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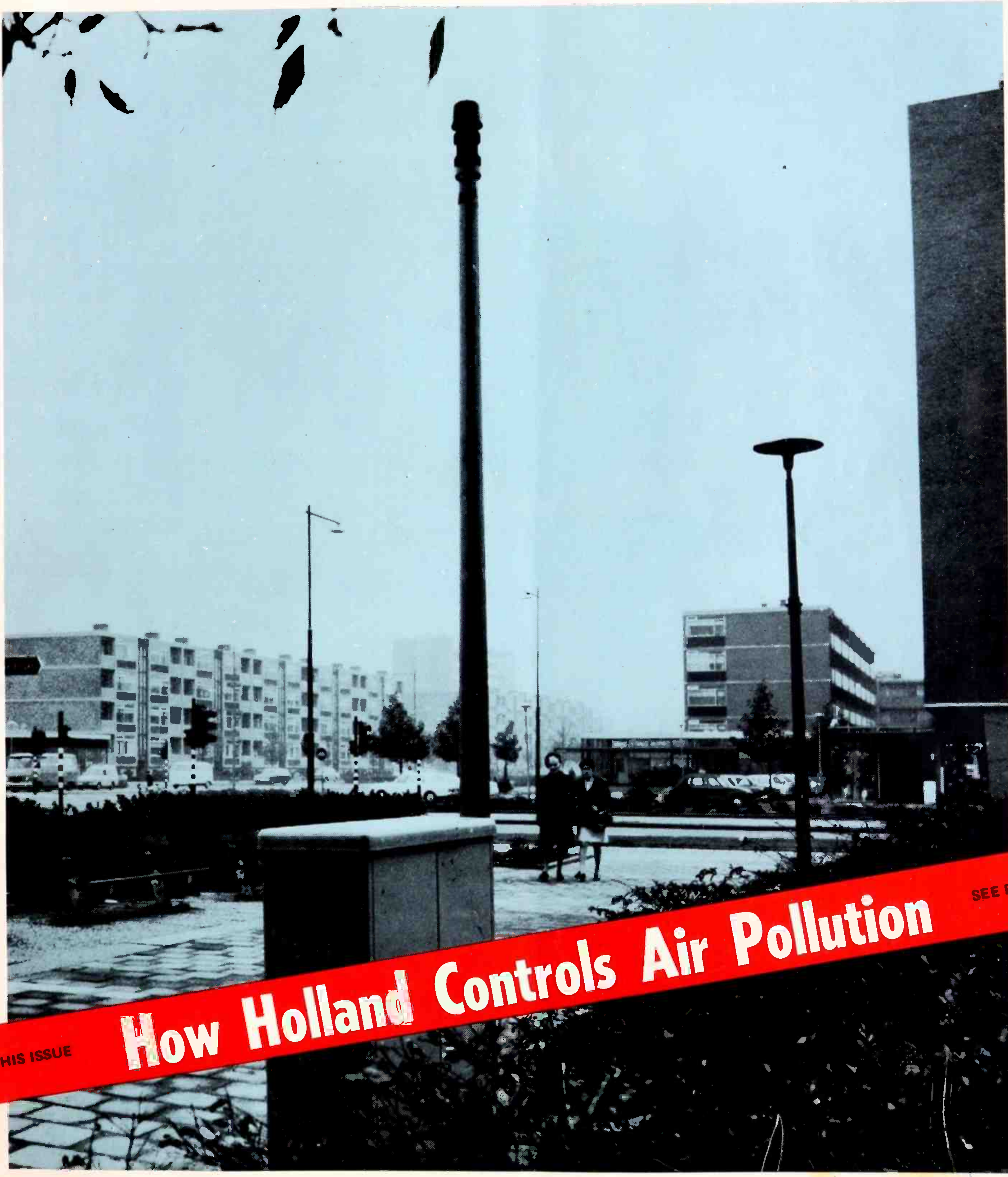

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# Electronics Digest

THE ELECTRONICS MAGAZINE FOR HOME AND SCHOOL

VOLUME FOUR / NUMBER SIX

May/June 1971

William M. Palmer, W5SFE
Editor

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# Look . . .

## For These Features In Our Next Issue

Electronics in Oceanology . . . Reporting the latest news in important areas of research which are paving the way for future development of our vast, resource-rich, ocean world.

Discovery of the first molecule in space to contain four chemical elements . . . made with the 140-foot radio telescope of the National Radio Astronomy Observatory at Green Bank, West Virginia.

Ambulatory heart patients recovering at home or in a hospital room remote from the hospital's monitoring center can be monitored for cardiac irregularities via miniature radio device.

Classroom training system for children with hearing losses that provides total sound uniformity throughout the room.

Computers will soon be introduced to a new role in electric power generating stations with the goal of extending the life of multibillion dollar steam generators, and prevention of electrical blackouts and brownouts.

Pictorial History of Electronics — photographs of West Virginia's outstanding collection of early day radio receivers, including a 1907 battery-powered model made by Signal Radio Company of Menominee, Michigan.

Old-Time Radio Project — Complete constructional details on the once famous "Gernsbach Interflex Receiver," including a replica of the old deForest D - 101 Dust Proof Crystal Detector. A great addition to the school or home museum.

You'll enjoy reading America's RELEVANT electronics magazine . . . Electronics Digest!

Photo Consulate General of The Netherlands

*Detector Mast in the Rijnmond region of Holland*

# New Motors Run on Power From Earth's Electric Field

## Dr. Oleg Jefimenko, brilliant physicist at West Virginia University, has developed an almost "wireless" motor which runs on energy drawn from the earth's electric field—a hitherto untapped source of energy

Special Science Report
*West Virginia University*

The world's first motors powered by the Earth's electric field have been developed by a West Virginia University physicist, Dr. Oleg Jefimenko.

"Our experiments have proved that the energy of the Earth's electric field can be converted into continuous mechanical motion," Dr. Jefimenko observed. "We also have demonstrated the unique properties of electrostatic motors.

"The consequences of this development are difficult to predict. The components of our motors and their design can undoubtedly be improved. Our motors were made by us here in the lab under far from ideal conditions. And we made no effort to design efficient Earth-field antennas."

If the technology can be developed to fully utilize Dr. Jefimenko's basic research, the Earth's electric field could become a source of energy that would help avert the power shortage facing the Western world.

"There is no question that the Earth's electric field can be used to generate power," Dr. Jefimenko explained. "The trouble is that, although very high voltages can be obtained from this field, only very small currents can be extracted from it by means of presently available techniques.

"Therefore, our main problem was to develop new motors that would run from relatively high voltages but that would consume only minute amounts of current," he said. "We solved the problem theoretically a long time ago; however, it took us some time to come up with practical designs."

On the night of September 29, 1970, Dr. Jefimenko and David K. Walker, a WVU graduate student in physics from Monroeville, Pa., took one of their new motors to a large, empty parking lot in front of WVU's Engineering Sciences Building for the final test. They also had an Earth-field antenna, which was simply a 24-foot wooden pole with a speck of radioactive material at one end and a wire attached to it.

Thus far the motor isn't very powerful (it produces less than a millionth of a horsepower), but it runs. (The Wright brothers' first airplane flight lasted 12 seconds and covered only 120 feet.)

This motor is of the electret electrostatic type and its design is extremely simple. The complete motor consists of a carnauba wax electret, several pieces of plastic and aluminum, two mica disks, two fine wires, an axle, and two jewel bearings.

The heart of the motor is the electret - - a body with a permanent positive charge at one end or one side and a negative charge on the other.

"At first glance the idea of using the Earth's electric field as a source of power looks like you are getting something for nothing - - but in a sense all natural resources are free," Dr. Jefimenko observed.

