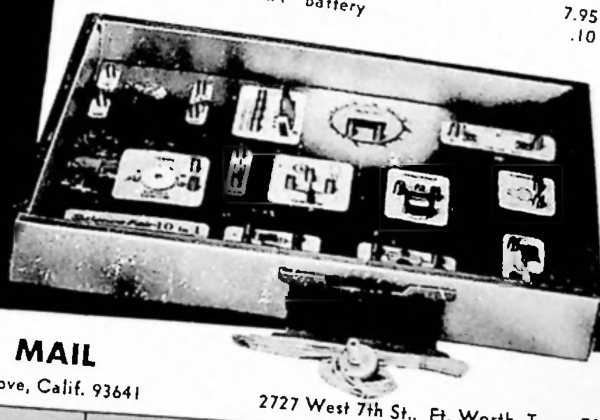

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