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Pacific Gas & Electric Co.

COVER STORY

The Geysers Power Plant, in remote northeastern Sonoma County, California, is the only geothermal power plant in North America. There are only six countries in the world using underground steam to spin the turbine-generators to produce electric power. Read this interesting article on page 10.

Visit the Atom

Looking for a fascinating field trip for students, or vacation side trip? Why not visit the atom? There are some 30 major exhibits of nuclear energy throughout America

Most of the exhibits are information centers owned by utilities producing electricity from nuclear steam-electric plants and feature concise explanations of radiation and nuclear fission, movies, slide shows, and special lecture-demonstrations.

Special Report

Are you looking for some fascinating weekend outings or vacation side trips? Then why not visit the atom.

There are some 30 major exhibits of nuclear energy throughout the United States, ranging from a replica of a cavalry fort in Colorado to a converted ferryboat in New Jersey. Most of these exhibits are information centers owned by utilities who are turning to nuclear energy for the generation of electricity, and they hold a variety of treats for their visitors: concise explanations of radiation and nuclear fission, movies and slide shows, special guided tours, classroom facilities, lecture-demonstrations, models of nuclear reactors, closed-circuit television presentations, Geiger counters and other nuclear apparatus, picnic tables, boat docks and many other attractions.

Tourists can enjoy many of these information centers year-round and in almost every part of the country. Travelers in the East could visit, among others, The Second Sun, a refurbished ferryboat loaded with nuclear exhibits that New Jersey's Public Service Electric and Gas Co. has stationed in Lower Alloways Creek Township, eight miles southwest of Salem, N.J.

The Second Sun attracts more than 70,000 visitors a year to enjoy its 15-minute multi-media presentation, five dioramas tracing the use of energy through history, a "neutron gun" that visitors aim at the center of a screen to start a motion picture depicting the splitting of an atom, a reactor model, and many other informative exhibits.

One of several such exhibits in the Midwest is the Point Peach Information and Training Center 8½ miles north of Two Rivers, Wisc., on state highway 42. There the visitor steps directly into a circular area laid out in the pattern of fuel assemblies inside a reactor, with control rods overhead connected to a fuel assembly protruding from the floor. The push of a button begins a multi-media presentation on how nuclear reactors produce electricity. The Point Peach Center, owned by Wisconsin Electric Power Co. and Wisconsin Michigan Power Co., also offers maps, slides, photographs, mechanical animation, and other exhibits to inform and entertain.

The nation's most elaborate nuclear exhibit is the AEC's American Museum of Atomic Energy in Oak Ridge, Tenn., which presents the complete story of nuclear energy and its applications through fascinating visitor-operated displays. In addition such large museums as the Smith-

Photo Courtesy Atomic Industrial Forum, Inc.

The Point Beach Information and Training Center attracts tourists to its interesting and educational nuclear exhibits at the site of Wisconsin Electric Power Company and Wisconsin Michigan Power Company's nuclear power plant. The Center also offers maps, slides, photographs, mechanical animation, and other exhibits of particular interest to students. It features a highly informative presentation on the nuclear reactor's production of electricity.

Photo Courtesy Atomic Industrial Forum, Inc.

The floating Second Sun, docked in the Delaware River, serves as an unusual nuclear information center for Public Service Electric and Gas Company of New Jersey. The Second Sun attracts more than 70,000 visitors a year to enjoy its 15-minute multi-media presentation.

sonian's Museum of History and Technology in Washington, D.C., the Museum of Science and Industry in Chicago, and the New York Hall of Science in Queens offer fascinating exhibits about nuclear energy and its many valuable applications.

These exhibits, and the many others throughout the nation, present information about the principles of nuclear energy, reactors, the generation of electricity, radiation and other aspects of nuclear power technology in a form understandable and entertaining to the entire family. Wherever you may be this vacation — at home or on the road — it will be well worth your time to make a detour to see the atom at these fascinating centers:

NUCLEAR INFORMATION CENTERS:

ALABAMA

Alabama Power Co's. Nuclear Information Center, opened July 16, is at 124 N. Oates St., Dothan, Ala. These exhibits portray the history of energy, with emphasis on nuclear power. A projection room is available for special programs for schools and adult groups. Closed Thursday afternoon and Sunday. Phone 205/794-6679.

CALIFORNIA

The **Morro Bay Power Plant Visitor Center,** owned by Pacific Gas and Electric Co., is located on the Embarcadero in Morro Bay, Calif. Its exhibits include the background of electricity, methods of generation, fuel bundle model, reactors, power plants, safety, and a tour of a steam plant. A number of recreational and eating facilities are in the area. Phone 805/772-2083.

The **Humboldt Bay Power Plant Information Center,** owned by Pacific Gas and Electric Co., is located on King Salmon Road, 5 miles south of Eureka, Calif. It offers displays of sources of power, nuclear fuel, reactors, safety, and a summer tour of two conventional steam plants and a nuclear plant. A variety of recreational and eating facilities are in the area. Phone 707/443-0821.

The **San Onofre Nuclear Information Center,** owned by Southern California Edison Co. and San Diego Gas & Electric Co., is located at the Basilone Road offramp from Interstate Route No. 5, about 4 miles south of San Clemente, Calif. Visitors can operate a "nuclear gun" that begins a simulated chain reaction illustrating the principle of nuclear fission. Other exhibits illustrate the history of nuclear development, nuclear safety, and functions of the San Onofre Nuclear Generating Station. Phone 213/435-1121 Ext. 318.

COLORADO

Fort St. Vrain Information Center, owned by Public Service Co. of Colorado, is located 4 miles northwest of Platteville, accessible from Interstate 25 or U.S. 85. This replica of a cavalry fort contains exhibits that explain energy and its control, including the use of nuclear energy to generate electricity at the nearby Fort St. Vrain station. Displays relate living standards to consumption of electricity and provide information about Public Service and its operations. Phone 303/297-7713.

CONNECTICUT

The **Connecticut Yankee Education & Information Center,** owned by the Conn. Yankee Atomic Power Co., is located in Haddam Neck, Conn., on the east side of the Conn. River. Its 12 major exhibits include explanations of the development of nuclear energy, the mechanics of nuclear reactors, the role of energy in modern society, and the Conn. River Study of the environment effects of the nuclear power plant. Picnic facilities on the grounds. Phone 203/267-9179.

The **Millstone Point Information Center,** owned by Northeast Utilities, overlooks the Millstone Nuclear Power Station in Waterford, Conn. This facility includes an A-frame building with a variety of photographic displays describing construction and operation of the plant, and a restored schoolhouse containing historical artifacts. Films and slides are shown to interested groups in the schoolhouse. Swimming, picnicking and fishing available on site. Open Tuesday through Sunday, mid-June through Labor Day. Phone 203/442-3105.

DISTRICT OF COLUMBIA

The Smithsonian's **Natural Museum of History and Technology** is located on Constitution between 12th and 13th Streets, Northwest. A permanent nuclear exhibit is now being planned, and temporarily being shown are a full-scale reproduction of Enrico Fermi's first reactor,

(Continued on next page)

VISIT THE ATOM *(Continued)*

a Van de Graaff accelerator, the first piece of the man-made element plutonium, and animated demonstrations of historic experiments. Cafeteria and snack bar in the building. Phone 202/381-5466.

ILLINOIS

Chicago's **Museum of Science and Industry** is located at 57th Street and South Lake Shore Drive. This famous technological museum features a 5,000-square-foot display of nuclear accomplishments, including a cutaway scale model of Dr. Enrico Fermi's first reactor; remote-control hands that can be operated by visitors; a radiation spectrometer that visitors can operate; three scale models of nuclear reactors; a Geiger counter that visitors can operate; exhibits of many diversified applications of radioisotopes; and a theater of nuclear science films. The largest nuclear exhibit is a two-story, full-scale operating reactor, which demonstrates the production of radioisotopes. Phone 312/MU4-1414.

MASSACHUSETTS

The **Yankee Atomic Electric Information Center,** owned by the Yankee Atomic Electric Co., is in Rowe, Mass., about 32 miles northwest of Greenfield. Its exhibits include a lecture, movie, slides, discussions of plant models, and a full-size fuel assembly. Special tours through part of the nuclear power plant can be arranged. Phone 413/424-5335.

The **Construction Overlook** of the Boston Edison Co. is located on Rocky Hill Road in Plymouth, Mass. It offers a view of the construction of Boston Edison's Pilgrim Nuclear Station and enclosed displays containing photographs and other material about the plant. Personnel are available to answer questions. Phone 617/424-2453.

MICHIGAN

Big Rock Point Information Center, owned by Consumers Power Co., is 15 miles north of Charlevoix, ½ mile off M-31; or 12 miles west of Petoskey off M-131. A scale model of the Big Rock Point Nuclear Plant, closed circuit television, and 12 exhibits throughout the center explain nuclear energy and how it is used to make electricity. A lecture explains the operation of the nuclear plant; there is also a movie and a session for questions and answers. Phone 616/547-9432.

Consumers Power Co. also owns the **Palisades Nuclear Information Center,** 5 miles south of South Haven, Mich. It offers exhibits of reactors, plant models, films, slide shows and lecture presentations. Phone 517/788-0111.

The **Cook Nuclear Center,** owned by the Indiana & Michigan Electric Co., is located on Lake Michigan, off I-94 between Stevensville and Bridgman, Mich. The architecturally unique center, overlooking the construction site for the Donald C. Cook Nuclear Plant, features exhibits and a 50-minute multi-media program on the development of nuclear energy. Snack bar and lakeside patio on premises. Closed Sunday morning and Monday. Phone 616/465-5901.

The Enrico Fermi Atomic Information Center is owned by Detroit Edison Co. at 6400 North Dixie Highway, Newport, Mich. This center contains movies and a slide presentation and exhibits of a neutron gun, control rod, reactor and steam generator models, and wall displays. Open Tuesday through Saturday. Phone 313/LU6-2070.

PENNSYLVANIA

Peach Bottom Atomic Information Center, owned by Philadelphia Electric Co., is on the west bank of the Susquehanna River in southeast York County, three miles east of Delta, Pa. Exhibits include a complete story line with models, animation and sound so the visitor can learn about energy, structure of the atom, and nuclear fission, and see how the Peach Bottom reactors operate to produce electricity. Displays include Geiger counters to demonstrate radiation detection and protection; comparison of energy in coal and uranium; and uses of radioisotopes in medicine, agriculture and industry. Auditorium programs include motion pictures, slide-illustrated talks and demonstrations. Open Wednesday through Sunday. Phone 717/456-5101.

Three Mile Island Observation Center, owned by Metropolitan Edison Co., is located five miles south of Middletown, Pa., on Route 441 along the Susquehanna River. This center features an entertaining 11-minute multi-screen, multi-media presentation, a model of the plant site with "hear phone" message, an observation balcony overlooking the construction site, and other displays. Park and picnic area. Open early afternoon until Labor Day. Phone 717/944-4621 Ext. 63.

SOUTH CAROLINA

Carolina Power & Light Co.'s Nuclear Information Center is located on Highway 151, 7 miles south of McBee, S.C. This center features a film and slide presentation of the history of energy, a colorful display of how electricity is made, a bicycle that generates power to light a 60-watt bulb, and a nuclear reactor model that illustrates the principles nuclear power. Picnic facilities on the grounds. Open Monday through Friday and Sunday afternoon. Phone 803/332-2633.

The **Keowee Toxaway Visitors Center,** owned by Duke Power Co., is located 13 miles north of Clemson, S.C., on SC 130 at Lake Keowee. Its full dimensional exhibits tell the story of hydroelectric, fossil-fuel and nuclear generation of electric power in seven automated chambers which comprise a non-guided tour through the center. A closed-circuit television and slide presentation is featured in the auditorium. Picnic tables, nature trails, and a boat dock are on the grounds. Closed Sunday morning. Phone 803/882-5620.

TENNESSEE

The **American Museum of Atomic Energy,** operated for the Atomic Energy Commission in Oak Ridge, Tenn., by Oak Ridge Associated Universities, is the country's best known nuclear exhibit. Located in the nation's "Atomic City" west of Knoxville, this museum tells a comprehensive story of nuclear energy and its applications in medicine, industry, agriculture, and research. Exhibit managers give lectures and demonstrations on such topics as nuclear reactors and their uses, and most of the exhibits are spectator-operated; for example, one device exposes a visitor's coin to enough neutrons to make it momentarily radioactive and register on a counter. Picnic facilities and a concession stand on the grounds. Closed

(Continued on next page)

Sunday morning. Phone 615-483-8411.

NEW JERSEY

The Second Sun Nuclear Information Center is a converted ferryboat which Public Service Electric and Gas Co. has docked at the site of its Salem Nuclear Generating Station in Lower Alloways Creek Township, eight miles southwest of Salem, N.J. In October 1970 it was moved to Newbold Island in the Delaware River, six miles south of Trenton, N.J. Visitors to the floating information center will see a 15-minute computer-controlled multi-media presentation about nuclear energy and a number of exhibits about the history of energy, electricity generation, a model of the Salem plant now under construction, and a model of a reactor that can be "activated" by visitors. Tables are available on the second deck for school groups. Phone 609/935-2555.

NEW MEXICO

The **Los Alamos Science Hall and Museum,** owned by the Atomic Energy Commission's Los Alamos Scientific Laboratory, is located 35 miles northwest of Santa Fe on Diamond Drive in Los Alamos, N.M. These exhibits illustrate the research and development activities of the lab. They include animation, document and photo displays, guided tours and discussions. Picnic facilities in the surrounding mountains. Closed Sunday morning. Phone 505/667-4444.

NEW YORK

The **Indian Point Information Center,** owned by Consolidated Edison Co., is located off Route 9A in Buchanan, N.Y., on the Hudson River. The center offers a color movie and displays that explain the use of nuclear energy to produce heat and electricity and the vital role of electricity in the N.Y. area. Outside the center are high-power binoculars that offer picturesque views of the Indian Point nuclear plants and the Hudson River. A special bus takes visitors to the nuclear plant and inside the control room. Picnic and recreational facilities on the grounds. Open afternoons Wednesday through Sunday. Phone 212/460-6910.

The **Brookwood Science Information Center,** owned by Rochester Gas & Electric Corp., is located 16 miles east of Rochester on State Highway 18 in the town of Ontario. This center includes exhibits of the production of electricity, the fission process, a detailed reactor model, a fuel assembly model, radiation detection and protection display, a turbine generator, and many other murals, photographs and models. Near several excellent parks and restaurants. Phone 716/546-2700 Ext. 291.

The **Niagara Mohawk Progress Center,** owned by Niagara Mohawk Power Corp., is located six miles east of Oswego, N.Y., off U.S. 104. The main attraction is a 40-minute 3-part program that begins in a wide-screen theater, tracing the development of electric power from the water wheel to the nuclear-electric station; the second part takes place in the Model Room, which contains a 38-foot scale model of the Nine Mile Point Nuclear Station; the final part is in the star-lighted Fission Chamber, where the atom and nuclear fission are dramatized. Picnic area on the grounds. Phone 315/343-5121.

The **New York Hall of Science,** located on the 1964 World's Fair site (48th Ave. and 111th St., Flushing Meadows Park, Queens), has several nuclear exhibits sponsored by Consolidated Edison Co. and the AEC. These include a working model of a nuclear power reactor, a model of a nuclear desalting plant, and an audio-visual display of the story of power in N.Y. City, traced from 1850. Snack bar in the building. Closed Monday. Phone 212/699-9400.

VERMONT

The **Vermont Yankee Observation Building,** owned by the Vermont Yankee Nuclear Power Corp. is located on Governor Hunt Road in Vernon, Vt. Its exhibits include 12 color slides and several photographs of construction progress, plus three schematic drawings of the reactor, reactor building, and turbines and generator. Picnic facilities are on the grounds. Phone 802/773-2711 Ext. 264.

VIRGINIA

The **Surry Nuclear Information Center,** owned by Virginia Electric and Power Co., is located in Surry County, Va., on Route 650, five miles east of Bacon's Castle. The exhibits explain nuclear fission and pressurized water reactors, and an auditorium program presents a movie and a slide show. A picnic area is on the grounds. Closed Sunday morning. Phone 703/771-3194.

WASHINGTON STATE

The **Hanford Number One Information Center,** owned by the Washington Public Power Supply System, is located at the AEC's Hanford Project, approximately 35 miles from Richland, Wash. Panels explain nuclear power generation, Pacific Northwest's requirements for additional energy produced by both nuclear and hydro projects, nuclear safety, environmental concepts and careers in nuclear industry. The center of the exhibit is a detailed model of the world's largest nuclear generating power plan. Visitors must make arrangements in advance by phoning 509/783-6141.

The AEC's **Hanford Science Center** is located in the Richland Federal Building, 825 Jadwin Ave., Richland, Wash. Its exhibits relate the development of the nuclear industry and activities at the adjacent AEC Hanford Plant, where plutonium is produced for defense purposes and research work is conducted on peaceful uses of the atom. A cafeteria is in the Federal Building. Opens at noon during the summer. Phone 509/942-1111 Ext. 6-5338.

WISCONSIN

The **Point Beach Information and Training Center,** owned by Wisconsin Electric Power Co. and Wisconsin Michigan Power Co., is located north of Two Rivers (100 miles north of Milwaukee) on Hwy. 42. In an area shaped like a nuclear reactor, the visitor steps into a tiled circular area in the pattern of the fuel assemblies inside. At the push of a button five projectors produce a sequenced visual, synchronized to a narration on how a nuclear reactor produces electricity. Other stationary and audio-visual exhibits tell the story of energy generation with emphasis on nuclear power. State park nearby. Phone 414/273-1234 Ext. 2954.

Photo Courtesy of Little Rock Corps of Engineers

Progress Can Begin With a River

The development of the Arkansas River and its tributaries for navigation, flood control, and hydroelectric power is the Corps of Engineers' largest civil works project

A Special Report for Electronics Digest
by the Little Rock Corps of Engineers

A different application of proven equipment has been put into a unique combination for a new powerplant near Ozark, Arkansas, on the Arkansas River that may be an answer to making profitable, otherwise marginal hydroelectric generating sites. The Little Rock District of the Corps of Engineers is installing in the Ozark powerhouse on the McClellan-Kerr Arkansas River Navigation System five inclined-axis turbines, especially designed for large, low-head (35 feet), run-of-the-river installations.

The need for additional hydro generating capacity to meet peak loads throughout the United States is crucial. But at the same time, scarcity of medium- and high-head dam sites has presented special challenges to design engineers who must develop the existing low-head sites within acceptable cost limits.