Thus far Dr. Jefimenko and Mr. Walker have been

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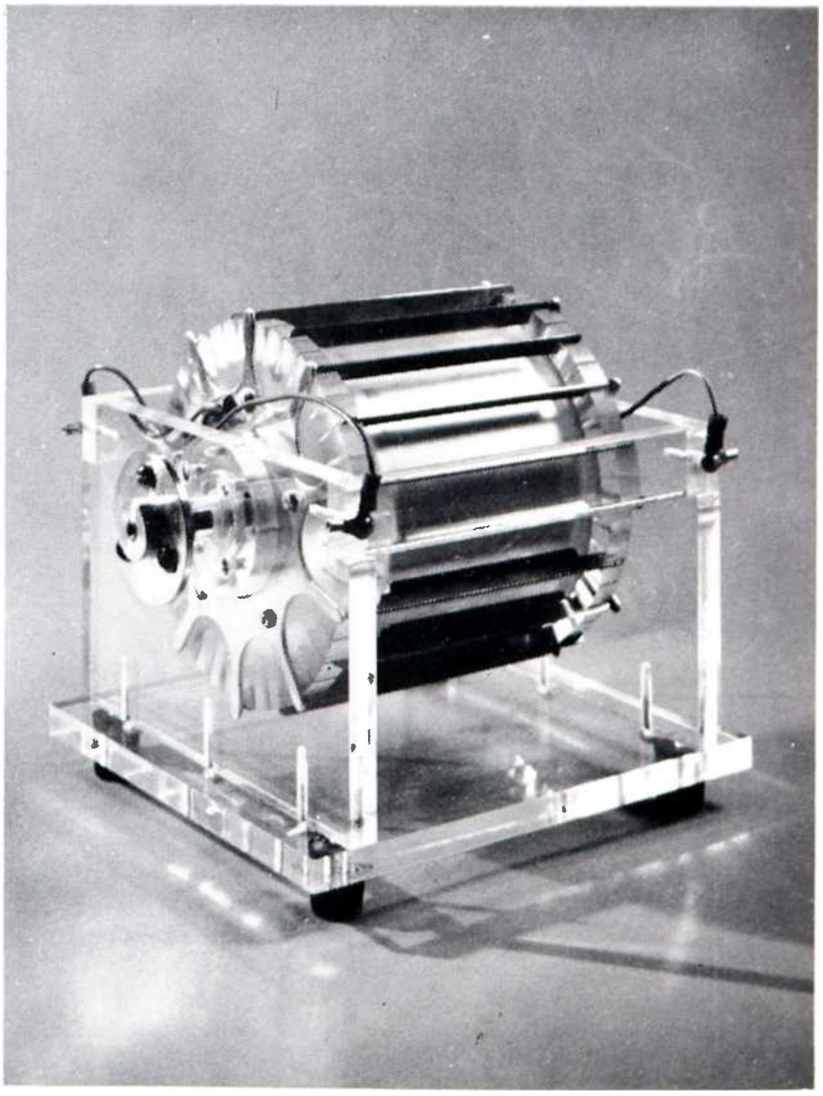

Photo Courtesy West Virginia University

*This photo shows the corona motor which operated from energy drawn from the Earth's electric field, but with an antenna of different design. Utilization of energy from the Earth's electric field may one day be regarded as one of the greatest achievements in the history of mankind.*

## NEW MOTORS

*(Continued from page 4)*

working essentially on the theoretical aspects of this development. Last summer they presented a paper on electret motors and measuring devices at an international conference on dielectric (nonconducting) materials at the University of Lancaster in Great Britain.

The moderator who reviewed the paper, Professor T. J. Lewis of the University College of North Wales, observed:

"The authors finally report on a multiple electret machine using 0.5 mm thick mica electrets. This promises to be an almost 'wireless' motor and is made even more exciting by the proposal that an aerial suitably coupled to the electric field of the Earth might be sufficient to power it. This surely is in the best traditions of Benjamin Franklin..."

(In July the motor hadn't been built but it now is on display at WVU.)

Man's desire to heat things, move things, and stop things is unending. He has tried just about everything imaginable in his quest for motive power. The wind, the Sun, the Moon, and even his own strong back have been harnessed - - either directly or indirectly - - to satisfy man's desire for changing things.

Waterwheels and windmills have turned for centuries - - - but droughts and calm days make them unreliable. Wood, coal, gas, and oil have been gathered from the Earth - - but the supply goes down as the demand for power goes up. The inner forces of the uranium atom are also being used to produce power - - but again the supply of uranium is limited.

To find new sources of energy and better ways of using the old ones are two of the most challenging problems facing today's scientists. And the Earth's electric field is a potential source of energy that until now has been completely ignored.

The awesome power of atmospheric electricity - - lightning and its thunder - - is known to everyone. What is less known is that atmospheric electricity is always with us and that lightning is merely a manifestation of its abnormal concentration.

Rain or shine, the air always contains positive electric charges that form an invisible blanket over the entire surface of the Earth. Scientists call this blanket the Earth's electric field and estimate that it is 10 miles thick.

The Earth's electric field changes from place to place and varies with atmospheric conditions. But if everything else is equal, the strength of the field varies with the distance above the Earth. (In the Morgantown area, its strength increases by about 100 volts for every three-foot increase in height.)

Except for lightning, the Earth's field normally makes its presence known by St. Elmo's fire - - that bluish glow occasionally seen near sharp-pointed objects, such as airplane wing tips, on stormy nights.

Lightning and St. Elmo's fire are other manifestations of static electricity.

Lightning is the movement of static electricity (involving millions of volts) from one cloud to another and from clouds to the Earth. Lightning usually comes in bolts or sheets and is like a spark - - now you have it and now you don't.

But sometimes it comes in the still mysterious and unexplained form of "ball lightning" - - luminous balls of electricity that slowly float through the air and sometimes suddenly explode with tremendous force. (It could be that some of the "flying saucers" are ball lightning.)

St. Elmo's fire is more of a continuous nature and only involves several thousand volts. This form of static electricity moves from a sharp metal point to the air, or vice versa, in a steady flow. (The Earth-field antenna of the new electret motor actually extracts electricity from the air by means of St. Elmo's fire.)

The Greek philosopher Thales of Miletus (circa 600 B. C.) is credited with first describing what we know today as static electricity. By rubbing amber - - a fossil resin - - with a piece of cloth it was found that the amber could pick up bits of lint, straw and other light objects. (The Greek word for amber is elektron.)

The same thing is seen today when you comb your hair on a dry day. The comb, which must be made of rubber or plastic, will attract your hair after a few strokes. Another example where static electricity makes itself known is when you walk on a carpet made of synthetic fibers on a dry day, then touch a water fountain or a metal doorknob and get a shock.

"Static electricity" is perhaps an unfortunate choice of words. It refers to a quantity of plus or minus electric charges that is stationary under certain conditions. Under other conditions, like when lightning strikes, the charges do move.

"Current electricity" refers to the movement of charges -- as in the wiring system in a house or a car. Static electricity is usually associated with very high voltages and current electricity is usually associated with low voltages.

But whether moving or stationary, the charges are exactly the same - - plus and minus. And the attractions and repulsions that these charges exert upon each other are the strongest nonnuclear forces presently known to exist in nature.

The cause of the Earth's electric field isn't fully understood. According to one theory, the minute particles of dust in the air rub against the air molecules and become charged - - just like rubbing amber with a cloth. Another theory suggests that the wind breaks the small droplets of water in the air into parts that have an unequal distribution of plus and minus charges.

Still another theory attributes the field to radioactive substances within the Earth. The Sun appears to be responsible for at least part of the field.

On a clear day the air above one square mile of the Earth's surface contains about 3,000 joules of electric energy - - this is just about enough energy to light a 100-watt bulb for 30 seconds. During electric storms, the air above one square mile can contain up to a trillion joules of electric energy - - enough to light 500 such bulbs for at least a year.

"But nobody yet knows what percentage of this energy can be converted into useful work and how fast the Earth's field would replenish itself once part of the energy has been extracted from it," Dr. Jefimenko explained.