The total estimated hydroelectric power potential in the United States is approximately 127 million kilowatts. Less than one-half of the sites are developed, and most of the sites already developed are the more ideal, high-head locations. Much of the remaining potential sites are marginal, low-head, and not economically suitable for development by conventional generating equipment.

The development of the Arkansas River and its tributaries for navigation, additional flood control, and hydroelectric power is the largest civil works project ever undertaken by the Corps of Engineers.

River navigation was opened to the project's entire length of 436 miles in December 1970 from the Mississippi River to Tulsa, Oklahoma. There are ten hydroelectric powerplants in the overall plan. Seven are operating and eight of the ten plants are to be conventional, high- and medium-head installations, with a total installed capacity of 680,000 kilowatts. The other two powerplants are the large, low-head installations; one at Ozark with an installed capacity of 100,000 kilowatts and the other further upstream at

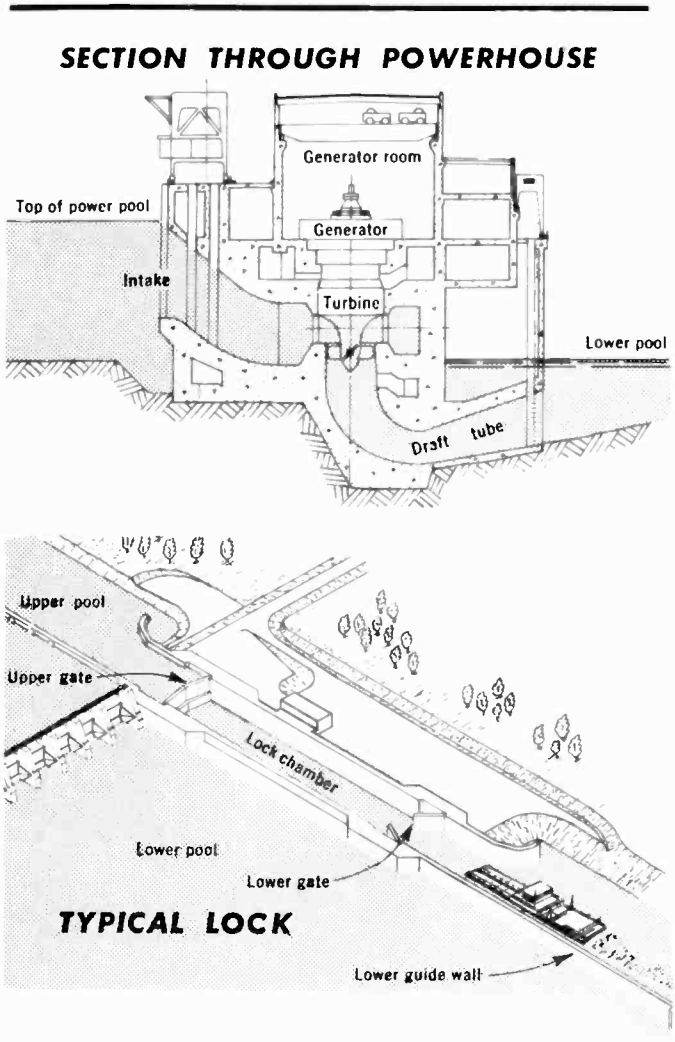


Photo Courtesy of Little Rock Corps of Engineers

Webbers Falls, Oklahoma, with an installed capacity of 60,000 kilowatts. Major parts in these two plants are interchangeable.

Had conventional hydroelectric equipment been installed at Ozark's powerhouse, it would have cost $5 million more, mostly in additional rock excavation to have sufficient depth for that type installation and a larger powerhouse structure.

The basic difference between the inclined-axis units being installed at Ozark and the conventional units is that the rotating axis of the main shaft is near horizontal while conventional units have their main shafts mounted vertically. The units at Ozark are being installed at 12 degrees from horizontal with the shafts sloping upward from upstream (turbine end) to the downstream (generator end).

The inclined-axis type hydroelectric units have been in operation since 1938 and have progressed in size up to 10,000 kilowatts for units operating in France. The units being installed at Ozark are double this capacity, or 20,000 kilowatts.

Though there are no new components in these units at Ozark, they are familiar. They just have never appeared together in the sizes and groupings that are being used by the Engineers on the Arkansas River. Each unit will have a 33,000-horsepower turbine, a main shaft connecting it to a speed increaser which is coupled to a 20,000-kilowatt generator.

An example of the immense sizes is the 26-foot-diameter adjustable four-blade runners (propellers) which are classified with the largest Kaplan-type runners ever built and makes them the largest inclined-axis turbines in the world. The main shafts are another example of large sizes. They are 56 feet long and 53 inches in diameter. Each weighs 97 tons, in spite of being nearly hollow for most the length. Each shaft was formed in Japan of a 6.5-inch-thick steel plate, rolled and welded, leaving a 40-inch inside diameter. The shafts were machined in York, Pennsylvania, and rank among the largest and longest used in hydroelectric installations.

The speed increasers were originally designed for large ships to reduce their higher shaft speeds of turbines driving slower turning large-diameter ship propellers. At Ozark, they have been modified to operate on a slant and to increase the slow speed of 60 rpm of the turbines to a faster speed of 514 rpm for the generators. The modification also allowed the weight of the speed increasers to offset the hydraulic thrusts of large turbines.

In tests, the Corps of Engineers found that the efficiency losses of the speed increasers could be recovered in the more efficient, higher speed generators, which also are considerably smaller in size than slower turning generators used in conventional, vertical installations common in high-head powerplants.

The generators used in the Ozark installation are of a manufacturer's standard design normally used in large engine-driven units like gas turbines or diesel engines. They were modified to operate on a slant for the inclined-axis installation.

Also, the inclined-axis arrangement reduced the excavation needed to accommodate the large-diameter draft tubes and intake and outlet openings that increase in size to about double the 26-foot diameter of the runners.

Another economy resulting from this unique combination of "shelf" items was a smaller powerhouse. The faster turning generators required less space for the same amount of output capacity and the inclined-axis arrangement allowed each unit to be placed in a narrower bay. The overall width of the bays was reduced to approximately 40 percent of conventional installations. The length of the bays is about the same for either type installation.

The Corps of Engineers constructed the first phase of the powerhouse under the same contract it used to construct the lock and dam. Work started on the second phase of the powerhouse, that is, the installation of hydro units, in November 1969, and by late spring of 1971 the contractor was about half completed with the installation. The first unit is scheduled to begin producing power in the summer of 1972 and all five units will be on the line a year later.

When all ten hydroelectric plants of the Arkansas River Project are operating in 1973, the average annual potential energy from these powerplants will be in excess of 3 billion kilowatt-hours, enough to supply the electrical needs of one million persons. One-fifth of that power will be produced by these unique, low-head, inclined-axis units.

ELECTRIC POWER GENERATION

Geyser steam powers electric plant

The earth at its birth was a mass of liquid and gaseous matter. As much as five to ten percent of this mass was steam. As the molten glob cooled, an outer crust formed over the hot mass and the steam then condensed to form surface seas and lakes.

About 20 miles below the crust of the earth, the molten mass — called magma — is still in the process of cooling. In some places earth tremors of the early Cenozoic era have caused fissures to open and the magma to come quite close to the surface. This can cause active volcanoes and, where there is surface water, hot springs and geysers. The hot magma is also responsible for steam vents, termed fumaroles, like those found at *The Geysers* in California. These steam vents are natural escape lines for the giant cauldron that boils below them.

The steam thrown off by cooling magma is called magmatic steam. When surface water seeps down into porous rock heated by magma, the steam formed is called meteoritic steam, probably the biggest source of geothermal steam.

History

Natural steam spouts from the earth in a number of places around the world. Roman documents 2,100 years old tell of a steam field at what is now Larderello, south of Florence, Italy. During the 19th Century, Larderello natural steam was harnessed for industrial heating and mechanical power. Today, Italy can produce more than 400,000 kw. of electricity. Another steam field at Wairakei, New Zealand, supplies a 192,000 kw. plant. The Russians, Japanese and Icelanders also have begun using geothermal power. In Mexico, a 75,000 kw. plant is being constructed south of Mexicali.

The feasibility of developing geothermal steam fields is being investigated by Chile, Czechoslovakia, Hungary, Turkey, El Salvador, Nicaragua, and The Philippines.

The Geysers Power Plant in remote northeastern Sonoma County, California, is the only geothermal power plant in North America. There are only six countries in the world using underground steam to spin the turbine-generators that make electric power.

About 90 highway miles north of San Francisco, *The Geysers* is located on the steep slopes of a canyon near Cobb Mountain, an extinct volcano.

The geysers here are not really geysers, but fumaroles and steam vents. The difference is that geysers, like famed *Old Faithful* in Yellowstone National Park, send up fountainlike jets of hot water and steam at intervals. Fumaroles are fissures in volcanic areas emitting vapor steadily.

The first attempt at developing *The Geysers* power potential was made in 1922. Drillers successfully tapped the steam source. But the piping and turbines of that time simply could not withstand the corrosive and abrasive effects of natural steam and the impurities it contained. Nor was the time ripe. Hydroelectric sites, then more economical, were still available. The project was abandoned.

Magma Power Company and Thermal Power Company, working jointly, again tapped the area in 1956. By that time, great progress had been made in finding stainless steel alloys that could withstand corrosion. Now geothermal steam could be produced economically, so PG&E contracted to build a plant and buy steam from the Magma-Thermal wells.

Operation

The first generating unit at The Geysers Power Plant, 12,000 kilowatts, began operation in 1960.

Unit 2, 14,000 kw, began operation in 1963, and Unit 3, 28,000 kw, in 1967.

Pacific Gas and Electric Co.

Pacific Gas and Electric Company engineers study the pressure and temperature of this geothermal steam well at PG&E's The Geysers Power Plant in Sonoma County, California. Wells to produce steam for the plant have been drilled to a depth of more than a mile and a half. Behind the steam wells can be seen Unit 3.

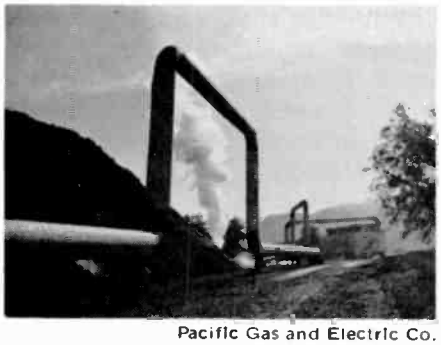
In late 1968, The Geysers Power Plant's capacity was raised to 82,000 kw, with the addition of the fourth generating unit. The fifth and sixth units, each 55,000 kw, are scheduled for completion in the summer and fall of 1971.

Units 7 and 8, also rated at 55,000 kw, are scheduled for service in 1972. The plant's total generation capacity then will be 302,000 kw.

In 1967, Union Oil Company of California joined with Magma-Thermal to develop steam.

Spins turbines

Slightly more than 1.5 million pounds of steam are needed every hour to drive turbines in the four generating units. As the steam leaves the well heads at about 350 degrees Fahrenheit, it is first cleansed of minute fragments of rock by "whirling" them off. Otherwise, these particles could damage the turbines.



Pacific Gas and Electric Co.

The steam suppliers provide the pipe lines up to the power plants. Giant loops in the pipe help to cleanse the steam of minute fragments of rock before it reaches the power plant, otherwise these particles could damage the turbines.

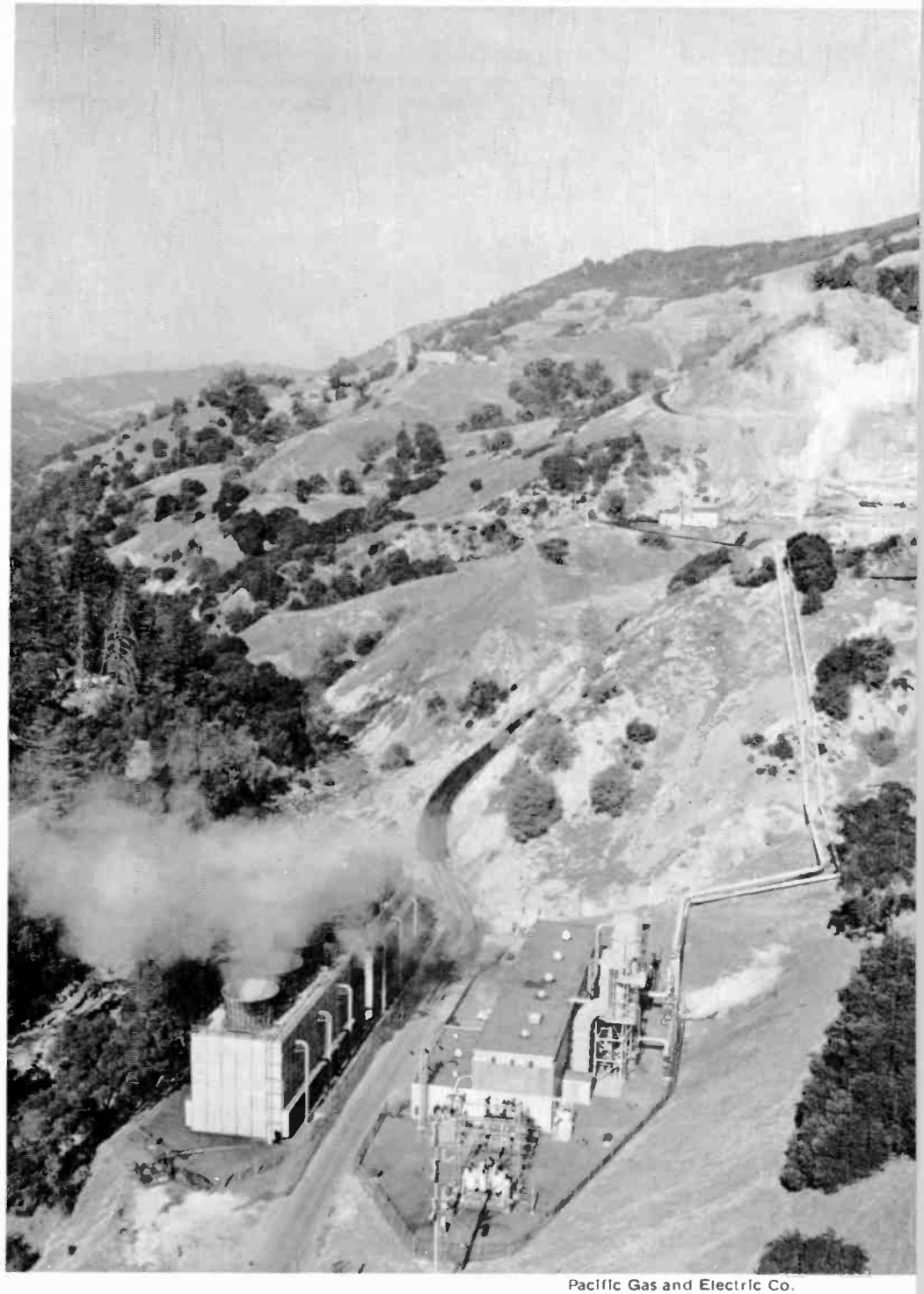
The steam is then piped into the power plants to spin the blades in the turbines, which in turn drive the generators that produce electricity. After the steam has done its job, it is piped to a condenser, which returns the steam to water by combining it with cooling water. The combined waters are pumped to the cooling tower where the water temperature is reduced. One of the unique aspects of the operation is that no makeup water is required for the cooling tower because it is supplied by the condensing geothermal steam.

Progress

Geothermal steam is just one of four sources of energy PG&E uses to produce electric energy for northern and central California.

PG&E is spending more than $1 million each working day for expansion of its gas and electric systems. By 1980, the company's generating capacity should rise to about 19 million kilowatts. This is enough to serve the needs of 33 cities the size of San Francisco.

Besides supplying economical gas and electricity, the company provides campgrounds and picnic areas at its reservoirs and watershed lands, provides college scholarships and career opportunities for young people, and aids in bringing new industries to the state. These are just a few of the activities of PG&E in its role as a corporate citizen of California.



Pacific Gas and Electric Co.

These are Units 1 and 2 of Pacific Gas and Electric Company's The Geysers Power Plant in Sonoma, California. On the knoll, upper left center, are Units 3 and 4. Note the vapor rising from the cooling towers in the lower left foreground. Water from the condensed geothermal steam, which is stored in a cooling tower basin, may be treated and used for other purposes.

NUCLEAR POWER PLANTS

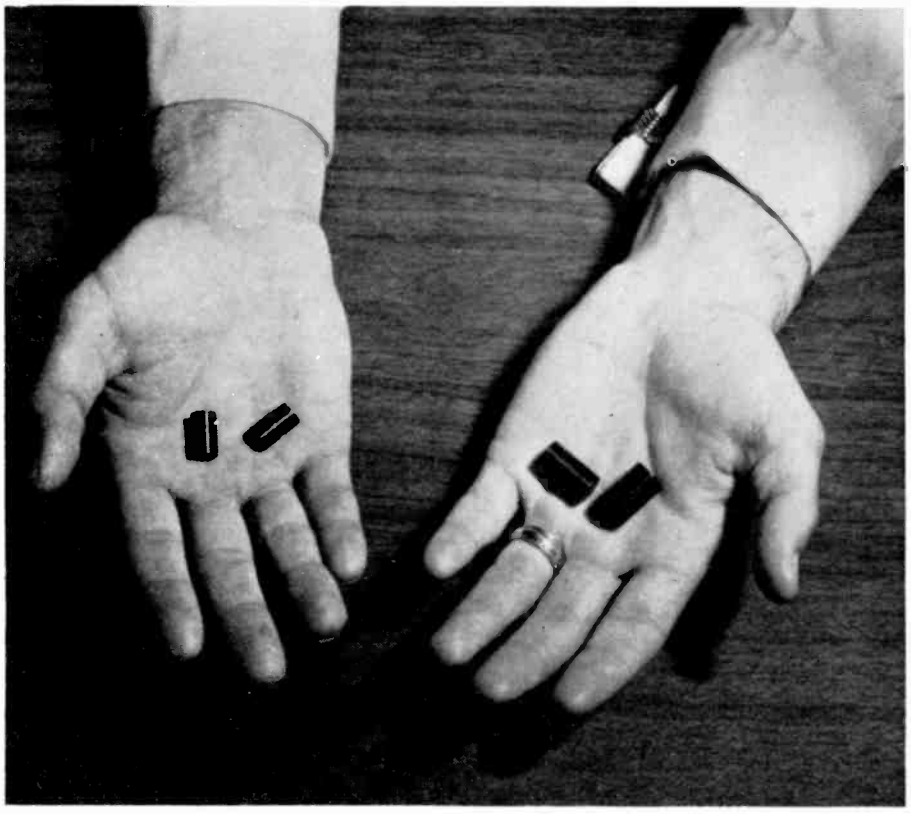


Photo Courtesy of Tennessee Valley Authority

These are facsimiles of the nuclear pellets that will fuel TVA's two nuclear power plants. The smaller pellets, on the left, will be used in the Sequoyah Nuclear Plant; each pellet is equal to a little over one ton of coal. The larger pellets will be used in the Browns Ferry Nuclear Plant; each pellet is equal to nearly two tons of coal.