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"At the present time this energy is simply wasted in the form of electric currents flowing from the air into the Earth and from cloud to cloud. The power dissipated by these currents is estimated to be between one million kilowatts to one billion kilowatts. The latter figure exceeds the entire world's output of electric power," Dr. Jefimenko said.

Because of buildings, trees, power lines, and so forth, the Earth's electric field isn't uniform near the surface. This is why Dr. Jefimenko and Mr. Walker used the parking lot, which is fairly clear of obstructions and is near the top of a hill, for their first experiment with the new electret motor.

Electric phenomena are usually measured in forms of two quantities - - voltage and current. (Voltage is analogous to pressure in a water system and current is like the amount of water flowing through the system each second.) Voltage alone isn't enough to run a motor or to light a bulb. To do any useful work you must have power, which is voltage multiplied by current. And only very small currents can be sustained by the Earth's field under normal conditions.

However, because the voltage of the Earth's field increases by about 30 volts for every foot change in height, it's possible - - with a sufficiently long antenna - - to generate the power needed to run an electrostatic motor.

The electric motors that are in common use today are based on the principles of electromagnetism. (They use electric currents but are moved by magnetic forces.) These principles were established by Michael Faraday in the early 1830s and he may have invented the first electromagnetic motor.

By 1873 Thomas Davenport, a New England blacksmith, used a battery-driven electromagnetic motor to operate a drill press. However, because of the efficiency of the steam engine and an apparently unlimited supply of wood and coal, Davenport's motor and similar devices developed during the following 30 years were looked upon as mere curiosities and not as useful mechanical inventions.

Electromagnetic motors require large currents and can't possibly use the Earth's field as a direct source of power. Electrostatic motors, however, require only very small currents and can use relatively large voltages. They work on the principle that like charges repel each other and unlike charges attract each other.

Electrostatic motors presently being studied at WVU are of three general types - - spark, corona discharge, and electret.

The first spark electrostatic motor - - and the first electric motor - - was made by Benjamin Franklin in the 1740s. It was powered from condensers (Leyden jars), which were in turn charged by mechanically turning a glass globe and rubbing it with a piece of buckskin.

The simplest form of the motor consisted of a horizontal wooden disk fitted with narrow strips of glass with brass thimbles on the ends. The disk was placed between two oppositely charged Leyden jars and, as each thimble approached the first jar, it received a spark. Since the thimble and the first jar now had the same charge, the thimble was repelled and caused the disk to turn. As that thimble approached the second jar, it was attracted and this force was

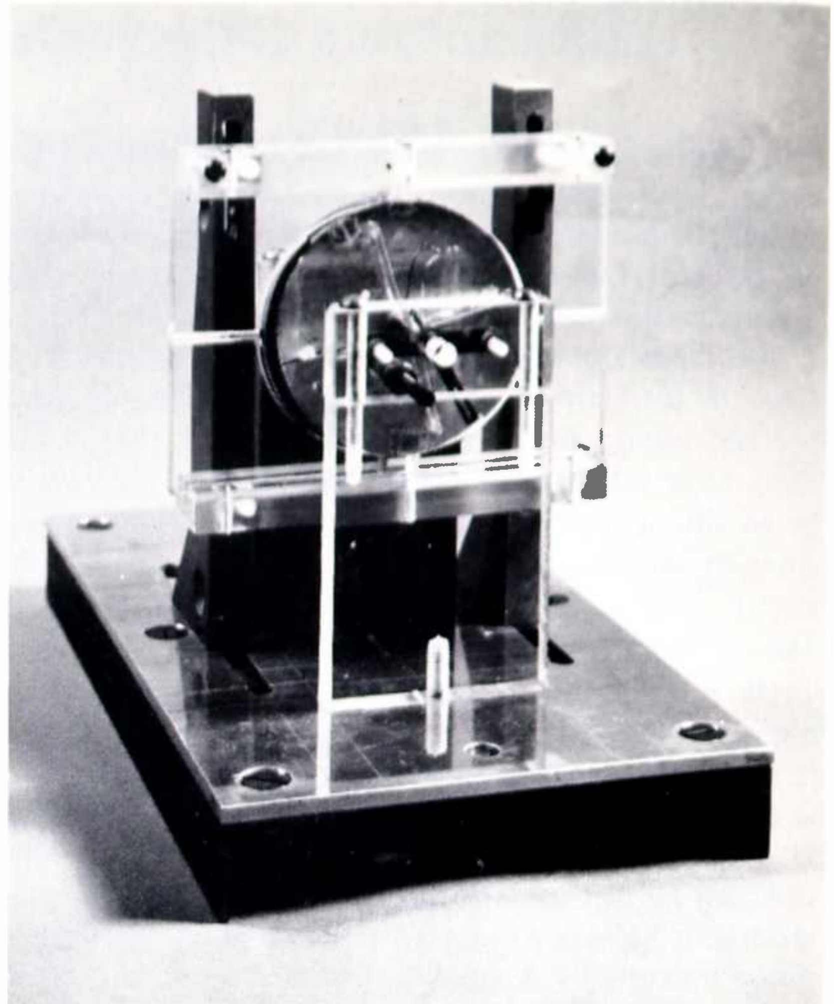

Photo Courtesy West Virginia University

*The World's first motor powered by energy from the Earth's electric field is shown above. It was developed by Dr. Oleg Jefimenko, professor of physics at West Virginia University. When the motor is running, the entire electret is shielded by a circular disk, which is one of the two mica-supported aluminum electrodes that rotate.*

added to turning the disk. Because the charge on the second jar was much greater than that on the thimble, a spark would again pass to the thimble. Now the thimble and the second jar would have the same charge and the thimble would be repelled again.

Spark electrostatic motors require thousands of volts to operate and aren't very powerful. A model of the Franklin motor made in the WVU physics laboratory generated less than one-thousandth of a horsepower.

According to Dr. Jefimenko, the first corona discharge electrostatic motor was made by the German physicist, Johann C. Poggendorff, who described it in an article published in 1870. (Corona discharge is the same thing as St. Elmo's fire except that it is artificially produced with an electrostatic generator or a high voltage power supply while St. Elmo's fire is a natural phenomenon.)

The corona motor differs from the spark motor in that its rotor isn't fitted with electrodes (the thimbles in Franklin's motor). (Both the inner tap and the body of a spark plug can be considered to be electrodes.)

Poggendorff's motor consisted of a glass-plate rotor placed between two ebonite crosses that were fitted with sharp needles. The needles were connected to a manually driven electrostatic generator. The charges were sprayed onto the rotor, which in effect took the place of Franklin's thimbles, in a continuous manner by means of the corona discharge. The attraction and repulsion between the charges on the rotor and the needles acted in the same way as in the Franklin motor and caused the rotor to turn.

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## NEW MOTORS

*(Continued)*

Corona motors are more powerful than spark motors and can be operated on as low as 2,000 volts.

Although it has been 100 years since Poggendorff's work, a practical corona motor still isn't on the market. According to Dr. Jefimenko, one of the main reasons for this is that Poggendorff himself declared that neither his motor nor any other electric motor could ever develop enough power to be of practical significance.

Poggendorff's negative attitude about electricity as a motive power was shared by many physicists of his time.

For example, a physics textbook published in London in 1877 said: "Electric prime movers can never successfully compete in power or economy with those in ordinary use, such as steam engines . . . The reason of this is given by the principles of the mechanical theory of heat . . . Experience has entirely confirmed this conclusion."

By 1890 the idea that electric motors could be economically used had been disproved by a "mathematical proof." A textbook published in New York in that year stated:

"But, though an interesting application of the transformation of energy, these machines (electric motors) will never be practically applied in manufactures, for the expense of the acids and the zinc which they use (the materials of the batteries) very far exceeds that of the coal in steam-engines of the same force . . . A pound of coal yields 7,200 thermal units, and a pound of zinc only 1,200; and as zinc is ten times as dear as coal, engines worked by electricity, independently of any question as to the cost of construction, or of the cost of the acids, are sixty times as dear to work as steam-engines."