TVA's nuclear power plants

Special Report

Construction continues on the world's largest thermal power plant, the Tennessee Valley Authority's Browns Ferry Nuclear Plant. The space-age power plant is located on the north shore of Wheeler Reservoir in northern Alabama. It will be comprised of three units, each generating 1,152,000 kilowatts of electricity. The first unit is now scheduled for completion in April 1972.

Also under construction in the giant TVA electric system is the Sequoyah Nuclear Plant, located 18 miles northeast of Chattanooga, Tennessee, on Chickamauga Lake. The plant, which will have two generating units of 1,220,580 kilowatts capacity each, is scheduled to begin operation in April 1974. Steam will be supplied by pressurized-water reactors.

A 23-mile line from TVA's Sequoyah Nuclear Plant will provide an interconnection with Georgia Power Company near the state line.

TVA's new nuclear steam-electric plants will be attractive additions to these scenic areas and will provide clean, quiet, and smoke-free electric power generation for residential and industrial use.

A nuclear pellet, such as used to fuel the Browns Ferry Nuclear Plant, is the equivalent of nearly two tons of coal, which it is destined to replace.

Unlike the conventional coal-fired steam plants, there will be no unsightly stock-piles of fuel, and no smoke to pollute the air. New technology will keep thermal pollution of nearby water at safe levels.

This represents but one of many ways America has developed the peaceful use of nuclear energy — of benefit not only to our country but to other progressive nations of the world.

Sea platform for nuclear power

Westinghouse Electric Corporation recently announced the formation of a new division to develop the concept of platform-mounted nuclear power plants for off-shore locations to serve major metropolitan areas in the United States.

Joseph C. Rengel, executive vice president, nuclear energy systems, has formed a Special Project Division, headed by A. P. Zechella, general manager, to carry out the project. Mr. Zechella had been general manager of the Westinghouse Astronuclear Laboratory.

"With this concept, a deep water shipyard or construction facility would be organized and equipped to build complete nuclear power plants in specially designed floating platforms," Mr. Rengel said. "When completed, the platform will be towed to a permanent coastal site for installation in a breakwater-enclosed basin.

"We consider this a natural progression in the advancement of the nuclear power business in the United States," Mr. Rengel said. "Considering the amount of new generating capacity utilities will be needing in the next 30 years, and the diminishing availability of suitable land-based sites, this off-shore siting concept became inevitable."

The completed plant is expected to weigh about 150,000 tons, and have an elevation of 200 feet from the keel plate to the top of the containment structure. The company envisions 345,000-volt underwater transmission lines to carry the power to the mainland.

Nuclear plant orders surge

A surge of nuclear power-plant orders in the first four months has added weight to industry forecasts that 1971 will be the second best year ever for the number of reactors sold, and may set a record in terms of generating capacity that these units represent.

Buoyed by a $1-billion, four-reactor commitment announced April 30 by Carolina Power & Light Co., the Atomic Industrial Forum's 1971 sales tally now stands at 13 re-

(Continued on next page)

NUCLEAR PLANT ORDERS

actors, with a combined capacity of 12,780 megawatts (12,780,000 kilowatts). In all of 1970, U.S. utilities bought only 16 reactors (16,600 Mw). The Forum shows 1967 as the record sales year to date, with 30 units (25,000 Mw), followed by 1966, in which 24 reactors (19,500 Mw) were sold. As these figures indicate, the trend in recent years has been to larger nuclear generating units, and among the 13 reactors sold so far this year the smallest is rated at 850 Mw.

Government and leading industry chartists agree that domestic nuclear capacity on line by the end of 1980 will reach about 150,000 Mw, or roughly 22 per cent of the total U.S. generating capacity at that time. To date, U.S. utilities have committed themselves to about 98,000 Mw of nuclear capacity. Assuming a six-to-seven-year lead time for construction of a nuclear plant, orders in the next three years will need to average about 17,000 Mw per year to reach the 1980 forecast.

Not counting several small developmental power-producing reactors and the government's large dual-purpose N reactor at Hanford, Washington, the Forum lists 16 commercial nuclear stations on line, 56 under construction and 44 under firm order.

ELECTRONICS OUTDOORS

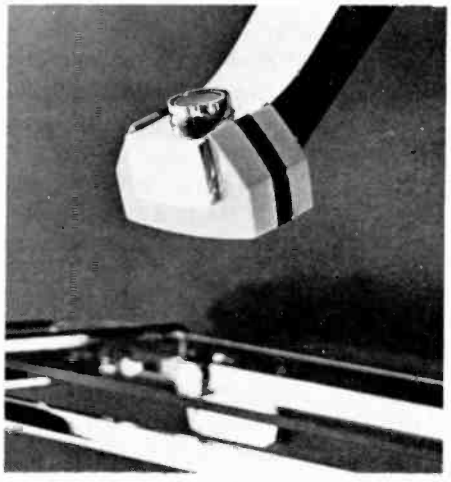
Pocket guide for outdoorsmen

A special pocket guide for outdoorsmen is available from Zenith Radio Corporation. It gives some sound electronic tips for outdoor adventurers.

There is a map of all the weather stations nationwide. There are quickie ideas on drying out a drenched radio without a repair bill, tips on how to decorate for a patio party, hunting electronically, packing, navigating with a radio, and the latest information on electronic products.

A free copy may be otbained by writing to: Outdoor Guide, Zenith Radio Corporation, 1900 North Austin Avenue, Chicago, Illinois 60639.

MEDICINE



The Netherlands Consulate

Water mixing tap

A Dutch company has developed an electronically-controlled mixing tap which can be turned on and off without being touched by hand, and can supply cold or hot water or a mixture of the two as required. This tap is ideal for use in places where a high degree of hygiene is necessary, such as in sterile rooms, laboratories, operating rooms, doctors' surgeries, hospital toilets, etc.

According to the manufacturer, Venlo Sanitair of Venlo, the Netherlands, the mixing tap consists of a chromium-plated arm with a plastic sensor on it, a small box containing electronic equipment, two magnetic valves and the necessary connecting wires. The sensor is equipped with elements, housed in a capacitance circuit, which react to movements performed by hand or an artificial hand in the area of the tap. These movements cause control signals to be sent in the capacitance circuit.

CIVIL DEFENSE

Nationwide radio warning network

U. S. Civil Defense Director John E. Davis today approved a contract for start of work on a new federal radio network to give faster, more informative warning of both nuclear attack and major peacetime disasters. The contract covers the first, prototype unit of Office of Civil Defense's (OCD) proposed "Decision Information Distribution System" (DIDS).

DIDS is a warning system which will position receivers in law enforcement offices, fire houses and selected state and local government agencies which, in turn, will relay the warning to citizens.

Ten prospective contractors were solicited and two proposals were received. The contract in the amount of $2,720,012, has been awarded to the Westinghouse Electric Corp., Systems Development Division, Baltimore, Maryland.

Work under this first contract, to be completed by July 1972, calls for (1) construction of a 50,000-watt low-frequency radio transmitter at Edgewood Arsenal, Maryland, and (2) installation of 500 special receivers in eight eastern States and the District of Columbia. The states are Virginia, West Virginia, Maryland, Delaware, Pennsylvania, New Jersey, New York and Connecticut.

Another 1,600 receivers are scheduled to be installed next summer in these and two other states, Rhode Island and Ohio, with a total of 65 million residents. People who live in communities having DIDS receivers will benefit through better warning of severe storms and other peacetime disasters, as well as attack.

"The complete DIDS system, plus a possible later tie-in with TV sets in American homes, could save many additional millions of lives in case of nuclear attack," Director Davis said.

Main advantages of the DIDS system are faster warning, wider coverage, greater reliability, direct automatic control of community warning sirens, and the capability of giving direct and more complete information through radio and TV sets.

NEW RESEARCH

Upper atmosphere studies planned

A $15 million Upper Atmosphere Observatory to study relations of space energy to weather, radio communications and other phenomena on earth is being planned by scientists of the United States and Canada.

Preliminary engineering studies

(Continued on next page)

are under a $99,950 National Science Foundation grant to the University of Illinois at Urbana-Champaign. Prof. Sidney A. Bowhill of the electrical engineering department heads an international group of consultants for the project.

The tentative site for the observatory is near the central or eastern Canadian border, where, because of the earth's magnetic field, ionized layers of the upper atmosphere form a low-density "trough" offering opportunity for a variety of research activities not possible elsewhere.

To study winds and ionospheric disturbances 50 to more than 6,000 miles above the earth, the observatory will use incoherent scatter radar, a new system developed within the last 10 years. Its very high-powered signals can track and study rarefied gases and particles at extreme altitudes.

Support and use of the observatory is planned to be international, with a strong research and educational program involving resident and visiting scientists and graduate students.

The transmitter will have an antenna 300 feet in diameter. Powerful receivers will be located more than 100 miles away in four directions. Two probably will be in Canada. They will be linked to a computer at the transmitter.

The general structure of the upper atmosphere has been sampled and charted with satellites, rockets, radar and other devices, but an understanding of what goes on requires a facility capable of making a continuous record 24 hours a day.

The new observatory will provide this data, which is essential to understand the behavior of the whole system—the winds, weather and electric fields of the upper atmosphere and their effects on lower levels.

Involved are physics, chemistry, mathematics, electronics and other sciences, and technology and analytical studies which may provide experience valuable for research in other complex areas such as urban problems, pollution and transportation.

Low pollution vehicle planned

To combat automobile exhaust pollution, electrical engineering students in the University of Illinoise at Urbana-Champaign propose gasoline engines running at constant speed and ultra-modern electronic circuits to cut in battery power for starting, pickup and top speed.

Under an electrical engineering special problems course, they are designing such an automobile for the nationwide Urban Vehicle Design Competition, an extension of the Clean Air Car Race of past years.

The constant speed, low-pollution exhaust, gasoline engine will drive a generator. An electric motor will power the wheels. Electronic circuits with solid state devices will automatically cut in battery power when needed and at other times direct excess current to recharge low-weight aircraft type storage batteries.

The vehicle is one of two entries planned at the U. of I. for the competition. The other, by mechanical engineering students, centers on a Wankel engine, a non-reciprocating, rotary internal combustion engine.

WEATHER

Weather Service alert broadcasts

Of particular interest to schools, hospitals, civil defense, and civil disaster agencies is the 24-hour year-around weather data available through broadcasts of the National Weather Service.

The NWS lists the following stations on the air at the common frequency of 162.55 MHz:

Akron, Atlantic City, Boston, Brownsville, Buffalo, Chicago, Charleston, Corpus Christi, Galveston, Honolulu, Jacksonville, Kansas City, Lake Charles, Los Angeles, Miami, New Orleans, New York, Norfolk, Portland (Maine), Portland (Oregon), Sandusky, San Francisco, Seattle, St. Louis, Tampa, and Washington, D.C.

Stations on 162.40 MHz are Cleveland and New London (Connecticut). Baton Rouge is at 162.45 MHz.

New stations coming on the air this spring on 162.55 MHz, will include: Dallas, Detroit, Erie (Pa), Milwaukee, Minneapolis, Mobile, Monterey, Savannah, San Diego, Sacramento, Wichita, and Wilmington, N.C.

Reception distance for most of these stations, depending on individual broadcast equipment and receivers, is up to 40 miles.

Each of the stations, except Baton Rouge, features tone alert capabilities. When a warning of severe weather is issued by the Weather Bureau which affects any portion of the station listening area, a one is transmitted.

AIR POLLUTION

Laser detects air pollution

Rapid, precise, on-the-spot identification of pollutant gases in the air may become possible using a laser-light technique devised by two Bell Laboratories scientists. The measuring system could replace certain time-consuming, less sensitive tests currently required to analyze air samples.

Bell Telephone Labs

POLLUTION TESTERS – C. Kumar N. Patel and Lloyd B. Kreuzer (left to right) of Bell Labs measure the amount of nitric oxide gas in an air sample using a new laser-light absorption technique they devised.

C. Kumar N. Patel and Lloyd B. Kreuzer, adapting components of their own design, devised a system for measuring several kinds of gases that are oxides of nitrogen in quantities as small as ten parts per billion parts of air. Nitrogen oxides such as nitric oxide and nitrogen dioxide are quite toxic, and are among the main pollutants found in automobile exhaust and smoke stack emissions.

MILITARY

U. S. Army training simulates missile attack

A new training system for the U. S. Army's Safeguard Systems Command incorporates five Varian 620/i minicomputers—a master and four slaves—to simulate missile attacks by displaying maps and trajectories on video screens in real-time, thereby testing operator responses under emergency conditions.

The system—called the Manual Intervention Facility (MIF) by its designer and manufacturers, Compunetics, Inc. here—is determining the operational characteristics and system requirements for actual ABM Safeguard System sites and provides a method of familiarizing personnel who will eventually be working at each site. The system is now operating at White Sands Proving Ground, New Mexico.

Designed with versatility, expandability and compatibility with a wide range of peripherals and overall system central processors in mind, the MIF uses a 620/i with 16K of 16-bit-word memory to set the function and state of all other components and retain them in memory.

Four slave 620/i minis in the MIF act as data buffers for the graphics program stored in the master. This releases a large central processor in the total system, a Univac 1108, of bookkeeping functions.

In the Safeguard MIF, a typical simulation procedure's sequence of events is as follows:

Either automatically or manually, an emergency condition is generated by projecting on a display screen one of up to 40 reference background slides. These can be maps, charts or other graphics over which trajectory data is superimposed.

When an operator responds to the emergency condition, such as a missile trajectory change, the control console instantly senses his action and calculates all the new variables, transmitting the results of the response to any particular module for presentation. The results of the operator's responsive action can then be detected and evaluated. At any point in a series of tests or simulations, an interrupt control unit can direct the master 620/i to actuate a corresponding interrupt routine, and a mid-test evaluation can be made.

The MIF system being used is actually a replica of the real Safeguard control and command system manufactured by Bell Laboratories.

Other Compunetics systems are available for process control applications, such as automating steel mills; line concentration and communications systems; and for data logging and acquisition.

Photo Courtesy of Varian Associates

THIS SPACE-AGE ELECTRONIC TRAINING SYSTEM called Manual Intervention Facility (MIF) is used by the United States Army's Safeguard Systems Command to train and test potential operators of the Nation's ABM equipment. It provides realistic simulation of missile attacks.

EDUCATION

Wireless audio language learning

The ESE System with its ten channel audio capability serves as a reliable method of extending the teacher, allowing for a greater role in dealing with individual learning.

Teachers can effectively provide for exceptional language programs through this updated form of group instruction.

A teacher can literally be in 30 places at one time, conducting a variety of lesson material and accomplishing a greater amount of skill development.

Taped materials serve as the master speaker. All student stations provide for individualized drill and practice. Students proceed with content and level of difficulty at a rate appropriate to individual needs.

The new learning system was developed by ELECTRONIC SYSTEMS FOR EDUCATION, INC.

TRANSPORTATION

Varian Associates

Electronic brain routes luggage

Baggage handlers at the nation's busiest airport now are operating mini-computers to make sure passengers and their luggage depart on the same flight.

The new United Air Lines baggage handling system uses a Varian Data Machines 620/i minicomputer to remember the destination of as many as 12,000 suitcases an hour. Designed by the Industrial Systems Division of Aerojet-General Corporation of Frederick, Md., the automated baggage handling system expedites handling of luggage of any size or shape, including golf bags and even mail sacks.

Installed in anticipation of jumbo jet passenger loads, the new system is used for all United's O'Hare departures, plus interline transfers.

Physically, the computer-operated material handling system consists of a giant triangular network of conveyors — each side of the triangle measuring 300 feet in length. As the tagged luggage whizzes by two corners of the triangle at the rate of up to 200 pieces per minute, a dispatcher at each corner enters the destination code of each bag into the minicomputer terminal keyboard.

From this point, each piece of luggage is transported on its own sorter tray to the destination accumulation conveyor. Known as a "controlled tilt tray sorter," the sorting systems allows each tray to tilt under remote command. Since the Varian minicomputer remembers the destination of every suitcase, it instructs the tilt tray mechanism to divert each piece to the proper accumulation lane. Here, baggage handlers load the luggage onto baggage carts destined for every aircraft scheduled to depart during the next two hours.

Under peak conditions, UAL said, the average time elapsed between the acquisition of a piece of baggage into the system and its delivery to the appropriate inbound chute is from four to six minutes.

MEASUREMENT

New thermometer

Scientists have developed a new type of thermometer which can measure changes of one two-thousandth of a degree in temperatures hundreds of degrees below zero.

The thermometer was developed at the University of Illinois at Urbana-Champaign by Prof. Dillon E. Mapother of the department of physics and the Materials Research Laboratory and Roger P. Ries of the department of electrical engineering.

They reported its performance at the fifth Symposium on Temperature, sponsored by the American Institute of Physics, the Instrument Society of America and the National Bureau of Standards.

The thermometer measures in the range of 459.13 to 457.69 degrees below zero, Fahrenheit, (1.1 to 0.3 Kelvin) where very small temperature changes are important in various cryogenic phenomena.

Unlike other devices used to measure at such low temperatures, it can be moved from place to place without recalibration, and can serve as a standard to check the others.

The thermometer consists of an aluminum wire, a solenoid whose magnetic field affects the aluminum's superconductivity, and detection coils to reveal the superconducting condition of the aluminum.

The unit used at Illinois is about ¼ inch in diameter and 2 inches long (6 mm. by 7.5 cm.), but it could be made smaller.

Its operation is based on the fact that at extremely low temperatures, certain materials become superconducting, losing all resistance to electricity, and this superconductivity can be affected by a magnetic field.

Mapother explained the operation of the thermometer by pointing out that superconductivity is a phase transition phenomenon like the boiling of water.

Boiling, a transition from liquid to vapor, can be suppressed by increasing pressure of the vapor. The amount of pressure controls the liquid's temperature—as in a housewife's pressure cooker.

Superconductivity can be similarly suppressed by a magnetic field, and the amount of magnetic "pressure" can be used to regulate, or to indicate, the precise temperature at which the superconducting transition occurs.