In 1873 electricity was first transmitted over considerable distances by means of wires, but apparently the advantages of generating electricity at a central location and sending power throughout a large area - - something that couldn't be done with a steam engine - - hadn't been realized.

In a textbook published in Boston in 1892 this idea was expressed. Although the author said that it would cost a hundred times as much to run an electric motor as a steam engine with the same power, he added:

"But where the absolute amount of power is of less consequence than the facility of producing it instantaneously and at will, electro-magnetic engines may be used with advantage, as in driving sewing machines."

It also appears that Poggendorff's work on corona motors is still practically unnoticed. Dr. Jefimenko cites three recent articles - - one each from the Soviet Union, South Africa, and Poland - - in which the authors claim that they have invented novel motors.

"On examination it is found that these motors are merely modifications of Poggendorff's device, of which they obviously had no knowledge," Dr. Jefimenko said.

"Today electrostatic motors based on the corona effect are probably the most promising ones," according to Dr. Jefimenko. "Even in the simple form used by Poggendorff they were quite efficient. Furthermore, they are extremely lightweight in comparison to the horsepower they produce. Another advantage of corona motors is that theoretically there are no limits to the speeds that they can attain. (One of the corona motors built in Dr. Jefimenko's lab runs at about 10,000 rpm.)

It was originally thought that a specially designed antenna would be needed to run a corona motor from the Earth's electric field. However, Dr. Jefimenko decided to try one of these motors with a makeshift arrangement attached to a balloon.

The helium-filled balloon was about two feet in diameter and the antenna was a 22-inch-long piece of piano wire with one end filed to a very sharp point. No radioactive material was used with the antenna. A fine wire and a heavy string, which were about 100 yards long, connected the antenna to the motor.

The balloon was first flown from the roof of the WVU Engineering Sciences Building, which is about 11 stories above the ground, on December 10, 1970. The balloon didn't go much higher than the roof, but in such an arrangement the only problem is to get the antenna away from the building into a region where the Earth's field isn't disturbed.

The corona motor ran much slower than it normally does in the lab when it is connected to a high-voltage power supply, and it is estimated that the motor was producing one ten-thousandth of a horsepower. The rotor of this motor, which is of the multiple electrode type, weighs about one pound. (The rotor of the electret motor that was run from the Earth's field weighs about one-eighth of an ounce. When the electret motor was connected to the antenna on the balloon, it ran so fast that it had to be disconnected for fear of damaging the commutator.

Voltages up to 6,000 volts were measured during this experiment.

According to Dr. Jefimenko, this experiment proves that large electrostatic motors can be operated from the Earth's electric field provided that appropriate antennas are used to power them.

"But, despite all of their desirable properties, corona motors have an important limitation - - normally they can't be operated from less than about 2,000 volts," Dr. Jefimenko explained.

However, electret motors don't have this limitation - - it is known that they can operate from less than one volt.

It's thought that the first electret electrostatic motor was built by the Russian physicist, A. N. Gubkin, in 1961. Like spark and corona motors, electret motors operate on the principle that like charges repel and unlike charges attract. (The first electret was made by the Japanese physicist, Motataro Eguchi, in 1919.)

The Russian motor had two wax electrets mounted on a shaft that was fitted with an axle. The electrets were alternately attracted and repelled by two sets of electrodes. The motor was powered by high voltage batteries.

Dr. Jefimenko has been able to improve the design of early electret motors by using what has been called the electret "slot effect."

The electret motor that was powered from the Earth's electric field has a single carnauba-wax electret that is one-half inch thick and three inches in diameter. Besides being

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## NEW MOTORS

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able to run from the Earth's field, this motor can be powered by 60-volt dry cell batteries, ac-to-dc converters, condensers, and electrostatic generators. Power for this motor - - and for certain corona motors - - also can be transmitted directly through the air without wires.

"Present electrets have only moderately strong charges, thus electret motors can't compare with corona motors in regards to power. On the other hand, electret motors can operate at low voltages so there should be many situations where they will be useful," Dr. Jefimenko said.

"A more important point is that the various types of electrostatic motors offer new and unique possibilities for use in numerous areas of science and technology. The absolute rule of electromagnetic motors, which has now lasted for some 100 years, may soon be ended.

"As to the significance of the Earth's electric field as a source of power, a great deal of research will be needed before any certain statements can be made on the subject. At WVU we certainly intend to continue our work in this area."

Dr. Oleg Dimitri Jefimenko, professor of physics at West Virginia University, was born in Kharkov, USSR, and studied in Germany before coming to the United States in 1951. He then studied at Lewis and Clark College and the University of Oregon where he received his Ph.D. in physics in 1956. He joined the West Virginia University faculty in 1956.

Besides his work in electrostatics, Dr. Jefimenko is known throughout the scientific community for his research on the production and absorption of light by colliding atoms and molecules. This work resulted in a new model of the atom.

In Jefimenko's model, the nucleus of the atom is surrounded by a thin spherical shell of negative electricity formed by the electrons. The electrons' charges are uniformly distributed. This model has the simplicity of the orbital one and is almost as accurate as the quantum one for calculating atomic forces. It has been used to calculate the forces involved when atoms collide and the frequency of the light that they emit and absorb.

*In the below photo Dr. Jefimenko (left) is holding the electret motor which is powered by energy form the Earth's electric field. David K. Walker, a graduate student in physics, is holding the field antenna. The insert shows the electret motor.*

Photo Courtesy West Virginia University

This new model has been used by Dr. Jefimenko in a study which indicates that many of the yet unidentified spectral lines - - and possibly some of the lines detected in the Sun and other stars – aren't the product of unknown elements but are caused by the collision of atoms of known elements. These lines, which Dr. Jefimenko has named "satellite bands," are currently being investigated by members of the WVU Department of Physics and in several other American and European laboratories and observatories.

Dr. Jefimenko also has developed theories on the unpredicted behavior of artificial satellites - - they aren't exactly where they are supposed to be at a given time - - and on why one side of the Moon always faces the Earth.

According to Jefimenko, artificial satellites are pulled out of position by electromagnetic drag, which is caused by the Earth's magnetic field. The electromagnetic drag only accounts for a small part of the total drag on a satellite (the rest is caused by friction), but it is enough to throw the calculations off. This theory has been used by other scientists to account for the motions of the moons of Jupiter.

Jefimenko's theory on the rotation of the Moon is still open. However, the discovery that the Moon has no magnetic field (or at least a very weak one) has raised some doubts about the theory. This is true because the theory is based on the assumption that the rotation of the Moon has been retarded by either its own of the Earth's magnetic field.

Dr. Jefimenko's book, "Electricity and Magnetism" (Appleton-Century-Crofts, New York, 1966), is considered to be a significant contribution to the teaching of physics. This book, which was written for advanced undergraduate students, represents an entirely new approach to the teaching of electricity and magnetism.

It received some stiff opposition before it was published- and much praise after it was published. One reviewer of the manuscript seemed to think that everything (about the teaching of electricity and magnetism) was just fine until Jefimenko got into the act. In his words: ". . . In a single burst of arrogance Jefimenko created a whole new mess."

Instead of using the traditional sequence of presentation and going from cat skins and amber to Coulomb's Law and Maxwell's equations, Jefimenko used a logical approach. In this approach all electric and magnetic phenomena can be derived from six basic equations. Although Dr. Jefimenko didn't discover the equations (they have all been known for at least 100 years), he was able to put them together in a very simple manner.

By presenting the equations in this manner, Dr. Jefimenko has been able to obtain several previously unknown relationships of fundamental significance. As one of the reviewers of the book commented: "Professor Jefimenko has succeeded where most contemporary authors have failed."

# How Holland Controls Chemical Air Pollution

## A new computerized sulphur dioxide monitoring system tests the air sixty-four times each hour, and the findings are reported electronically to a computer at the warning center at Schiedam

**Special Report**

The growing menace of air pollution in many areas of America has underlined the need for priority programs to cope with this hazard as well as other environmental problems brought about by our industrial complex and rapidly increasing population.

Some highly effective environmental programs are already in operation, and others are in the planning stage. One of the most successful programs, and perhaps the least costly from the long-range viewpoint, is the Tennessee Valley Authority's "total" resource development program. It is based on the concept of improvement of ALL areas of the environment. The program has returned millions of acres of eroded or otherwise unproductive land to new productivity by reforestation. It has promoted the development of lakes and waterways for low-cost barge traffic, such as the 650-mile Tennessee River waterway. TVA has produced low-cost, clean, electric power from hydro-electric and steam-electric power plants for industrial and residential use, while at the same setting up systems to encounter the effects of "thermal" pollution of water by use of modern hyperbolic cooling towers. It has cleaned up the lakes and streams of the region. It will soon be producing electric power from nuclear steam-electric plants.

A "spin-off" of TVA's unified resource development program is one of America's finest and cleanest recreational regions for camping, fishing, swimming, and boating . . . with less water pollution, and with cleaner air to breathe. During this clean-up process, the region's economic base has been tremendously improved, and its potential for industrial growth is enormous. But a "total" development program takes time, and time is running out for many of the great industrial areas of the country.

For some regions of the nation, a more rapid means of bringing air pollution down to safer levels must be employed now in order to protect not only the health of human inhabitants, but also the wildlife and natural vegetation until long-range programs can remedy the basic causes of environmental pollution of all kinds.

A new, effective, means of controlling air pollution, utilizing a computerized sulphur dioxide monitoring system has been developed and is in current use in Holland. It is available in the U. S. through Philips Electronic Instruments of Mt. Vernon, New York.

In the densely populated and highly industrialized region between the harbors of Rotterdam and the North Sea known as the Rijnmond, nearly a million people live and

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Photo Courtesy Consulate General of the Netherlands

*Thirty-one detector masts in the Rijnmond region test the air sixty-four times each hour for chemical air pollution and automatically reports the findings to the Air Pollution Warning Center at Schiedam for evaluation by computer. The equipment measures wind velocity and force in addition to air pollution.*

Photo Courtesy Consulate General of The Netherlands

*THE AIR POLLUTION WARNING CENTER AT SCHIEDAM features a large wall map of the region on which the locations of "air sniffing masts" are shown by lights. At right is the computer which is linked to a typewriter. This system permits localizing an abnormally high source of pollution within 60 seconds. In addition to sampling the air, the monitoring system also measures wind velocity and force.*

## How Holland Controls Chemical Air Pollution
*(Continued)*

work.

Situated along natural and artificial waterways, and near one of the greatest ports in the world, the Rijnmond has attracted a large number of oil refineries, petrochemical and other chemical plants which constantly fill the atmosphere with various quantities and types of pollutants.

One of the methods employed to counter air pollution here is constant measurement of the atmospheric sulphur dioxide content, which may be taken as the norm for the total pollution level. If this shows that a fixed threshold value is being exceeded, and if rapid clearing of the pollution by the winds is not imminent, a warning is sent out to industry through a semaphore network. A large number of restrictions will then be voluntarily imposed by industry on itself, aimed at drastic reduction of the pollutant discharge.

The 31 detector masts which are located in the Rijnmond region have already been popularly dubbed "sniffing poles." Sixty-four times each hour, they test the air for the dreaded $SO_2$ and report their findings electronically via telephone lines to a computer at the warning center at Schiedam.

By comparing the average values with calculated values from the same measuring points at the same time on a previous day, a figure is obtained that indicates the trend of the alteration in the $SO_2$ content at each individual measuring point.

The new computerized sulphur dioxide monitoring system was developed by N.V. Philips Gloeilampenfabrieken of Eindhoven. They worked closely with technological and scientific specialists of the Netherlands State Institute for Public Health and the Technological University of Eindhoven. The equipment measures wind velocity and force in addition to the air pollution.

Since 1948, a committee has been active in Rotterdam, checking soil, water, and air pollution. This is an official body, maintaining close contact with the Rijnmond authorities and the Netherlands labor inspectorate. The committee meets each month and regularly visits the plants concerned. Its findings are submitted to the advisory committee of the Netherlands State Institute for Public Health.

Not long ago, the Rotterdam committee concluded that much of the success which has been achieved by the air pollution measuring network in the Rijnmond region is the result of close, voluntary cooperation between the industries concerned and the Rijnmond authorities.

Recently, the amount of sulphur compounds in the atmosphere above the region has gone down significantly, and the quantities of nitrogen oxides have been maintained at a constant level.

In spite of doubled production in the industrial area concerned, the amount of soot and sulphur dioxide in the atmosphere has also been reduced, partly owing to the changeover from heavy fuel oil to natural gas and low-

*(Continued on page 11)*

sulphur fuel oil.

### THE AIR SAMPLING SYSTEM

The air sampling units, which were specially designed for this work in Holland, are self-regenerating and self-calibrating, thus allowing them to operate for three months at a time.

The operation of this equipment is based on the well-known coulometric principle. The air to be sampled is first passed through a glass fiber filter, which is heated in order to prevent $SO_2$ absorption from taking place there. The dust-free air is then fed at a speed of 150 ml per minute through a special filter, in which nitrogen oxide, ozone, and other undesired matter is neutralized.

Next, the air goes into a measuring cell which is kept at a constant temperature of 95°F. It contains a solution of potassium bromide, sulphuric acid, and bromine in water. The redox potential is measured by two electrodes, and compared with a known reference potential.

If the bromine-bromide equilibrium is upset by a reaction with sulphur dioxide, the difference between the two above-mentioned potentials activates a generator electrode via an amplifier so that a generator current converts the bromide ions which have been formed back into free bromine. This insures that the bromine concentration in the measuring cell remains constant.

The strength of the generator current is proportionate to the quantity of bromine used, and, consequently, to the amount of sulphur dioxide flowing through the measuring cell per unit of time. In this way, the strength of the generator current also determines the strength of the output signal, which indicates the sulphur dioxide content of the atmosphere.

The 31 detector masts are located throughout the Rijnmond region in such a way that regardless of wind direction, there are always eight of them downwind of the principal sources of pollution. The number and location of these masts was established with the aid of a mathematical model.

### THE DATA TRANSMISSION SYSTEM

The signals obtained are transmitted from the 31 measuring boxes to the computer, and calibration command signals are sent from the computer to the boxes by a combination of a Multi-Tone-Telesupervision system (M.T.T.) and existing telephone lines. The M.T.T. units are housed with the $SO_2$ detectors in a box standing beside each sniffing pole.

During transmission of the measured values to the computer, the electrochemical part of the measuring units emits a direct current of between 0 and 20 mA. This current is converted into an impulse frequency of from 5 to 25 Hz which is modulated by a tone transmitter to a low-frequency telephone carrier wave. The modulated signal received at the computer is demodulated, and the remaining impulses fed into the computer. The transmission system has a built-in automatic monitoring unit which prevents faults from occurring in the system.