Research in which the new thermometer was developed was supported in part by the Advanced Research Projects Agency of the Department of Defense and the U. S. Army Research Office through contracts with the University of Illinois.

Cubic Corporation

Electronic surveying

A new, automatic, infrared land-surveying instrument that will measure distances from one meter to more than a mile in less than 10 seconds has been announced by Cubic Corporation of San Diego.

Called "Cubitape," the instrument gives distance readings that are easily read from a numerical display on its front panel.

All the operator has to do is to

(Continued on page 21)

history's hall of honor™

BIOGRAPHICAL SKETCHES OF GREAT MEN IN ELECTRONICS

Frank Conrad

May 4, 1874 – December 10, 1941

Engineer, Inventor, and Radio Broadcasting Pioneer

A glimpse of the American scene through the window of history shows a unique success formula in action throughout the length and breadth of the land. The people of many countries joining hands to build a great nation . . . in an atmosphere of individual freedom and opportunity for achievement consistent with ability. Everywhere, one notes a contagious display of self-reliance, perseverance and ambition—a deep sense of national pride and patriotism.

This is the heritage of the United States of America which had its beginning nearly 200 years ago—July 4, 1776.

From this way of life has come many of our great men of science—men like the late Dr. Frank Conrad, often cited as the radio pioneer whose research and creative thought paved the way for today's commercial broadcasting industry.

Dr. Conrad, the son of a railroad mechanic, was born in Pittsburgh, Pennsylvania, on May 4, 1874. His father, according to some accounts, believed profoundly that mechanical ability was a greater asset than formal schooling. Thus, young Frank may well have been influenced by his father's philosophy, in addition to his own developing interest in mechanics, to drop out of school after completing the seventh grade at the old Sterrett Grammar School.

In October, 1890, at the age of 16, he went to work as a bench-hand in the original Westinghouse plant in Garrison Alley, Pittsburgh. His keen grasp of mechanical problems soon won him a transfer to the testing department. This was the beginning of a brilliant career that was to span 51 years, and would carry him up the ladder of success to a position as assistant chief engineer of the company.

An unceasing quest for knowledge—which overcame the handicap of limited formal schooling—combined with an extraordinary aptitude for analyzing mechanical operations to produce many noteworthy contributions in his chosen field of engineering.

By age 23, Dr. Conrad had developed his first important contribution for his employer and the world—the round type electric watt-hour meter now in universal use. Many notable inventions followed—pantagraph trolleys to power the nation's trains, electric clocks, automotive electric apparatus, and countless other useful inventions. More than 200 patents were granted to the wizard of mechanics.

Photo Courtesy Westinghouse Electric Corporation

This photograph, taken in the later years of his life, shows Dr. Frank Conrad as he thoughtfully examines a new radio tube. His early experiments led to establishment of the famed Westinghouse radio station KDKA.

Perhaps the greatest achievement of Dr. Conrad's long and distinguished career was his experimental work in radio broadcasting which led to the establishment of the Westinghouse radio station KDKA and modern radio broadcasting, and to the world's first regularly scheduled radio broadcast on November 2, 1920.

(Continued on page 19)

Photo Courtesy Westinghouse Electric Corporation

Frank Conrad

May 4, 1874 – December 10, 1941

Engineer, Inventor, and Radio Broadcasting Pioneer

DR. FRANK CONRAD

(Continued from page 17)

It is said that Dr. Conrad's interest in radio began in 1912 as the result of a friendly $5 wager on the accuracy of his watch against a more expensive one owned by another engineer. A Western Union clock was the arbiter. Dr. Conrad won the wager. But more important the incident awakened a keen interest in time synchronization. As a result, he proceeded to build a simple radio receiving set in order to pick up the time signals transmitted by the Naval Radio Station at Arlington, Virginia. This experimental venture led to a friendship with a young wireless experimenter who lived less than a block from the Conrad home. They built sets to communicate with each other.

These circumstances led to even greater enthusiasm in the new field of radio when Dr. Conrad began operating his own amateur radio station, with the call letters 8XK, in the garage at the rear of his residence in Wilkinsburg, a suburb of Pittsburgh. The first official record of his station appeared in the August 1, 1916, edition of the Radio Service Bulletin issued then by the Bureau of Navigation of the U. S. Department of Commerce.

During World War I, the government drafted the young engineer and his talent for invention. Shortly thereafter Dr. Conrad developed one of the first practical aircraft radio transmitters.

After the war, he resumed his broadcast experiments, adding a notable substitute for spoken words during tests, popular phonograph records, in October, 1919. Overnight he found himself deluged with requests from fellow amateurs seeking to convince skeptics among their acquaintances that music could be sent through air by radio.

These requests prompted Dr. Conrad to play phonograph records several nights during the week while conducting his broadcast experiments. Then, in September, 1920, the Joseph Horne Company, a Pittsburgh department store, ran an advertisement in the newspaper listing radio sets to enable listeners to hear these "special music broadcasts." The matter came to the attention of the late H. P. Davis, then a Westinghouse vice president, and later chairman of the board of the National Broadcasting Company. It resulted in an application to Federal authorities to use the station for commercial broadcasting. New call letters were assigned for "a commercial land broadcast station." Thus began the famous Westinghouse radio station KDKA, the world's first commercial broadcast station. Its first regularly scheduled broadcast began on November 2, 1920, fifty-one years ago.

Dr. Conrad, like other famous men of science, has been accorded many honors in recognition of his achievements. In 1928, he received the honorary degree of Doctor of Science from the University of Pittsburgh. In 1936, he was awarded the Morris Liebman Prize by the Institute of Radio Engineers; the Edison Medal of the American Institute of Electrical Engineers in 1931; the John Scott Medal of the City of Philadelphia in 1933; and the Lamme Medal of the A.I.E.E. in 1936.

Dr. Conrad was an authority in the fields of biology, botany, and astronomy. He was a fellow of the Institute of Radio Engineers, a member of the American Society for the Advancement of Science, and a member of the Society of Automotive Engineers. He also held the rank of Lieutenant Commander in the U. S. Naval Reserve.

Dr. Conrad was unanimously selected by the Awards Committee of the Radio Pioneers as the fourth annual award for the Radio Hall of Fame on April 27, 1953. Receiving the award on behalf of Dr. Conrad was his son, Francis Conrad, director of radio, Western Division, American Broadcasting Company.

Dr. Frank Conrad, a great American and a great man of science, died in Miami, Florida, on December 10, 1941.

Photo Courtesy Westinghouse Electric Corporation

The late Dr. Frank Conrad, assistant chief engineer of the Westinghouse Electric & Manufacturing Company and famous radio pioneer, at work in his laboratory at the Company's headquarters works, East Pittsburgh, Pennsylvania.

Photo Courtesy Westinghouse Electric Corporation

One of the most famous of all broadcasting events, KDKA began broadcasting November 1, 1920. In the picture is the entire personnel and equipment, including the station engineer, announcer and two assistants obtaining news reports. The broadcast consisted of reports of the Harding-Cox election returns. Left to right: R. S. McClelland; William Thomas, licensed operator; L. H. Rosenberg, announcer; and John Frazier.

FROM AN ALBUM™

Photo Courtesy of Zenith Radio Corporation

Incredible progress has been made in the design and production of portable radios since 1924. This old photograph shows one of America's most famous Arctic explorers, the late Commander Donald B. MacMillan, with one of the world's first portable radio sets. The portable radio set, which was manufactured by Zenith Radio Corporation in 1924, represented a sensational advance in radio technology of that era. Commander MacMillan field-tested one of these sets on one of his expeditions.

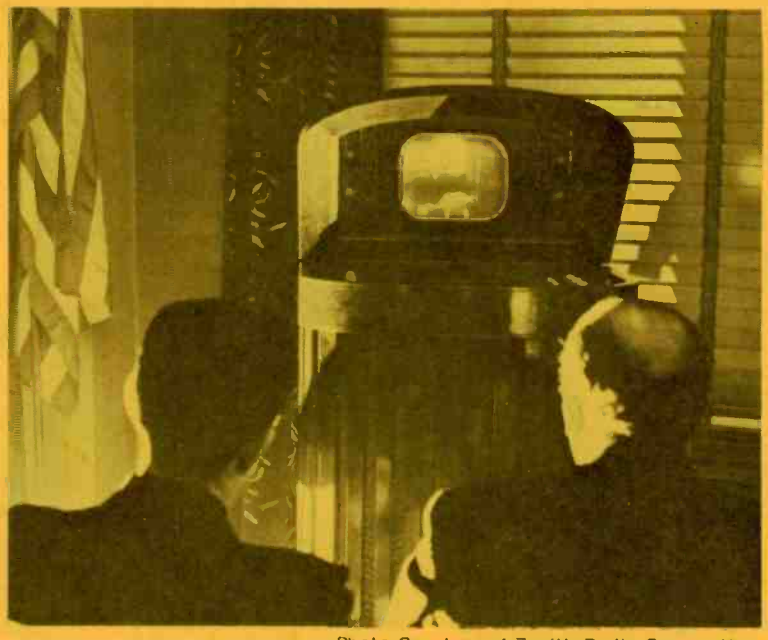
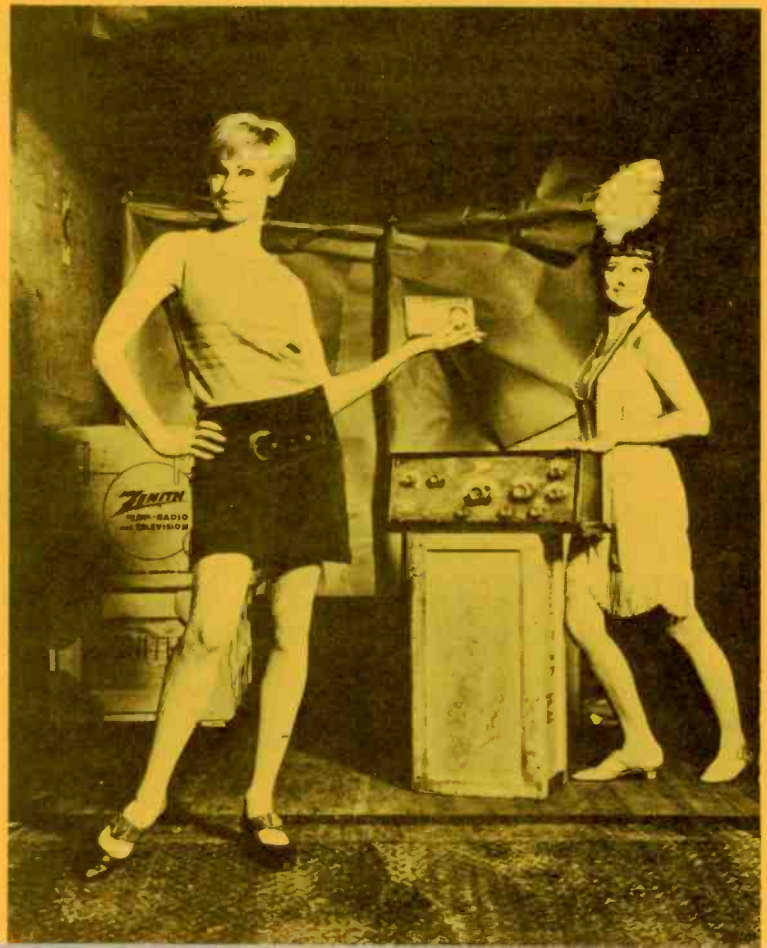


Photo Courtesy of Zenith Radio Corporation

The world premiere of the motion picture "Patrolling the Ether" was telecast by Zenith Radio Corporation's television station in the early 1940s at the request of the Federal Communications Commission.



Hemlines of the flapper era are not much different from today's mini-skirts, but an incredible change has taken place in the world of radio receivers. The feathered femme is leaning against the "hit" of 1923, a Zenith 4R — one of the first battery-operated receivers of moderate size contained in a single unit. At left, a modern miss holds a tiny transistorized FM/AM portable radio . . . today's radio "hit."

Photo Courtesy of Zenith Radio Corporation

ELECTRONIC SURVEYING

line up the target through a sighting scope, press a button, and read the distance which is displayed to the nearest millimeter.

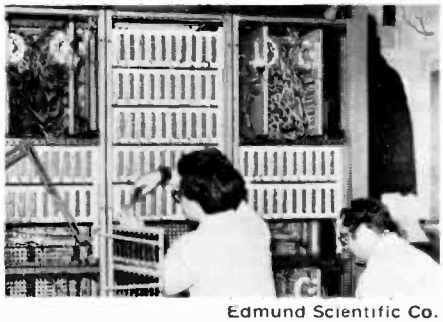
It is designed to function in a rugged field environment and will operate with its own internal battery power supply throughout a temperature range of from 10 to 120 degrees Fahrenheit. It weighs less than 10 pounds.

LIGHT / MUSIC

Light theatre

"Fantastic," is the best description of Edmund Scientific's new Multi-Media Light Theatre — said to be the first of its kind anywhere in the world.

The Multi-Media Light Theatre has to be sensually perceived — with your eyes, ears, and body to be fully appreciated. It features lighting paraphernalia hanging from the ceiling, stereophonic sound pulsing in your ears, on your skin, a 96 foot curved "involvement" screen extending beyond peripheral vision, and multi-interflowing psychedelic impressions which play across the screen.



Edmund Scientific Co.

A maze of wires . . . a fabulous merger of sight and sound!

The massive Master Control System is impressive with its flashing panel lights and illuminated switches — 580 of them, plus miles of wiring. It is capable of 3,645 switching operations per second or 218,700 per minute. When functioning at full capacity the master control requires 120,000 watts of electrical power.

The theatre, which will seat 50 to 75 persons, has a floor area of 1,524 square feet. The unique "light theatre" is located in Barrington, New Jersey.

BOOKS, FILMS, CATALOGS

Electronic parts catalog

Allied Radio Shack's new 1972 Electronic Parts & Accessories Catalog lists thousands of hard-to-find electronic items, including those parts and pieces most often needed to keep equipment working, and the accessories used with them.

The 132-page catalog is a complete buying guide for hobbyists, kit builders, Hams, CBers, "fix-it" men, electricians, servicemen, technicians, hi-fi installers, experimenters and anyone interested in any aspect of electronics.

Exclusive Allied, Realistic, Archer, Micronta and Radio Shack brand products are listed, as well as the complete line of Knight-Kit and Science Fair kits.

Catalog 215 is available free on request from Allied Radio Shack, 2725 W. Seventh Street, Fort Worth, Texas 76107.

Allied Radio Shack, a Tandy Corporation Company (NYSE), now has more than 1100 stores in 49 states and Canada.

Musical instruments

A valuable reference for both electronically and musically oriented readers, this new volume is intended to acquaint readers having an electronic background with the artistic applications of his craft, and at the same time introduce the musically oriented to the unlimited variety of electronic adaptations to music. The author has successfully pursued his subject from both viewpoints and has achieved a seemingly insurmountable impasse between two fields.

However divergent they may be from a purely technical or artistic viewpoint, electronics and music are becoming increasingly inseparable insofar as progressive music is concerned. Technicians with a desire to break into a new and financially lucrative field, and musicians who are aware of the fantastic innovations possible with electronics, will find this book of infinite value.

CONTENTS: Electronics and Music — Amplification for Traditional Instruments — Electronic Modifiers — Fully Electronic Instruments — Amplifiers & Speaker Systems — Synthesizers — Troubleshooting — Your Place In Electronic Music. Glossary and Index.

192 pps., over 100 illustrations. Tab Book No. 546, published by Tab Books, Blue Ridge Summit, PA 17214.

Color films for school showing

A new 28-minute color film, *Threads of Technology*, is offered by Raytheon Company for school, industrial, and club showings.

The film presents the story of a science-based enterprise and the threads of technology that bind it together to produce a wide range of innovative products and services for the home, education, medicine, business & industry, and national security. Scenes include: (1) applications of microwave energy in radar, communications, and electronic ovens; (2) electronic aids to navigation and safety at sea; (3) geophysical probes to aid in locating oil; (4) water-pollution controls; (5) computers in industry and in space; (6) home appliances; (7) classroom learning aids; (8) light amplification devices; and (9) air traffic control advances.

The film won a Gold Camera Award at the U.S. Industrial Film Festival and a Blue Ribbon Award at the American Film Festival.

Threads of Technology is available for free showings from Raytheon Film Library, Bedford, Massachusetts 01730.

Manual

A new 252-page Electronics Experimenters Circuit Manual, ETRM-3960A, is now available from General Electric for hobbyists, students, engineers, and technicians.

The new publication contains 44 different, highly illustrated, easy-to-build electronic projects and has a list price of $2.

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An Experimental FM "Wireless" Record Player

This do-it-yourself project will provide a well-deserved sense of accomplishment, followed by many hours of rewarding listening to high-quality reproduction.

by Art Trauffer

An AM "wireless" record player, amplitude-modulated by a crystal or ceramic phono pickup, and reproduced through an AM superhet radio, cannot give you the best from modern hi-fi records because of the limitations of the phono pickup and the radio. On the other hand, an FM "wireless" record player, frequency-modulated by a crystal or ceramic phono pickup through a reactance stage to the oscillator, is again limited by the phono pickup.

This article describes the construction of an FM "wireless" record player which is directly frequency-modulated by a capacitance-type phono pickup. If the capacitance pickup is well designed, the quality of reproduction will be limited only by the records and the amplifier and speakers following the FM tuner.

As shown in the illustrations, a small low-power transistor oscillator, working in the 88-108 MHz FM band, is mounted on top of a wood tone arm. A capacitance-type phono pickup, consisting of a phono stylus having a small metal angle plate mounted beside it, is connected across the tank circuit (coil & capacitor circuit) of the oscillator. As the stylus rides in the record grooves, the capacity between the stylus and metal plate varies according to the wave forms in the record grooves, and the frequency of the oscillator is shifted by this varying capacitance. This is frequency modulation in its simplest and purest form, and the highest possible quality is within reach.

However, if you want a record player that you can put together in a hurry and sit back and enjoy your favorite discs, this project is not for you. This project is a challenge to the experimenter, and it will give you electronic engineer and mechanical engineer fellows a good chance to show what you can do. This is a fine project for Science Fairs, and electronics classes, to demonstrate the fundamental principles of FM.

Brief History: The capacitance-type phono pickup is an invention of Ben F. Miessner, of Miessner Inventions, Inc., Morristown, N. J. It was used in a phono system by RCA Victor in the late 1920s. In the 1950s Paul Weathers, of Weathers Industries, Barrington, N. J., produced a high-quality record player using a capacitance phono pickup to frequency-modulate an oscillator which was then detected and passed into the audio amplifier and speaker. The Weathers system was considered by some experts to be the finest record-playing system in the world, but, due to complications, it was given up when stereo records came in. Also in the 1950s, Motorola produced a radio & phono combination using a capacitance phono pickup to modulate the RF circuit in the receiver before detection, but this was also given up when stereo came in.