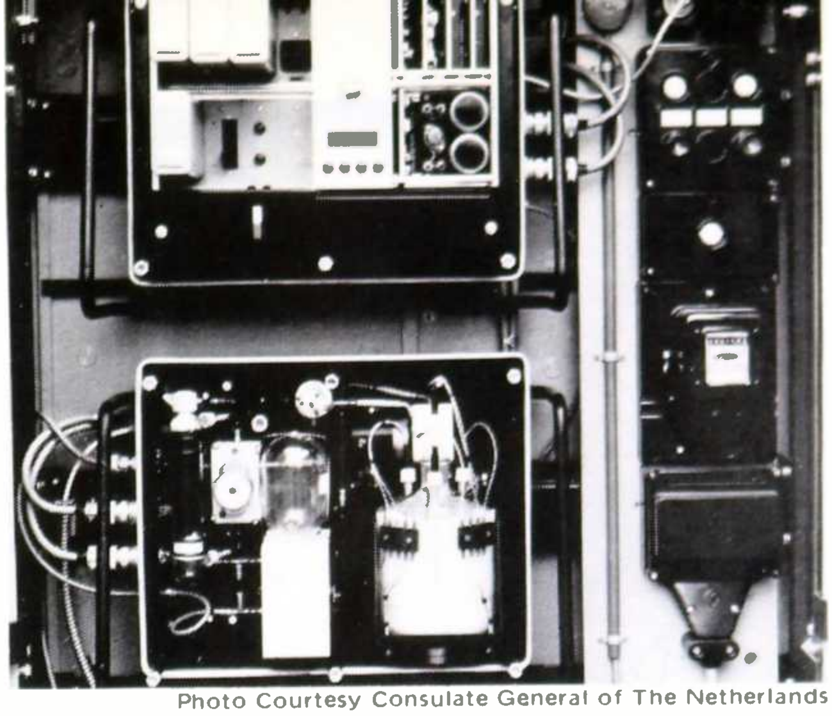


Photo Courtesy Consulate General of The Netherlands

*AUTOMATIC AIR POLLUTION MONITOR being used in the Rotterdam area to provide constant measurement of the sulphur dioxide content of the city's air. Shown above is one of the monitoring systems which is comprised of two devices; one is a fiber-glass reinforced casing in which the chemical unit is housed, and the other unit is the telemeter system, electronic components, and a pump.*

### THE DATA PROCESSING EQUIPMENT

Processing of the data is performed by a computer which is equipped with a real-time clock. Data output is via a typewriter linked to the computer, a rapid paper puncher, a data logger, a recorder, and a plotting board.

Each hour, the average $SO_2$ concentration is calculated for each measuring unit and recorded by the typewriter in micrograms per cubic meter, stating date, time, and wind direction. In addition, a trend figure known as the delta value is shown along with the delta values of the eight units in the region giving the highest readings during the past hour.

If the average delta value of all the measuring points exceeds a fixed threshold value, the computer sounds an internal warning. If the weather forecast at that moment predicts unfavorable conditions for the next six hours, a coded warning signal is given by the semaphore network to 21 large plants. The person operating the system needs to dial only one telephone number in order to notify everyone concerned.

### THE WARNING CENTER

The warning center also has a large wall map of the Rijnmond region on which the positions of the masts are shown by lights. Thus, it is possible to represent an average value for each measuring unit during a certain period.

An abnormally high source of pollution can thus be localized within 60 seconds. For this purpose, the computer is provided with a threshold value switch, which leaves on only those lights which signify high $SO_2$ concentrations.

The center also houses the complaints telephone. Anybody who feels that pollution has reached a nuisance level can call to camplain. The reports for 1970 will probably exceed 10,000. Supervisory staff in fast cars investigate all complaints.

Thus, the Rijnmond region, with its automatic warning system, is now in a position to forecast' a potentially dangerous situation and take the necessary measures to control the pollution level.

Photo Courtesy Lockheed-Georgia Company

*The C-5's flight engineer matches live wave forms with one from stored photo file, thus helping to keep the Galaxy in the air and on the job.*

# Electronic Cardiograph for Aircraft Watches and Listens for Malfunction

by Bob Norwood

When the world's largest (length, wingspan, height, and maximum gross weight) airplane is airborne, the U. S. Air Force crews can monitor its performance by using an amazing electronic subsystem called MADAR, an acronym for Malfunction Detection, Analysis, and Recording subsystem.

Lockheed - Georgia Company, manufacturer of the C-5, says that MADAR is like an electronic cardiograph in that it continually watches and listens for signs that something's not right. Able to check more than 1,200 test points throughout the airplane, MADAR uses a digital computer to diagnose possible system trouble.

It senses, locates, and identifies any failed line replaceable unit (LRU). Test point readings go to the flight engineer's station (see photograph) through an automatic printer and an oscilloscope.

Matched with each LRU is a series of oscilloscope wave form photographs depicting symptoms of sick systems. When the flight engineer matches live wave forms with one from MADAR's stored photo file, he has nailed down the source of trouble.

The oscilloscope's cathode ray tube can display line and stored wave forms simultaneously, thus providing the flight engineer with decision-making choices.

MADAR will show the defective part's name, location, and number; and the time and special tools (if any) required for replacement. If the necessary spare part is not aboard, a radio call to the next destination will have it available at touchdown.

The continual in-flight airborne troubleshooting produces a printed record that is invaluable to maintenance personnel for their review and action. The record comes from sample test-point readings which the digital data processor translates into numerical codes on a five-digit printer.

# Answers to Questions on Stereo FM Broadcasting

When you listen to a "live" performance of an orchestra your ears are able to locate sources of sound from left to right across the stage. This perception involves the "stereophonic effect"

1. What is Stereophonic sound reproduction?

When you listen to a "live" performance of an orchestra your ears are able to locate sources of sound from left to right across the stage. This perception involves the "stereophonic effect," which must be included in sound-reproducing systems to give full realism. To accurately bring the stereophonic sound of the concert hall performance by recording or by broadcast to the listener at home, separate microphones are used to "hear" the performance for you. When this sound is recorded on tape or discs, what each microphone picks up is recorded on a separate channel.

To reproduce this music in the home, the two tracks or channels of sound are picked up and amplified by two separate amplifier systems and reproduced by two separate speaker systems. Your ears hear the same mixture of right and left channels as picked up by the two microphones, giving the same perception of sound sources. The result is that, you, the listener enjoy the full depth, dimension, and movement of the music, enriched by the overtones and harmonics as augmented by the acoustics of the concert hall, as if you were in a choice concert hall seat. You can readily identify the distinctive voices of the orchestra, recognize their placement in the orchestra, and follow the movement of the music as the performance develops, since you are hearing music reproduced by a separate speaker and amplifier system for each ear, just as you do at a live concert.

2. What is Stereophonic FM broadcasting?

It is a system of broadcasting approved by the Federal Communications Commission that will enable an FM radio station to broadcast true stereophonic sound over the same frequency it now uses. Stereo FM brings to FM radio the same depth, dimension, and powerful illusion of presence at the actual performance, that many music lovers now enjoy with the stereophonic record players and tape playbacks at home. All the listener will have to do to get Stereo FM is tune in the station on his Stereo FM receiver to bring this new dimension in FM listening right into his home.

3. How does an FM station broadcast stereo programs?

In Stereophonic FM broadcasts the two separate stereo channels or sources of sound are woven together into one FM signal on a single FM station broadcasting frequency or channel. Stereo FM radios hear both the main channel and the stereophonic channel, and their highly sensitive circuits act as a traffic cop to route each stereo signal to the proper amplifier and speaker systems. As a Stereo FM listener, you hear the broadcast of both channels with full high fidelity plus the separation, movement, and color of music, with the effect that the orchestra is spread out before you.

4. How does Stereo FM differ from stereo radio broadcasts on the air prior to FCC authorization of the new broadcast service?

Prior to FCC authorization of national broadcasting standards for Stereo FM, two radio or TV stations had to combine their facilities for a stereo broadcast. One FM station, for example, broadcast the channel meant for your left ear and a second FM, or an AM, or TV station broadcast the sound meant for the right ear. This early method of supplying stereo over the air not only required two broadcasting stations but meant that those listeners tuned to just one of the two were getting only one-half of the broadcast. Because of this, station operators were forced to compromise and put on the air signals that were neither pure right channel nor pure left but somewhere in between. By contrast, the new Stereo FM broadcasts use only one FM radio station to send out both channels of stereophonic sound in full high fidelity, with each channel's response from 50 to 15,000 cycles per second. The resulting stereo signal is in precise balance to assure superior performance. In addition, those listening with a conventional FM radio hear a fully balanced monophonic FM program even though the station is broadcasting Stereophonic FM.

5. How did Stereophonic FM broadcasting come into being?

As a pioneer and leading proponent and developer of FM radio broadcasting and FM radio sets for over 20 years, Zenith has long been conducting extensive research on better FM broadcasting and receiving systems. One of these new ideas conceived by Zenith research engineers was a practical method of allowing one FM broadcast wave to carry another "piggy back," using a single FM channel in such a way that the listener in the home could receive both channels of true, high fidelity, stereophonic radio broadcasts via a single FM station.

After many months of exacting laboratory testing, Zenith applied to the Federal Communications Commission for permission to conduct experimental stereophonic FM broadcasts using the Zenith system over the company's pioneer FM station, WEFM, Chicago, the oldest FM station in the U. S.

After permission had been granted by the FCC, WEFM (using KS2XFJ experimental call letters) began transmitting Zenith Stereo FM broadcasts on June 30, 1959—without in any way interfering with conventional or monophonic FM reception that WEFM listeners had been enjoying for nearly 20 years.

Zenith revealed details of its Stereo FM broadcast system then being tested on WEFM in a progress report to the Federal Communications Commission in July, 1959.

These experimental broadcasts continued under special FCC authorizations until October 28, 1960.

On March 15, 1960, Zenith filed comments with the FCC proposing a system utilizing a sub-carrier frequency of 39 kilocycles and 19.5 kc. for the pilot frequency, and urged the adoption of the Zenith system as the national standard.

In the summer of 1960, Zenith, in cooperation with other members of the industry, made the fruits of its broadcasting experience available in field tests of all proposed Stereo FM systems in Uniontown and Pittsburgh, Pa.

Results of these tests and the detailed comments on Zenith's system and the five others then being considered for authorization by FCC were filed with the Commission in October, 1960.

On April 20, 1961, the Federal Communications Commission announced national standards for Stereo FM broadcasting, which the industry has since hailed as the greatest advance in broadcasting since the introduction of TV.

The FCC- approved Stereo FM standards, with only minor modifications, are those first proposed, developed, and air-tested by Zenith Radio Corporation. Their adoption and the beginning of Stereo FM bring a new dimension to FM radio and usher in a new era in the enjoyment of FM radio listening in the home.

# Coal Mine Rescue and Survival Systems

## Equipment developed with tools of America's aerospace technology is being applied to coal mine rescue and survival systems—including transmission of radio messages through the earth and life support capability

Special Report

A task force rolled out of Charleston into the mountains of West Virginia in January of this year to test a technological system for rescuing trapped miners.

Some 22 trucks were loaded with equipment developed with the tools of aerospace technology and tailored to the task of locating and opening an underground trap sprung on men by a coal mine disaster. The equipment ranges from sensitive electronic devices to hard-driving drills.

It included electronics that can detect and locate the thump from a miner's pick far below ground, transmit radio messages through the earth, and drills that can bore a hole 2,500 feet straight down and rig it for rescue. Other parts of the system apply underseas life support technology to underground survival.

With only short notice, the team of experts and equipment converged on a previously undisclosed coal mine location to carry out a realistic lifesaving simulation. The test was aimed at evaluating and further refining the system.

The evaluation test was the high point in a 9-month-long program launched by the Interior Department's Bureau of Mines to turn a conceptual study of coal mine rescue systems into hardware. The program is being carried out under a $3.4 million contract to Westinghouse Electric Corporation's special systems division at the company's Defense and Space Center in Baltimore.

The evaluation test staged in January will put the search and rescue components to the test. The survival systems will be evaluated in separate tests later.

### COAL – THE NEED AND THE HAZARD

Coal mining is an industry of necessity and hazard.

Necessary because the country will consume half a billion tons of coal in 1971 for industrial purposes and power generation. And even if the most optimistic projections for the growth of nuclear energy are fulfilled, the demand for coal will double by 1980 and increase another 40 per cent before the year 2000.

Although coal mining has the most stringent regulations of any of the mining industries, it is still the most hazardous. The very process of ripping coal from a subterranean workplace not only churns up a volatile black dust but also releases explosive methane gas.

Thirty-two times in the past two decades the hazards of coal mining have come into sharp public focus. These were the occasions of major mine disasters. Some 555 men were killed.

The good side of the statistics is that 1,690 miners involved in those major disasters walked out unaided and unharmed. Another 100 were rescued.

A study shows 126 miners, about 20 per cent of those whose cause of death is known, could have been saved with the proper knowledge, training, or equipment. The coal mine survival and rescue system could add favorably to the lifesaving odds.

### ORIGIN OF CONCEPTS

In early 1969 the Bureau of Mines asked the National Academy of Engineering to survey the nation's storehouse of technology and recommend the most up-to-date means available for survival and rescue of trapped miners. In March of the same year the Academy established a Committee on Mine Rescue and Survival and sent them on a wide search in fields ranging from earthquake measurement to petroleum drilling.

One of the objectives of the committee was to define a mine rescue and survival system that could be developed in approximately one year using existing technology. A report describing the system was published in November, 1969.

The concepts described in the report became the development guideposts for the Mine Rescue and Survival System. The following spring, the Bureau selected Westinghouse from among the firms competing for a contract to turn the Academy concepts into workable hardware.

Westinghouse Electric Corporation
*Modular Portable Survival Shelter Under Construction*

### CAPABILITIES

The request for proposals issued by the Bureau of Mines on February 20, 1970 offered what Westinghouse management considered exceptional opportunities for its high technology defense divisions' capabilities. The survival habitat and underground breathing apparatus concepts described in the Academy report, although dealing with different problems and a different environment, were still closely related to technologies developed at the Westinghouse Ocean and Engineering Center.

The company's Georesearch Laboratory in Boulder, Colorado, has already accumulated extensive experience in seismic communications techniques. This experience, coupled with work the Westinghouse Defense and Space Center had

*(Continued on page 15)*

## TRAPPED MINERS

*(Continued from page 14)*

done in through-the-earth communications, enabled it to match and in some cases exceed the capabilities called for in the Academy of Engineering report.

Finally, the report said the development of a rescue and survival system required systems management to achieve economically efficient integration of all components into a total system. The company quickly pulled in one of its most effective systems management specialists from California - - Robert P. Taber - - and put him to work at the company's special systems division in Baltimore.

Mr. Taber, a veteran of the company's Polaris program participation, assembled a team of systems management personnel to guarantee that the hardware was not a conglomeration of components but a smoothly functioning system. Aside from developing systems hardware, the team also began undertaking research on the geological characteristics of major coal mining areas, their accessibility to nearby airports, and even some limited studies of the behavioral patterns of trapped miners.

The coal mine rescue and survival system has three basic objectives:

1) To enable coal miners who have survived a disastrous explosion to survive the equal dangers that immediately follow, including carbon monoxide poisoning, smoke inhalation or suffocation, roof falls, and additional explosions.
2) To enable miners to receive and send emergency communications regarding their locations, available escape routes, nearby dangers that should be avoided, or advice on rescue.
3) To provide an escape shaft if operating shafts or tunnels cannot be safely reopened.

Immediately prior to a coal mine disaster, there could be several crews of 8 to 15 men working in an area within one or two miles - - but separated by as many as five or ten miles of tunnels. In addition to the larger work crews, smaller teams of two to four men could be engaged in coal hauling, maintenance, mine construction, or inspection.

Suddenly, an explosion occurs at one of the working faces where the coal is removed from the seam. Those who survive the blast may escape to the surface. Others may find their way to a refuge chamber, or to specially designated areas equipped for construction of barricades to keep out poisonous gas while awaiting rescue.

Smaller groups of men moving from one area to another might be trapped in locations without any special equipment. Their location may be completely unknown by other miners or those on the surface.

It is probable that power will be disrupted by a mine disaster or, if not, disconnected as a safety precaution. As a result standard telephone communications systems between surface and mine are not available during such emergencies.

Rescue forces on the surface will have information on the location of rescue chambers, preferred barricade areas, and sections of the mine being worked. All coal mines are required to maintain current maps of their network of tunnels.