Constructional Details

Motor, Turntable, and Cabinet: As shown in figures 1 & 2, the writer used a common low-priced three-speed phono motor and turntable, but a high-quality motor and turntable is recommended for minimum rumble and "wow." The wood cabinet was put together with one-by twos and a ½" plywood top, and measures 12" by 10" by 2½". The

Figure 1

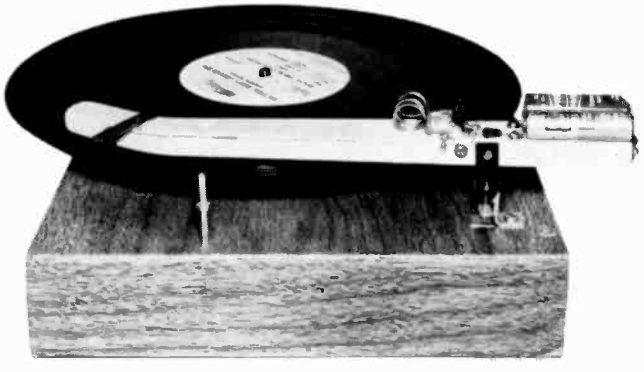


Figure 2

cabinet was covered with "Contact" adhesive plastic material.

Wood Tone Arm: Figure 3 is the plan for jigsawing the hardwood tone arm. Metal must not be used because the leads cemented along the sides from the pickup to the oscillator are not shielded. The writer used birch wood. Sand the arm smooth, and stain it to match the cabinet if desired.

Universal Joint for Wood Tone

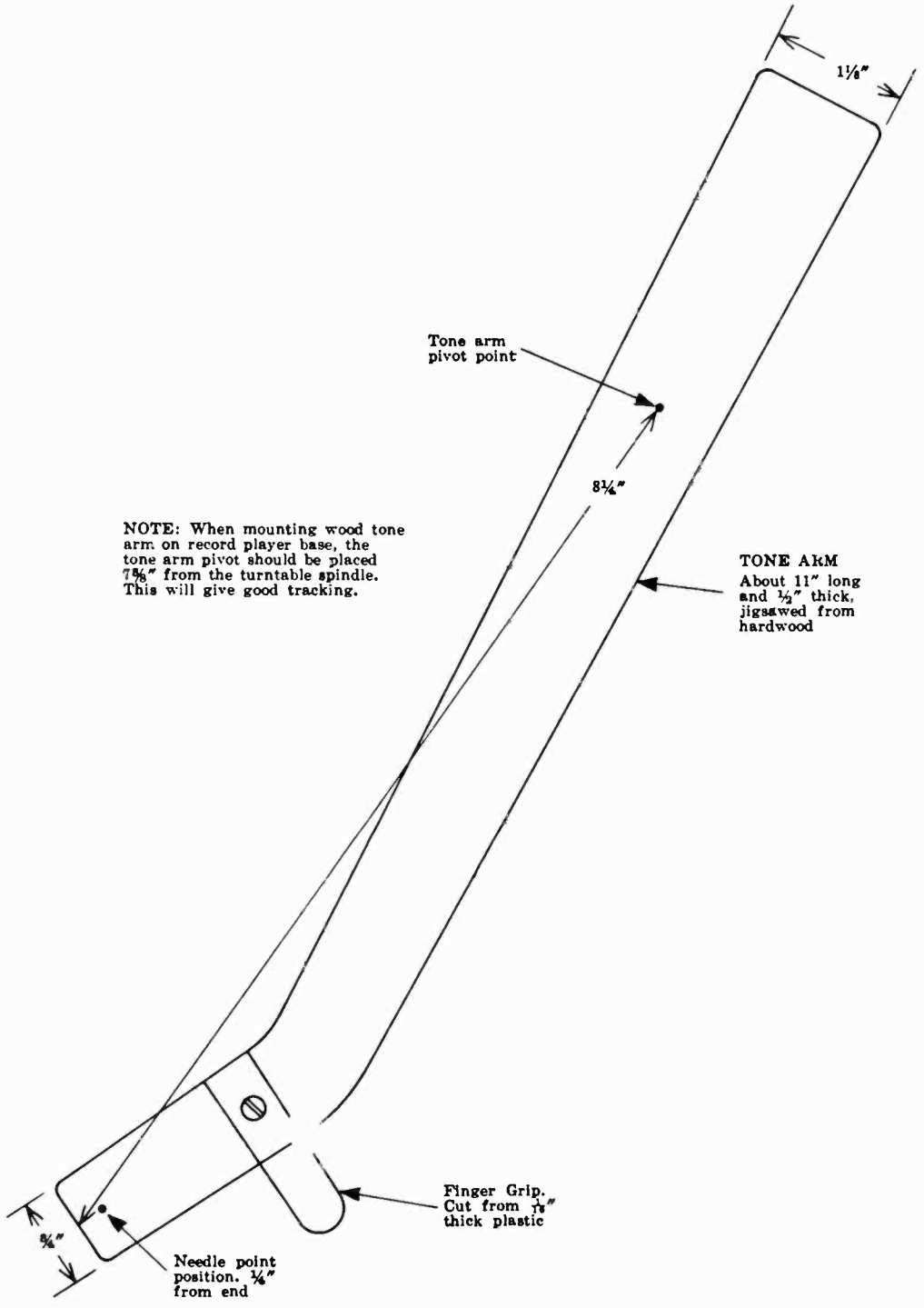


Figure 3
SIZE AND SHAPE OF HARDWOOD TONE ARM FOR CAPACITANCE PHONO PICKUP
(Copy this closely for good tracking)

Arm: Figures 4 and 5 give all details for making the brass universal joint for the tone arm. The main objective here is to strive for low friction, giving the arm very free lateral and vertical movement, which is very important when using a capacitance-type phono pickup having a highly compliant stylus, especially when playing records that are warped or have off-center holes. Note that the two side strips connected to the tone arm are made from insulating material (not metal) — this prevents metal-to-metal contacts which are picked up by the oscillator and heard in the speaker.

Oscillator and Battery Clips: Figure 6 is the schematic diagram for the low-power high-frequency transistor oscillator, showing how the capacitance pickup is connected across the tuned circuit (tank) of the oscillator. Figure 7 shows how the oscillator parts are mounted and wired on top of the wood arm, and how the battery clips are mounted and wired to the oscillator. The variable-trimmer capacitor is mounted with two wood screws, and the ends of the coil are soldered into the lugs on the capacitor. All wire leads should be soldered, be short and direct, and as rigid as possible to reduce microphonic effects. Parts and wire leads can be cemented securely to the tone arm with Duco cement. The correct polarity for the two batteries should be marked on the wood arm so you don't forget. The writer doesn't use a battery on-off switch (the batteries are removed when finished playing) but there is room on the tone arm for two miniature SPST toggle switches.

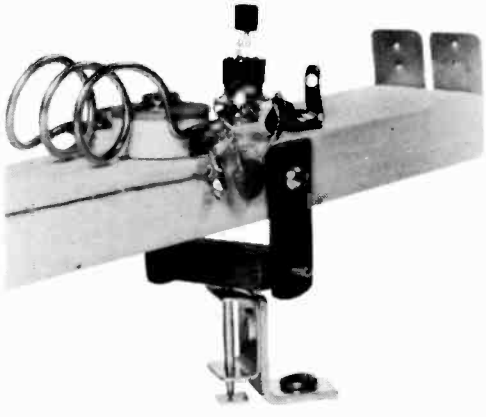


Figure 5

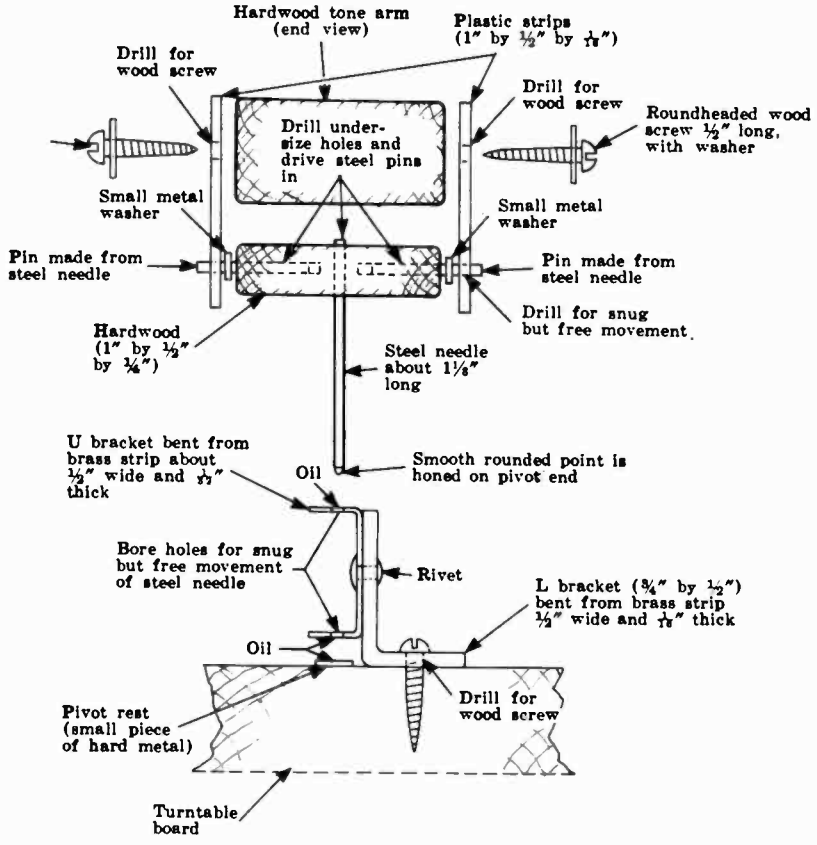
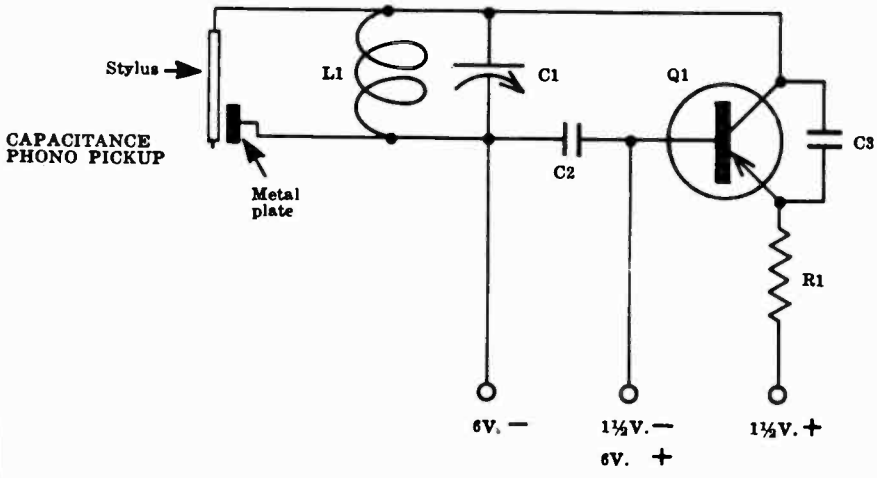


Figure 4
UNIVERSAL JOINT FOR WOOD TONE ARM
(Strive for free vertical and lateral movement of tone arm)



Capacitance phono pickup (see text).

L1 Oscillator coil (3-turns solid copper, #16, ½" dia).

C1 30 pF variable capacitor (Centralab trimmer capacitor, 4-30 pF Allied Radio Shack Cat. No. 748B7050).

C2 .001 mF disc capacitor (smallest size).

C3 7 pF disc capacitor (smallest size).

R1 500-ohm, ¼-watt, fixed resistor.

Q1 UHF pnp transistor (Motorola HEP 57, or equiv).

Figure 6
SCHEMATIC DIAGRAM FOR FM "WIRELESS" RECORD PLAYER

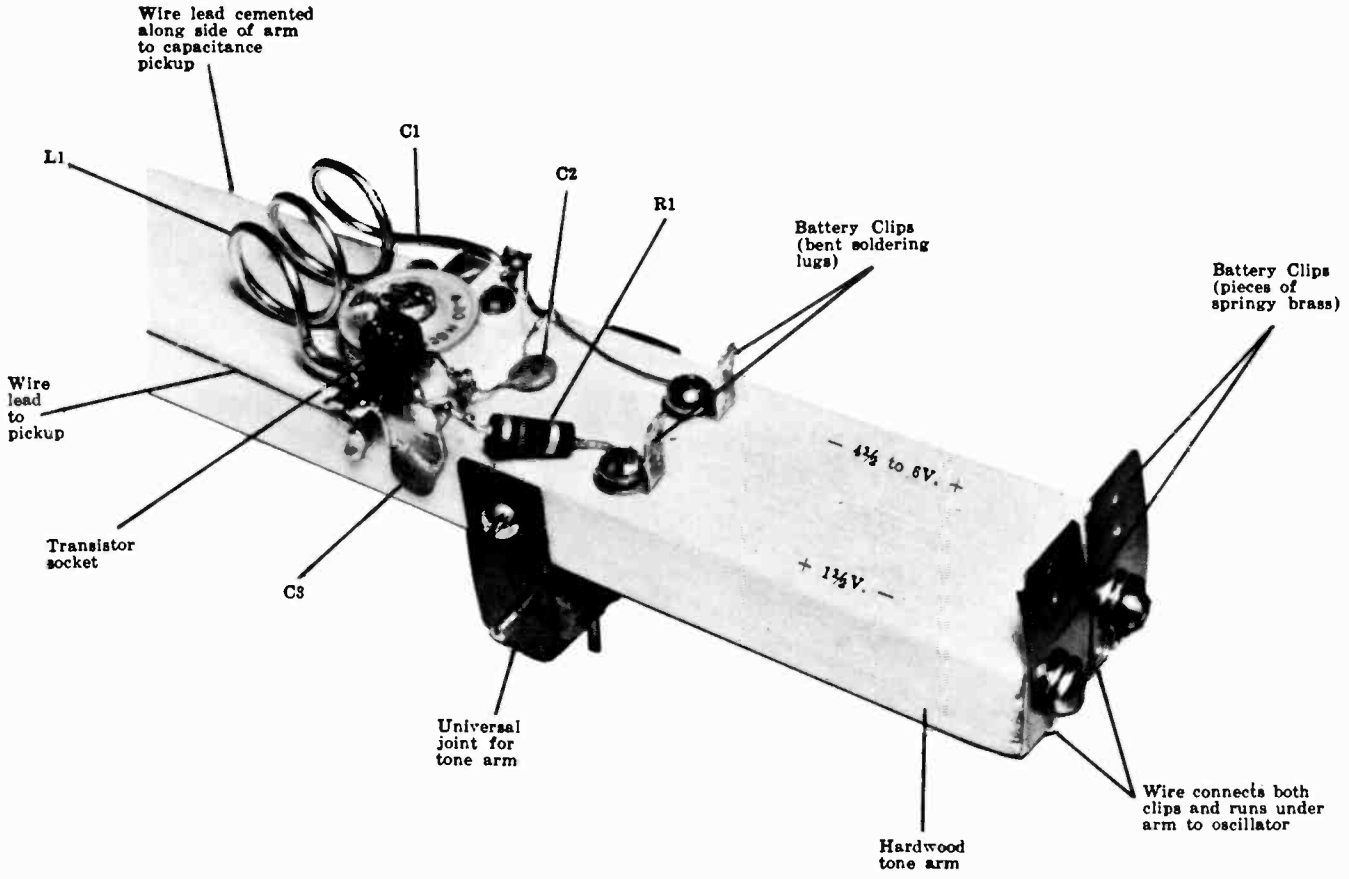


Figure 7
DETAILS OF OSCILLATOR, BATTERY CLIPS, AND UNIVERSAL JOINT FOR WOOD TONE ARM

The Capacitance Phono Pickup: Now we come to the most important part of the whole project. The quality of reproduction from a capacitance pickup depends on how well you design it. The stylus must have a very low mechanical resonance in the audio range. Stylus resonances that might not amount to much in a cheap crystal or ceramic cartridge, will stand out like a house on fire when used with a capacitance phono pickup.

The finest stylus ever used by the writer was made for the FM record player produced by Weathers Industries in the 1950s. This stylus had low mass, high compliance, and very low mechanical resonance in the audio range. Reproduction when using this stylus was beautiful. You may still be able to obtain one of these styluses from the Weathers Industries (if still in business), or from a well-stocked dealer selling replacement phono needles. Replacement styluses for the Weathers FM Record Player were also made by Jensen Industries, Forest Park, Illinois, and by Astatic Corporation, Conneaut, Ohio. If you can obtain a Weathers FM pickup stylus, mount it on the tone arm as shown in figures 8 and 9.

In the 1950s Motorola made a capacitance phono pickup cartridge for their Models 53F2 and 21F5 hi-fi radio & phono combinations. This cartridge number was 1C630821, and is shown in figure 10. If you can still get one of these cartridges from Motorola, or one of their replacement parts distributors, mount it as shown in figure 11. The cartridge is cemented in a slot sawed in the nose of the arm, and the wire leads are cemented to the two lugs in the rear of the cartridge, as shown. This Motorola capacitance cartridge has some stylus resonances and will not sound as good as the Weathers. It also has a .002" stylus tip for use with records of all three speeds, and this is not the best for playing LP microgroove discs.

A home-made capacitance phono pickup tried out by the writer is shown in figure 12. Needless to say, this is not the best way to do it, but it works well and costs practically nothing. If the stylus has low mechanical resonance, and if the trunnion bearing in the old cartridge has free movement, very good results can be obtained.

Another home-made capacitance phono pickup is shown in figures 13 and 14. Here, the top end of the stylus is seated in a plug punched out of a soft pencil eraser and pushed into a hole drilled in the nose of the tone arm, as shown. Fine results can be had with this simple pickup if the stylus has low mechanical resonance in the audio range.

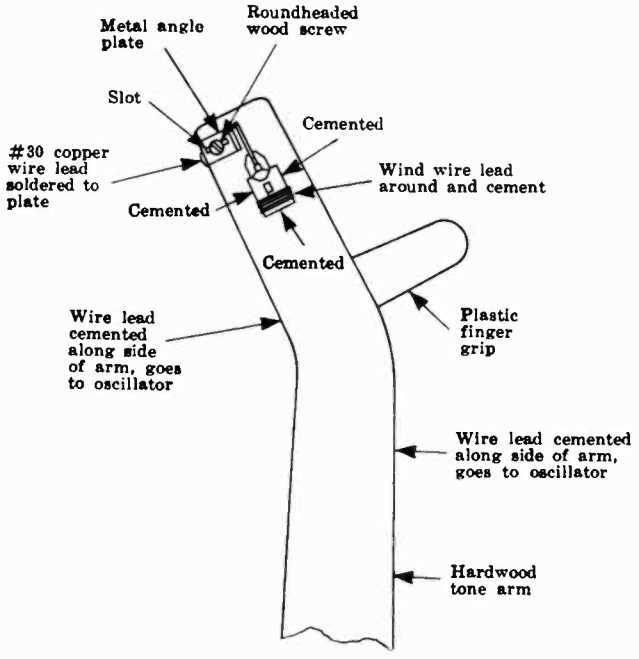


Figure 8
HOW THE WEATHERS INDUSTRIES CAPACITANCE PHONO PICKUP STYLUS IS MOUNTED ON ARM

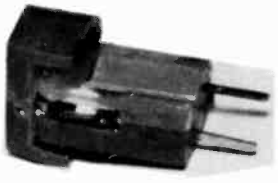


Figure 10

A Few Tips: When this capacitance pickup travels across the record towards the inner grooves, there will be some frequency drift of the oscillator due to the effect of the metal turntable on the pickup and its leads, but this shouldn't bother you if your FM tuner has AFC, or if your phono motor has a plastic turntable as some do.

As the pickup travels towards the inner grooves of the records you may notice a scratching noise in the speaker. This is due to the metal turntable center shaft turning in its socket (any metal-to-metal friction close to the pickup or oscillator will be transmitted to the FM receiver). The writer solved this problem by turning out a plastic turntable shaft on a lathe to replace the metal one.

All FM broadcast stations purposely boost the high musical frequencies (preemphasis), and all FM tuners contain a de-emphasis network to bring the frequency balance back to normal — this is done

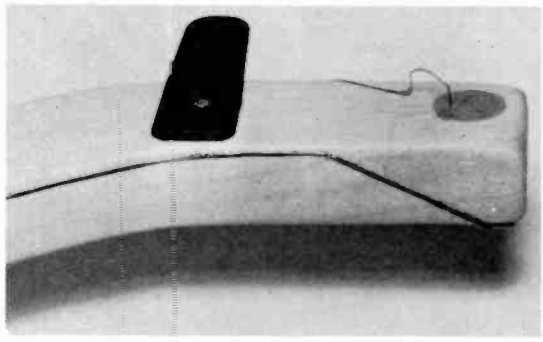


Figure 9

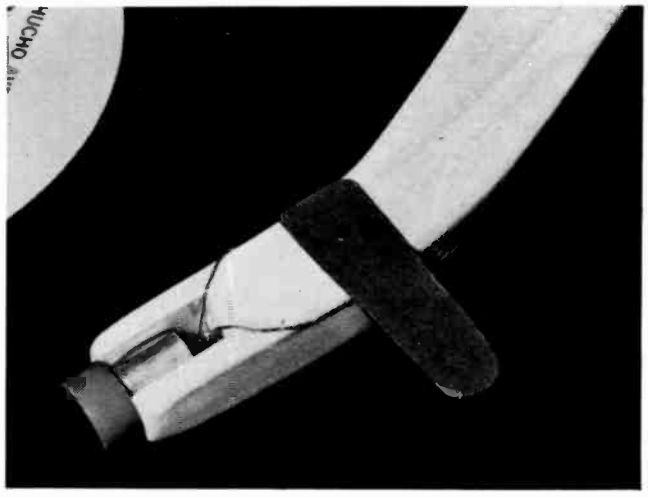
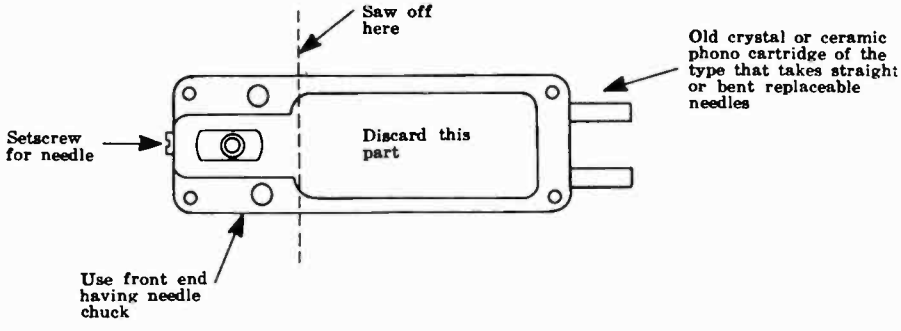


Figure 11



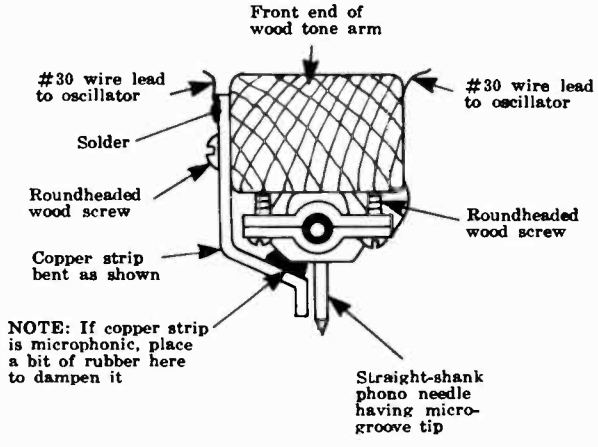


Figure 12
FRONT END OF DISCARDED CRYSTAL CARTRIDGE CAN BE USED TO HOLD NEEDLE FOR CAPACITANCE PHONO PICKUP

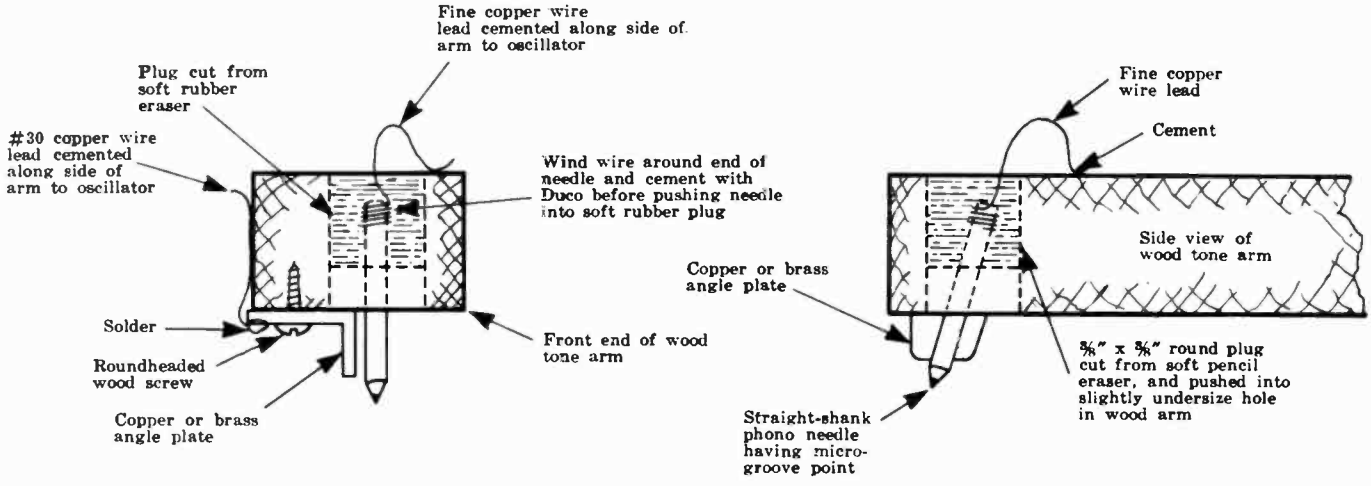


Figure 13
HOME-MADE CAPACITANCE PHONO PICKUP
(Hole in metal angle plate can be slotted to permit adjustable spacing between plate and phono needle.)

to reduce static and other high-frequency noises in the receiver. Since our FM record player has no high-frequency preemphasis, you can either disconnect the resistor and capacitor de-emphasis network in your FM tuner, or boost the highs in your audio amplifier.

Now that we have given you the main idea, put your electrical and mechanical engineering talents to work and produce one of the finest phono pickups ever conceived. Remember that the pickup stylus must have low mass, high compliance, and very low mechanical resonance in the audio range. Since the stylus has nothing to do but ride in the records grooves it will respond to a wider range of frequencies than anybody can put on a record!

To quote from a letter to the writer from the inventor of the capacitance phono pickup, Ben F. Miessner: *"The mass, and therefore the motional reactance of the needle, should be reduced to the lowest possible minimum consistent with stiffness and a very high natural vibration frequency. Obviously a tubular form, without such appendages as a needle chuck, a vibratory axis, or extra electrode section will accomplish this object and at the same time provide ample surface area for the capacitance pickup function. Duraluminum or magnesium is the best material. The jewel tip may be cemented into one end of this tubular needle with shellac or other thermoplastic material. This is a fascinating and fertile field for experimentation with rich rewards in very closely approaching, if not actually realizing, the dream of perfect fidelity of reproduction. Dynamically, the response of such a pickup is absolutely linear through much wider ranges of vibration amplitude than are encountered in phonograph recordings. The frequency response curve cannot be other than linear down to zero cps because this is an amplitude- and not a velocity-type of device when used with an FM or AM capacitive translator."*

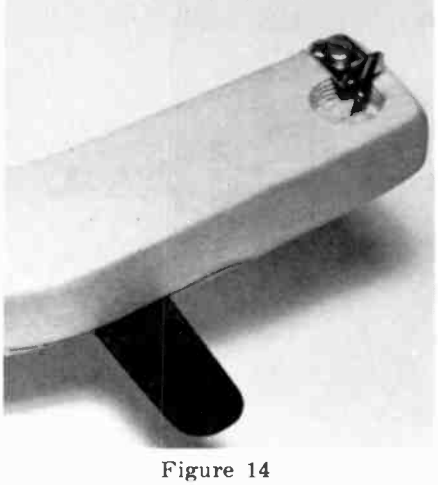


Figure 14

Materials List — FM "Wireless" Record Player

Oscillator:

1 foot #16 solid copper wire (for making L1).
(C1) small 30 pF variable trimmer capacitor (Centralab Trimmer Capacitor, 4-30 pF, Allied Radio Shack Cat. No. 748B7050).
(C2) .001 mF, small size disc capacitor (Allied Radio Shack).
(C3) 7 pF, small size disc capacitor (Allied Radio Shack).
(R1) 500-ohm, ¼-watt, fixed resistor (Allied Radio Shack).
(Q1) UHF pnp transistor (Motorola HEP 57, or equiv).
Transistor socket for above transistor.
One 4¼-volt transistor battery (Eveready No. 333).
One size AA 1½-volt flashlight battery (Allied Radio Shack).
2 long soldering lugs (for battery clips).
2" length ½" by 3/32" springy brass (for battery clips).
6 roundheaded wood screws ½" long, and 4 washers to fit.
Two-foot length #30 bare copper wire (for pickup-to-oscillator leads).

Capacitance Phono Pickup: (see text).

1 piece hardwood 12" by 3" by ½" (for jigsawing tone arm).

Universal Joint for Tone Arm:

1 piece brass band 1½" long, ½" wide, 1/16" thick (for L bracket).
1 piece brass band 1½" long, ½" wide, 1/32" thick (for U bracket).
1 rivet, and 1 roundheaded wood screw (for L-U bracket).
1 piece insulating material (plastic) 2½" long, ½" wide, 1/16" thick, (for making tone arm side brackets).
1 small piece hardwood 1½" by ½" by ¼" (for making block to hold pivots).
Few steel darning needles of various sizes (for universal joint pivots).
2 roundheaded wood screws ½" long with washers to fit (for holding plastic brackets to wood tone arm).
1 piece plastic about 1/16" thick (for making finger grip for tone arm).

Baseboard for Motor and Turntable:

4-foot length hardwood 2" wide, ¾" thick (for making sides of box).
1 piece plywood 10" by 12" by ½" (top of wood box).

Phono Motor and Turntable: (see text).

A Programmed Lesson on AM Radio Fundamentals

Learn the basics of AM radio in this self-teaching lesson. Modulation, detection, heterodyning, and basic AM diagrams will be discussed, along with other fundamentals.

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

Today we rely on radio and television for news, music, and entertainment in our everyday living. Communication via radio signals is also used in many other activities wherein man needs to coordinate his actions. These activities include, for example, industrial monitoring known as telemetry, police and fire protection, air and sea navigation, as well as sophisticated deep-space probes.

The basic elements for modern radio communication and broadcasting are shown in figure 1. Radio waves generated by the transmitter are controlled by the information to be transmitted via a key, microphone, or TV camera. These signals are then radiated into space by the transmitter antenna and intercepted by the receiver antenna shown in the diagram. At the receiver, selection and amplification take place so that the desired signals can be detected. After detection, the loudspeaker or picture tube reproduces the original information.

In this lesson, AM radio fundamentals will be discussed. Programmed lessons in future issues will include the basics of FM and digital communication techniques. Start by reading frame 1 and answering the questions at the end of the frame. Go to the frame indicated by your answer. Then continue through the lesson as directed in each frame.

Terms and Symbols Used in This Lesson

AM	— amplitude modulation
E_c	— peak voltage amplitude of modulating signal
E_s	— peak voltage amplitude of carrier signal
F_c	— carrier frequency
F_1	— lowest frequency in the audio spectrum
F_h	— highest frequency in the audio spectrum
F_m	— modulation or information frequency
i-f (I-F)	— intermediate frequency
r-f (R-F)	— radio frequency
m	— modulation index
P_c	— power level of the carrier frequency
P_t	— total AM power
v(t), i(t)	— voltage and current variations with time

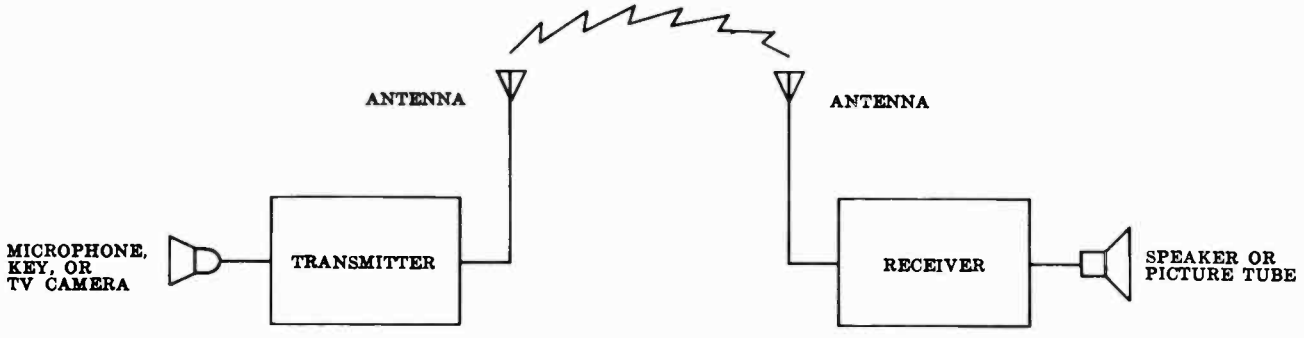


Figure 1
ELEMENTS OF A COMMUNICATION SYSTEM USING RADIO WAVES

1 The process of controlling radio waves for the purpose of transmitting a message is called modulation. Modulation is accomplished by controlling either the (1) amplitude, (2) frequency, or (3) phase of the radio wave known as the carrier. When the carrier is varied in correspondence with the strength of the audio (sound) signal, the radio wave is said to be amplitude-modulated. Hence the term "AM." Figure 2 shows typical signals for a simple sine wave, amplitude-modulating a higher radio frequency (r-f) signal. Of course, voice and other sound signals are much more complex than the sine wave, but this figure illustrates the basic amplitude-modulating process.

For an AM radio signal, the amount of change in amplitude as compared to the original unmodulated carrier amplitude is given by the term "modulation factor (m)." The modulation factor can be computed as $m = \frac{E_s}{E_c}$, where E_s represents the amplitude of the modulating signal and E_c, the amplitude of the carrier.

QUESTION: For the AM signal shown in figure 2, what is the modulation factor?

0.5 . . . go to frame 5

0.33 . . . go to frame 9

1.5 . . . go to frame 12

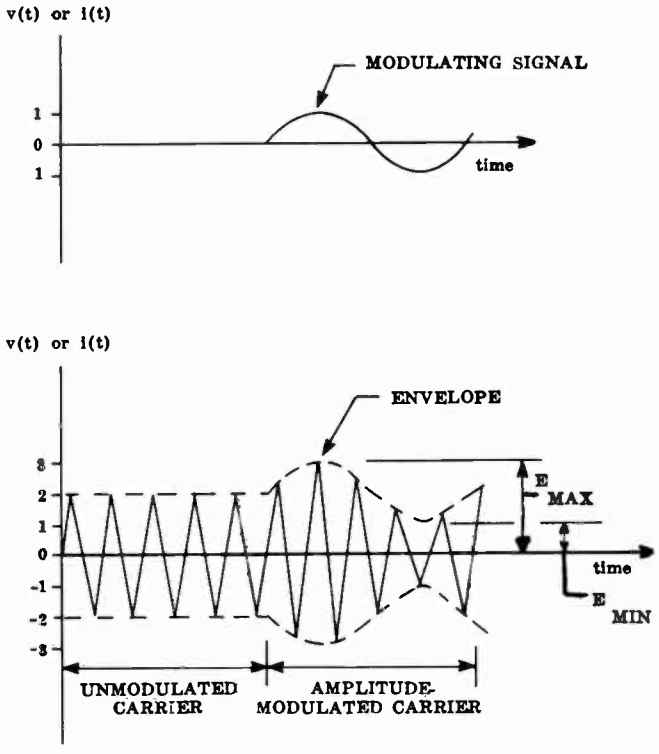


Figure 2
AM WAVEFORM

2 Your answer is incorrect. Note that the audio signal is 400 Hz, not 400 KHz. Return to frame 5 and choose another answer.

3 Your answer is incorrect. The r-f carrier does not need to be known in order to determine the AM bandwidth. The highest modulating frequency will determine the bandwidth, since its resulting upper and lower sideband components will be located furthest from the carrier. In general, the AM spectrum can be visualized as shown in figure 4. Note from this figure that the bandwidth equals twice the highest modulating frequency, independent of the r-f carrier. Return to frame 10 and choose another answer.

4 Your answer is incorrect. The function of the tuned circuits is to select the desired signal or radio station while excluding all others. Hence, the tuned circuits determine the receiver's selectivity — not its sensitivity. Return to frame 8 and choose another answer.

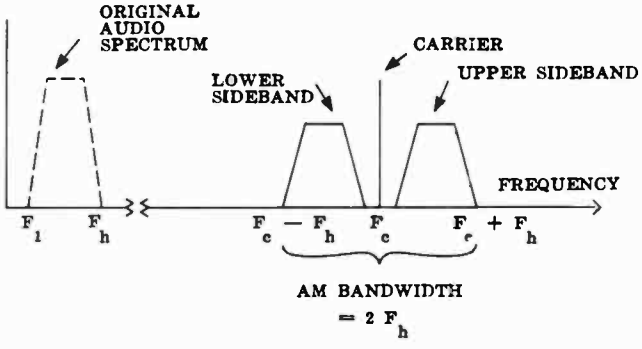


Figure 4
FREQUENCY SPECTRUM SHOWING AM BANDWIDTH REQUIRED TO TRANSMIT A TYPICAL AUDIO SPECTRUM

5 Your answer is correct. Many types of circuits are available to amplitude-modulate a carrier. Generally, the process consists of feeding the carrier and audio signals to a nonlinear device called the modulator. In actual practice, a tube, semiconductor diode, or transistor is used as a modulator when operated in the nonlinear portion of its operating characteristics. Because of this nonlinearity, the output signal contains many frequency components other than carrier and audio frequencies. Harmonics of each of these frequencies and components at the sum and difference frequencies appear. Filtering is necessary so that the final AM signal contains only three components: (1) the carrier frequency (F_c), (2) the upper sideband frequency equal to the sum of the carrier and modulating frequencies ($F_c + F_m$) and (3) the lower sideband frequency equal to the carrier frequency minus the modulating frequency ($F_c - F_m$).

QUESTION: A carrier frequency of 1360 KHz is amplitude-modulated by a pure 400 Hz audio signal. What frequency components exist in the AM signal?

960 KHz, 1360 KHz, 1760 KHz . . . go to frame 2

1359.6 KHz, 1360 KHz, 1360.4 KHz . . . go to frame 10

400 Hz, 1360 KHz, 1359.6 KHz, 1360.4 KHz . . . go to frame 16

6 Your answer is incorrect. The sideband frequencies produced range from $F_c \pm 50$ Hz to $F_c \pm 5$ KHz. Therefore, the bandwidth requirement is twice the frequency of the highest modulating frequency. Return to frame 10 and choose the correct answer.

7 Your answer is incorrect. The mixing action is nonlinear and similar to the modulator in the transmitter, but uses a filter to attenuate all but the difference frequency. Return to frame 21 and choose the difference frequency.

8 Your answer is correct. Regardless of type of signal or modulation, modern radio receivers perform the functions illustrated in figure 6. First of all, the antenna intercepts the passing radio signals. Next, the tuned circuits select the desired signal from the many radio signals received by the antenna. Then the usually weak signal is amplified by the r-f amplifier. By the process known as demodulation, the modulating signal is separated or detected from the modulated r-f carrier. Finally, the resulting audio signal is amplified for reproduction by the loudspeaker as shown in the figure.

QUESTION: What section of the receiver is primarily responsible for the receiver's sensitivity?

Tuned circuits . . . go to frame 4

R-F amplifier . . . go to frame 14

Detector . . . . . go to frame 19

Audio amplifier . . go to frame 23

9 Your answer is incorrect. The amplitude of the modulating signal is divided by the amplitude of the unmodulated carrier to find m. Either peak amplitudes or peak-to-peak amplitudes can be compared for sinusoidal signals. Return to frame 1 and choose another answer.

10 Your answer is correct. Figure 3 shows the "frequency spectrum" for the AM signal of the previous question. Notice that amplitudes of the upper and low sidebands are related to the carrier by the factor $\frac{m}{2}$. For 100-percent modulation, each sideband has one-half the carrier amplitude.

Most signals such as voice, music, and picture details are complex waves containing many frequencies. Each frequency component produces its own sidebands when mixing with the carrier. Consequently, for typical AM radio signals, a whole band of frequencies exists on either side of the carrier. This band of frequencies, including the carrier, is called the AM bandwidth and is measured in hertz (Hz).

QUESTION: An r-f carrier is amplitude-modulated by music signals with a frequency span of 50-5000 Hz. What bandwidth is necessary to transmit the resulting AM signals?

10 KHz . . . go to frame 17

100 Hz . . . go to frame 6

Cannot be determined unless

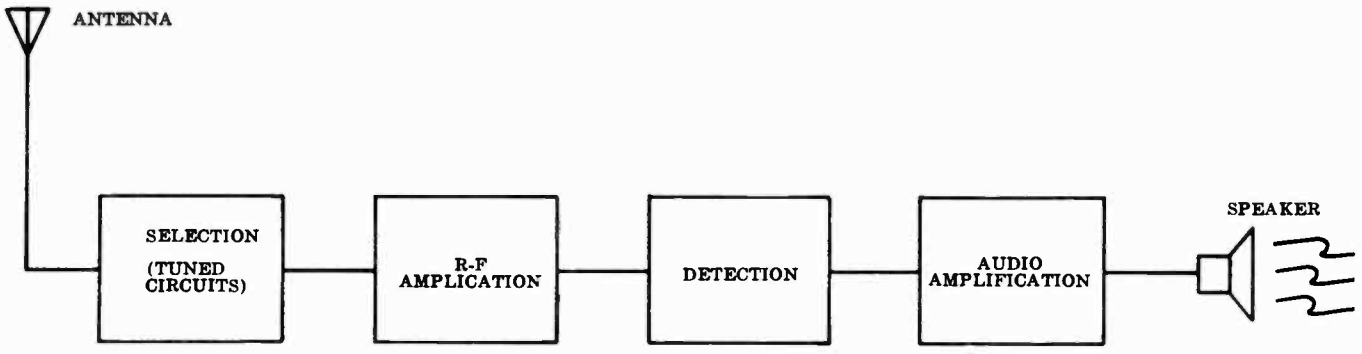


Figure 6
BASIC FUNCTIONS FOR
RADIO RECEPTION

carrier frequency is known
. . . go to frame 3

11 Your answer is incorrect. If the RC time constant is long with respect to the period of the audio signal, both i-f and audio frequencies would be shunted to ground. Therefore, the capacitor is chosen so as to respond to envelope variations, but does not allow the circuit to follow the i-f variations. Return to frame 22 and choose another answer.

12 Your answer is incorrect. The modulation factor will always be less than or equal to 1 in order to retain an undistorted envelope. Divide the amplitude of the modulating signal by the amplitude of the unmodulated carrier to find m. An alternate formula for finding m is:

$$m = \frac{E_{max} - E_{min}}{E_{max} + E_{min}}.$$

Recalculate m, using the alternate expression as a check and choose another answer to frame 1.

13 Your answer is incorrect. Did you forget to square the modulation factor when finding the sideband power? A 10-percent modulation level is equivalent to a modulation factor (m) of 0.1. In the expression for sideband power $(\frac{m^2}{2} P_c)$, the factor m^2 equals 0.01. Recheck your decimal point and choose another answer to frame 17.

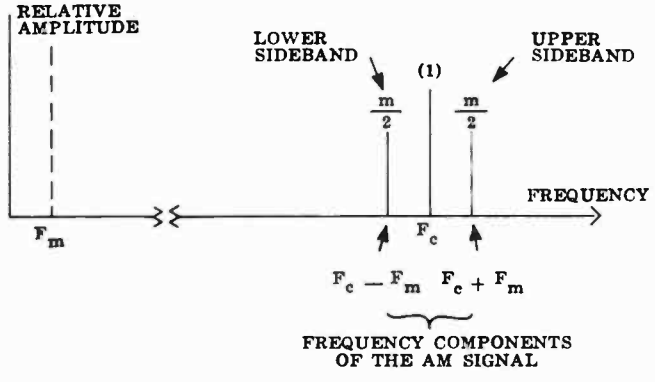


Figure 3
AM SPECTRUM FOR FRAME 10

14 Your answer is correct. Sensitivity is a function of the amount of amplification used in the receiver. The amplification can occur before demodulation in the r-f amplifier or after demodulation in the audio amplifier. Generally, receivers are designed with similar audio amplification so that a receiver's sensitivity rating is mainly dependent on the r-f amplifier. Standard broadcast receivers (540 KHz-1600 KHz), have a sensitivity of about 50 μv (microvolts). Commercial communication receivers may have a sensitivity below 1 μv. Go to frame 21.

15 Go to frame 26.

16 Your answer is incorrect. Only three frequency components exist for this AM signal. They are the carrier frequency and the upper and lower sidebands as discussed in frame 5. Return to frame 5 and choose another answer.

17 Your answer is correct. A block diagram for a standard AM broadcast transmitter is shown in figure 5. This is a simplified version with only the essential blocks shown. The oscillator is the source of the radio waves, since it generates the r-f carrier. Both the r-f carrier and audio signals are amplified and then combined in the modulator to produce the AM signals. These signals are amplified again before being radiated into space via the transmitter antenna.

As the carrier frequency is modulated, the power levels of the sideband frequencies increase with the degree of modulation. The carrier itself is unaffected so that there is no change in the carrier power level. Expressed mathematically, total carrier and sideband power is

$$P_t = P_c + \frac{m^2}{2} P = P \left(1 + \frac{m^2}{2}\right).$$

In this expression, P_t is used to represent the total AM power and P_c, the carrier power level.

QUESTION: A 20-Kw r-f carrier is modulated to a level of 10 percent. How much sideband power is required?

100 watts . . . go to frame 8

120 watts . . . go to frame 24

1 Kw . . . . . go to frame 13

18 Your answer is correct. The difference frequency is still an AM radio signal with modulation, but shifted down to a lower frequency. Because it lies between the original carrier and audio frequencies, it is called the intermediate frequency (i-f). Since no tuning is required in the i-f section, it is designed for maximum amplification with high selectivity. The i-f frequency normally used in broadcast receivers is 455 KHz.

QUESTION: AM transmitters use a bandwidth of 10 KHz centered about the r-f carrier. What bandwidth is required in the receiver i-f section so that no distortion occurs?

The i-f bandwidth is a function of the r-f carrier frequency
. . . go to frame 26

Much less than 10 KHz
. . . go to frame 15

10 KHz . . . . . go to frame 22

19 Your answer is incorrect. The primary purpose of the detector is to separate the audio component from the r-f component. Generally, receiver sensitivity is limited by other sections of the receiver. Return to frame 8 and choose another answer.

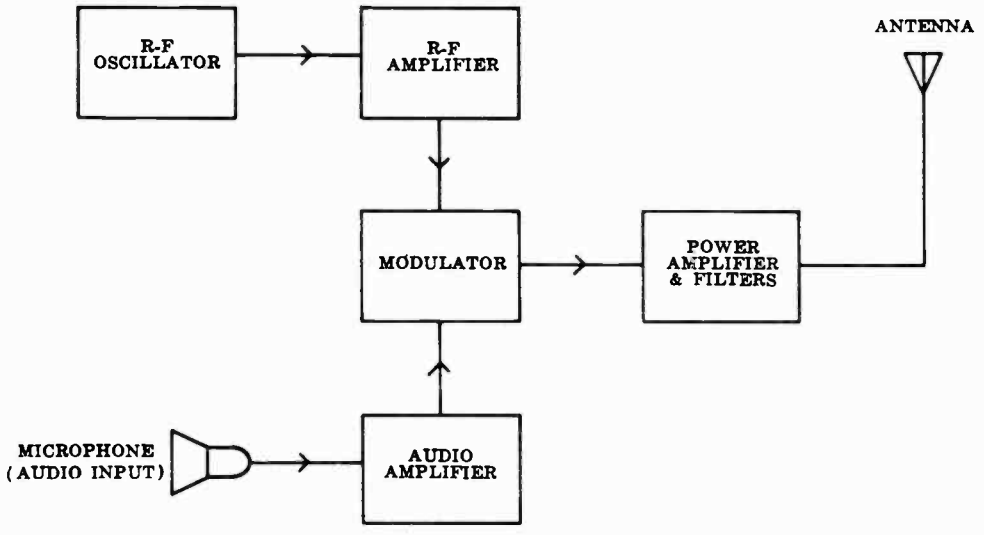


Figure 5
STANDARD BROADCAST TRANSMITTER

20 Your answer is incorrect. The primary purpose of the detector is to separate the audio component from the r-f component. Generally, receiver sensitivity is limited by other sections of the receiver. Return to frame 8 and choose another answer.

21 The earliest type of AM receiver was the crystal radio now considered a toy. Later, the tuned radio-frequency (trf) receiver achieved more gain and better selectivity by using several tuned LC tank circuits.

Let's now discuss the operating principles of the most widely used AM receiver called the superheterodyne receiver. This type of receiver is used in just about all standard AM radios today. It offers better selectivity, sensitivity, and stability than the trf receiver. A block diagram of the basic superheterodyne receiver is shown in figure 7. The first block is an r-f amplifier capable of being tuned over the entire broadcast band. The key to the superheterodyne action occurs in the mixer and local oscillator blocks. The output of the mixer is the difference frequency between the r-f signal and the oscillator frequency. This is possible because the oscillator frequency is variable but always a fixed amount higher than the resonant frequency of the r-f stage. Since nonlinear mixing occurs in the mixer similar to a modulator, filtering is required to suppress unwanted frequencies. The frequency conversion process is also known as frequency translation or heterodyning.

QUESTION: A modulated carrier of 945 KHz is fed to a mixer together with an oscillator frequency of 1400 KHz. What frequency or frequencies exist at the output of the mixer stage?

455 KHz . . . . . go to frame 18

455 KHz and 2345 KHz . . . go to frame 25

455 KHz, 945 KHz, and 2345 KHz . . . go to frame 7

22 Your answer is correct. The detector stage receives the output of the i-f amplifier, removes the i-f signal, and leaves only the audio signal. One common type of detector, known as an envelope detector, consists of a half-wave diode rectifier followed by an RC filter as shown in figure 8. The i-f signal is rectified by the diode and then filtered by the RC circuit so that only the audio signal results. Typical signals showing the detection process are also included in this figure. After detection, the audio signal is stepped up by the audio amplifier whose output drives the speaker.

The resistor in the envelope detector actually represents the equivalent input resistance of the audio amplifier, but must be considered in filtering action. The RC product has dimensions of time and is known as a time constant. Signals with a shorter period

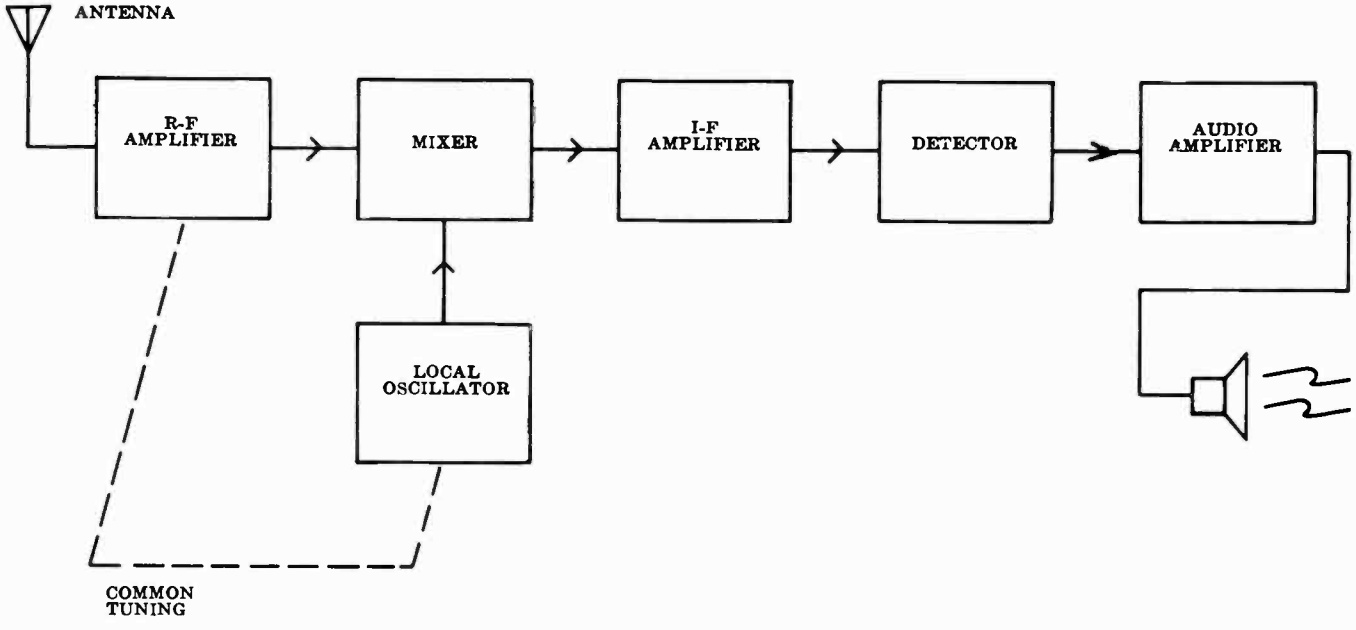


Figure 7
BLOCK DIAGRAM FOR THE SUPERHETERODYNE RECEIVER

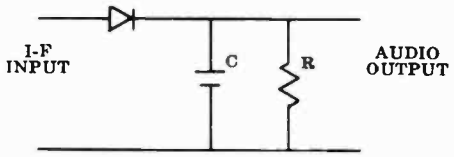
than the time constant are shunted to ground. Signals with a longer period pass through. (Remember, the period of a signal measured in time is equal to the inverse of its frequency.)

QUESTION: The RC time constant associated with the detector should have which of the following characteristics?

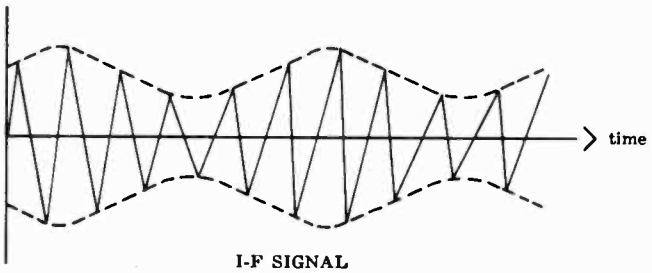
Should have a long time constant with respect to the period of the audio frequency
. . . go to frame 11

Should have a short time constant with respect to the period of the i-f frequency
. . . go to frame 20

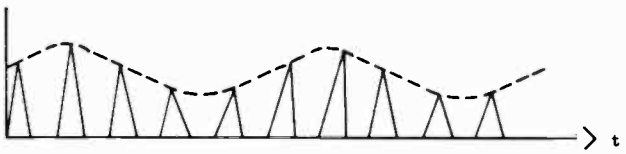
Should have a time constant intermediate between the period of the i-f frequency and the audio frequency . . . go to frame 27



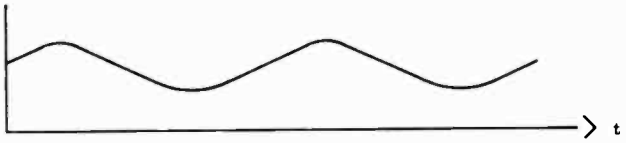
ENVELOPE DETECTOR



I-F SIGNAL



RECTIFIED I-F SIGNAL



AUDIO SIGNAL

Figure 8
ENVELOPE DETECTION PROCESS

23 Go to frame 14.

24 Your answer is incorrect. The power level in both sidebands is equal to $\frac{m^2}{2}P_c$. A modulation factor (m) of 0.1 is equivalent to the 10-percent modulation level. Recalculate the sideband power using the above expression and choose another answer to frame 17.

25 The frequency conversion process produces both the sum and difference frequencies as indicated by your answer. Actually, many other frequencies including harmonics of the sum and difference frequencies are produced by the nonlinear action of the mixer. Filtering occurs in the mixer, however, so that its primary output is the difference frequency. Return to frame 21 and choose the difference frequency.

26 Your answer is incorrect. During frequency conversion, the bandwidth associated with the r-f carrier is translated to the lower i-f region. Hence, the r-f and i-f bandwidths are the same. Return to frame 18 and choose the correct answer.

27 Your answer is correct. The RC circuit bypasses i-f frequencies to ground, while allowing audio signals to pass to the audio amplifier.

This completes our discussion of the superheterodyne receiver and introduction to AM radio. From an understanding of the basic theory presented in this lesson, you are now better prepared to understand the variations and refinements described in texts on this subject. In our next lesson, principles of FM communications will be presented and compared with the basic AM fundamentals from this lesson.

SECURITY

Australian Information Service

The general manager of Associated Controls Pty. Ltd., Mr. H. J. Stidston, adjusts the antenna of a radar scanner.

Radar alarm traps burglars

An Australian-made burglar alarm, sensitive enough to register the scampering of a mouse has been installed in more than 1000 warehouses, offices and banks in Australia and in six other countries — Britain, Sweden, Holland, Italy, South Africa and New Zealand.

Called a radar scanner, the system's electronic field can pick up movement which alters the pattern of microwaves over 5000 square feet.

This triggers a silent signal to a central security office. It can be adjusted also to sound bells and switch on lights.

The scanner sends out its invisible beams in every direction. The intruder is trapped whether he comes in through a skylight, through a door or wall or even through the floor.

Once the alarm is raised it will continue as long as movement continues and one minute afterwards. If the intruder moves after the alarm stops, it will operate again.

If a mouse runs near the antenna, or a small object falls off a shelf, a short signal is sent, but the device can be adjusted so that this slight movement does not trigger the alarm.

The makers of the scanner, Associated Controls Pty. Ltd., of New South Wales, claim that it is superior to similar radar detection systems because it can be adjusted to prevent the possibility of false alarms.

If a burglar cut the electricity a fail safe device would ensure that the scanner did its work with batteries.

Associated Controls Pty. Ltd., are at 14 Enterprise Avenue, Padstow, New South Wales, 2211, Australia.

NEW PRODUCT

Allied Radio Shack's "Stereo-4"

Allied Radio Shack has announced plans to market four-channel high-fidelity equipment under the "Stereo-4" name.

In a telegram to major manufacturers of records and tapes, Lewis F. Kornfeld, Jr., the company's president, disclosed that Allied Radio Shack will manufacture Stereo-4 components using the 4-channel system developed by Electro-Voice, Inc., a subsidiary of Gulton Industries. This will include receivers, amplifiers and an adapter which will make it possible for existing equipment to play back 4-channel sound.

Allied Radio Shack, a Tandy Corporation Company (NYSE), is the world's largest electronics chain.

NEW BOOKS

AEC publishes two new booklets

The AEC has published two new titles in its World of the Atom series for junior high school students, Atomic Energy and Your World, by Samuel Glasstone and S. Joe Thomas, describes the fundamentals of nuclear energy, radiation and their applications. *The Mystery of Matter*, by William G. Pollard, traces man's understanding of matter, energy and the atom. A complimentary copy of each is available from USAEC-Technical Information, P. O. Box 62, Oak Ridge, Tennessee, 37830.

America's Great Men in Electronics

Now available in a paperback edition is Volume One of *Great Men in Electronics* by William M. Palmer. It features seventeen biographies of some of America's most outstanding pioneers in electricity/electronics. *Great Men in Electronics* is highly recommended for the historian's library, and for teacher/student reference work.

The paperback edition of *Great Men in Electronics* is available at $2.00 postpaid. Orders should be mailed to: Special Orders Dept. 0055, Electronics Digest, P. O. Box 9108, Fort Worth, TX 76107.

DISCOVERY

Scientists solve light bulb mystery

Westinghouse Electric Corporation scientists have discovered that there are billions of bubbles in a light bulb filament that keep the white-hot bit of wire from sagging. If sagging occurs the glowing filament emits less light and the lamp has poor efficiency.

This new knowledge, the Westinghouse scientists say, may ultimately add to the quality of incandescent lamps.

The discovery ends a half-century search by lamp manufacturers to explain why modern processing of the metal prevents tungsten filaments from sagging as they did in early lamps. The processing, which involves the addition of small amounts of chemicals to the tungsten during refining, was learned by trial-and-error.

The bubbles are less than a millionth of an inch across and can be seen only with a powerful electron microscope. They contain the metal potassium in concentrations so low that lamp filaments are ordinarily considered to be pure tungsten.

Without bubbles, the tungsten wire is made up of many tiny tungsten crystals bound together. Sagging happens because at high temperature these crystals slide along their boundaries.

Present-day processing of a tungsten rod into wire causes bubbles to form in orderly rows along the wire, forcing the growth of a small number of very long tungsten crystals. The crystal boundaries are fewer and they interlock, so that the crystals cannot slide and cause sagging. The chemicals used to produce this effect in tungsten are oxides of silicon, aluminum and potassium.

The discovery was made jointly by scientists at the Westinghouse Research Laboratories, Pittsburgh, and the company's incandescent lamp division, Bloomfield, N. J. The research groups primarily responsible are headed by Dr. Roland Stickler, manager of physical metallurgy at the Research Laboratories, and Mr. Heinz G. Sell, manager of advanced metals research at the incandescent lamp division.

ELECTRONIC MONITOR

Electronic alarm monitors pressure-temperature

A new electronic alarm system takes the place of human supervision in recognizing, and warning of, excessively steep rises in temperature and sharp declines in oil pressure in the engine rooms of ships and industrial power plants.

The manufacturer is Technisch Bureau en Handelsonderneming Del Monte of The Hague, the Netherlands.

Sensitive feelers are installed at vital points in the machinery. Any failure is registered electronically on a control console and a red light comes on, accompanied simultaneously by a sound alarm. This alarm can be switched off, whereupon a green light goes out and a red general warning light appears.

The signals generated by the alarm installation can also be used for automatic operations such as the stopping of the engine if the oil pressure falls below an acceptable level, the starting of a pump if a sludge tank fills up, and so on.

The electronic circuits of the installation are printed circuits. If there is a failure in one of them, the entire print can be taken out and replaced. This can be done very quickly since use is made of multi-pin fittings.

On large ocean-going vessels and at shore installations, the signals are connected electronically by means of a ring manifold line to the signalling unit. For this purpose, a receiver installed in the unit selects the signals anew and transmits them to the respective indicating points on the control panel. This new method offers considerable savings on cabling and construction work as only one central ring line is required. The alarm installation can be powered by 24 or 110 volt d.c. current, or 110 a.c.

For further information, readers may write to the Netherlands Consulate General, Commercial Division, Dept. D-M, One Rockefeller Plaza, New York, N.Y. 10020.

What on earth would a man do with himself if something did not stand in his way?

—H. G. Wells

NEW TECHNOLOGY

Wire measured by laser

A paper presented at the Combined Nonferrous-Electrical Meeting of the Wire Association recently by V. J. Zaleckas of the Western Electric Company discussed the measurement of a moving wire's diameter with a laser.

In the paper, Mr. Zaleckas told of detection systems developed at Western Electric's Engineering Research Center in Princeton, N. J. that make it possible to accurately measure moving and vibrating wires without touching them in any way.

The new system of dynamic wire measurement is possible because of the clear, bright diffraction patterns formed by a laser's intense and coherent light. A sharp edge placed in the path of a laser beam will cause the light to bend around it. When the beam is broken by two edges of a wire, the bent or diffracted beams interfere and set up a regular, well defined pattern of fringes. By observing the location of the pattern intensity minima, the wire diameter can be determined.

ELECTRONICS HISTORY

History clips . . .

Guglielmo Marconi

April 25, 1874 • July 20, 1937

The famed Italian inventor, Guglielmo Marconi, died on July 20, 1937, at the age of 63, in Rome, Italy, and was buried in his native city of Bologna.

Marconi ushered in a new era in the history of mankind when, on December 12, 1901, his crude wireless apparatus atop Signal Hill in St. John's, Newfoundland, picked up the faint signal which had been sent from a transmitter at the little village of Poldhu in Cornwall, England. The signal had travelled through the air over an unheard of distance of nearly 2,000 miles.

Nikola Tesla

July 10, 1856 • January 1, 1943

This year marks the one hundred fifteenth anniversary of the birth of a man who is thought by many knowledgeable people to have been the world's greatest inventor, Nikola Tesla.

The fourth child in a family of five children, Tesla was born a few moments after midnight on July 10, 1856, in the tiny village of Smiljan in the province of Lika, Croatia (a part of modern-day Yugoslavia).

Among his brilliant discoveries was that of the principle of the rotating magnetic field in alternating current motors. This discovery paved the way for today's alternating current electricity which we use in our homes, businesses, industries, and government operations.

Vladimir Kosma Zworykin

Born July 30, 1889

Vladimir Zworykin was born in Mourom, Russia, on July 30, 1889. He came to America as an immigrant shortly after World War 1, and became an American citizen in 1924. The achievement of practical television stems to a large extent from the pioneering work of Dr. Zworykin, whose conception of the first practical radio tubes for picture transmission (television), the iconoscope and kinescope tubes, formed the basis for all important later advances in the field of television.

Lee de Forest

August 26, 1873 • June 30, 1961

Lee de Forest was born in Council Bluffs, Iowa, on August 26, 1873.

During his lifetime, de Forest was granted patents on more than 300 inventions, the best known of which was the Audion, a 3-element radio tube. It was the forerunner of the modern radio tube and it could perform as an amplifier, a detector of radio waves, or as a generator of radio frequency waves (carrier waves).

Alexander Graham Bell

March 3, 1847 • August 2, 1922

One of the world's most useful communication devices, the telephone, was born when Alexander Graham Bell received his first telephone patent on March 7, 1876.

Today, the telephone provides a vital link in government, business, and industrial operations, as well as a closer tie for families who use the instrument to "visit by phone" across the miles.

Alexander Graham Bell became an American citizen in 1882 — a fact of which he was very proud. At his request, the epitaph on his grave near Beinn Bhreagh reads: "Born in Edinburgh . . . died a citizen of the U. S. A."

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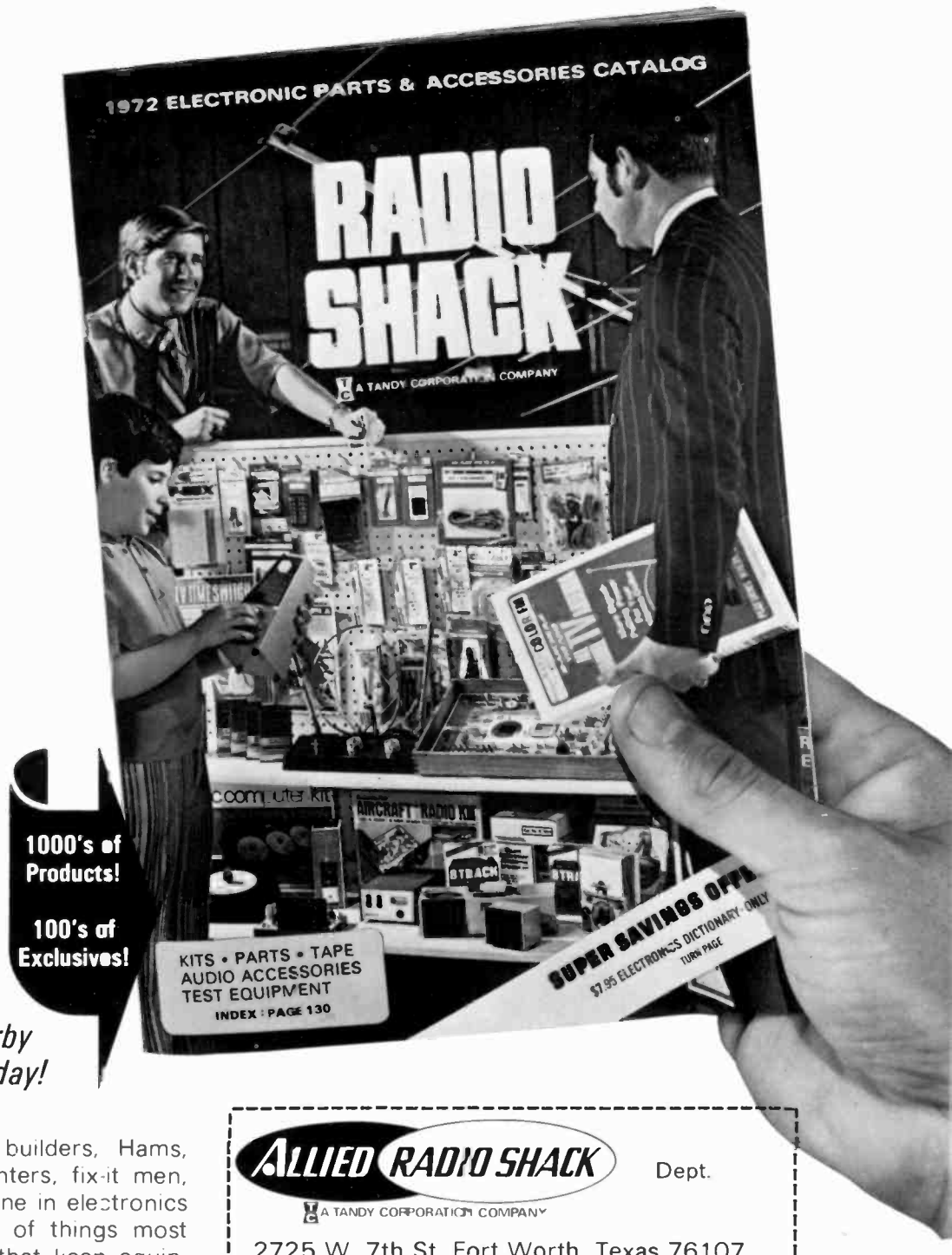

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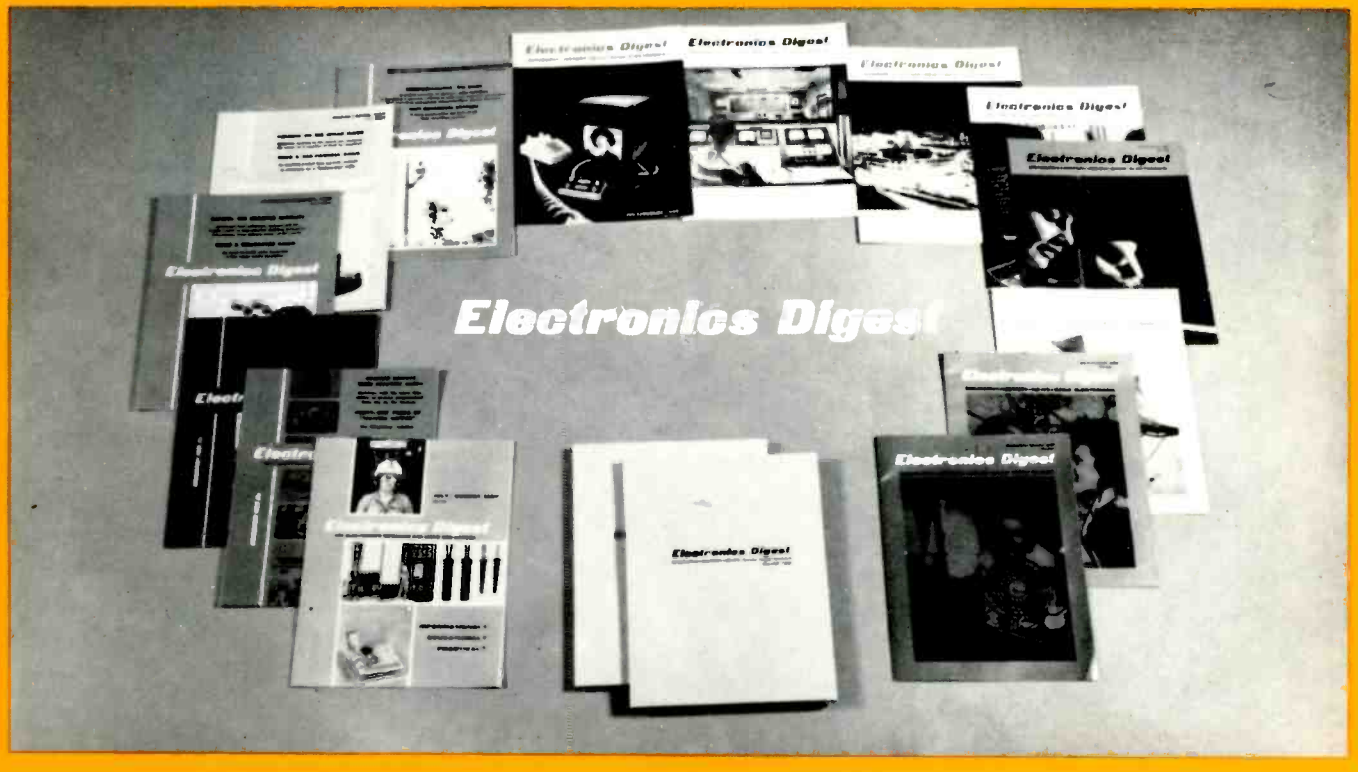

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