### SUBSYSTEM FOR SURVIVAL

In the aftermath of a fire or explosion, the coal miner may find a basic lifesaving link is missing: a supply of breathable air. To meet that need, law requires that each miner be provided with an emergency breathing device called a self-rescuer.

The self-rescuer filters out poisonous carbon monoxide but depends on oxygen remaining in the mine atmosphere. Although self-rescuer units have saved many lives, the National Academy of Engineering says they are "only marginally adequate for the job for which they are intended."

Personal Breathing Apparatus - the personal breathing apparatus designed by Westinghouse for coal mine emergencies provides a new meaning for the old acronym SCUBA: Self Contained Underground (instead of Underwater) Breathing Apparatus.

The new equipment is indeed self-contained. It not only provides a supply of oxygen, but filters out carbon dioxide after each breath and enables its user to rebreathe the unused oxygen.

The closed-circuit system uses standard materials such as lithium hydroxide to filter out carbon dioxide and chlorate candles to produce oxygen by chemical reaction. Chlorate candles are widely used as oxygen generators in aircraft.

The personal breathing apparatus consists of a mylar hood with fog-proof goggles and a rubber neck seal, connecting hoses, and a canister worn slung across the chest. Its design is such that it does not prevent its user from hearing or talking.

The unit is about the size of a cigar box when stowed in its carrying case or 10 by 11 by 3.25 inches. It weighs 7 pounds.

Survival Shelters - personal breathing apparatus is designed only to enable a coal miner to escape or reach safe refuge where he can await rescue. A refuge area could be a safer part of the mine or a place where materials are stashed to erect a barricade of brattice cloth and wood framing to keep out smoke and toxic gases.

From 1909 to 1961 more than 1,000 coal miners were rescued from behind barricades. Others died because their barricades were improperly erected.

Because of the life-saving potential of refuge areas and chambers, the National Academy of Engineering recommended development of advanced survival shelters. The Westinghouse Ocean Research and Engineering Center has applied its undersea life support expertise to designing two types of survival shelters.

One is a 15-man portable shelter to provide refuge near the mine face as work advances. Westinghouse life support engineers also drew up specifications for a large, centrally located, permanent chamber that could accommodate 50 men for two weeks.

The portable shelter can be folded into six modular packages with rubber-tired wheels that can be removed once the module is in place. The arched walls of the structure are made of steel and are ribbed for strength.

When the six modules are assembled, the bulkheads installed at each end, and the whole unit bolted to the mine floor, it provides a quonset-type structure 48 feet long, nine feet wide, and five and a half feet tall at its center. Beneath the floor of the shelter are stored food,

*(Continued on page 33)*

Westinghouse Electric Corporation

*Transmitting with a Pick*

# history's hall of honor T.M.

**BIOGRAPHICAL SKETCHES OF GREAT MEN IN ELECTRONICS**

# Commander Eugene F. McDonald, Jr.

**Electronics Industry Pioneer and Founder-President of Zenith Radio**
**1886-1958**

Biographical Sketch
Courtesy Zenith Radio Corporation

The late Commander E. F. McDonald, Jr., founder-president and first board chairman of Zenith Radio Corporation, served the company for almost forty years as its chief executive officer. Under his leadership Zenith grew from a kitchen table workshop to a leading position in the radio-television industry.

McDonald was a business leader and prominent citizen in Chicago from 1910 until his death in April of 1958. He was noted as a dynamic merchandiser, innovator, and explorer.

In 1921, after serving through World War I in Naval Intelligence, McDonald joined forces with two young radio amateurs, Karl Hassel and R. H. G. Matthews, who had formed a partnership called the Chicago Radio Laboratory, and were engaged in manufacturing and selling radio receivers. McDonald provided capital and promotion, and became general manager of the firm. From the call letters, 9ZN, of their amateur radio station they coined the trade name Z-Nith. In 1923, Zenith Radio Corporation was formed with McDonald as president.

Photo Courtesy Zenith Radio Corp.

*In 1925, the U.S. Fleet had scheduled a goodwill tour to New Zealand, Tasmania and Australia. It was also the year Commander McDonald went north on the MacMillan – National Geographic Arctic Expedition. The MacMillan expedition, aboard the Perry, reached Etah, Greenland, only 11 degrees from the North Pole, while the U.S.S. Seattle was off the coast of Tasmania, 12,000 miles away. Commander gave a convincing demonstration of the capability of short wave radio by putting a group of Eskimo singers before the microphone and sending their voices to Admiral Coonz on the Seattle, almost exactly half the world away.*

From the very first days of the Chicago Radio Laboratory, and through the years in which Zenith has grown to its present high stature, the company and McDonald personally have pioneered continuously in the field of broadcasting. From this pioneering have come many important contributions to the art, some of a technical nature and others in the development of new broadcast programs and public service.

In 1923, McDonald established one of the nation's first broadcast stations, WJAZ, with studios in the Edgewater Beach Hotel. This station pioneered many program innovations, including the presentation of grand opera, special transmission of news, and messages to members of an Arctic expedition.

In 1923 also, McDonald organized and became the first president of the National Association of Broadcasters. In that year he contributed to the development of commercial broadcasting, arranging to have a group of member stations broadcast excerpts from a radio magazine then on the newsstands. The publisher paid the NAB a $1,000 fee for this service. Results were so successful that the arrangement was continued. This is believed to be the first use of radio as a national advertising medium.

McDonald pioneered the development of short-wave radio for long-distance communications by outfitting the 1923 Donald B. MacMillan Arctic Expedition with transmitters and receivers. This equipment permitted MacMillan to keep in touch with the United States through the long Arctic night, the first Arctic expedition in history to do so. Radio station WJAZ broadcast special programs of news and messages to members of the expedition, a feature that became very popular with the radio listening audience.

At that time during the state of radio's development, the short wave band was considered of little practical value and assigned to radio amateurs. The U. S. and other navies, and the merchant marines of the world, were equipped with long wave radio which could not maintain day-time contact with shore stations when the vessels were a few hundred miles

*(Continued on page 18)*

Photo Courtesy Zenith Radio Corporation

# Commander Eugene F. McDonald, Jr.

**Electronics Industry Pioneer and Founder-President of Zenith Radio**

1886 - 1958

Photo Courtesy Zenith Radio Corporation

*THE FIRST SESSIONS OF THE NAB brought many letters of inquiries and information. The first president and organizer of the NAB was Comdr. Eugene F. McDonald, Jr. (fourth from left), the first president of Zenith Radio Corporation. At this 1923 meeting of the pioneer NAB board in Chicago's Drake Hotel were: (left to right): Raymond Walker; C. H. Anderson; Frank W. Elliott, WHO Des Moines, later an NAB president; Comdr. McDonald; Paul Klugh, manager of WJAZ (Zenith's early AM station); William S. Hedges, radio editor of the Chicago Daily News, then operating WMAQ; Elliott Jenkins, WDAP Chicago (now WGN); A. B. Cooper; John Shepard, 3rd; Powel Crosley, Jr., WLW, Cincinnati.*

## Comdr. E.F. McDonald, Jr.

*(Continued from page 16)*

from land, and which were limited in range even at night.

Realizing that there were wavebands in the short wave spectrum that would permit great distance with relatively low power, McDonald early in 1925 demonstrated the efficiency of short wave to the U. S. Navy by persuading Admiral Ridley McLean to send an amateur with Zenith equipment on the fleet's good will cruise which began in Pacific waters. Then McDonald took similar equipment to Greenland with the MacMillan National Geographic Arctic Expedition, maintaining radio contact while the expedition was en route to Etah, Greenland and the U. S. fleet steamed across the Pacific. From Etah, within 11 degrees of the North Pole, McDonald sent singing voices of Eskimos to the fleet while it cruised off the coast of Tasmania, 12,000 miles away.

That was the start of practical use of short wave radio by the U. S. Navy. It is interesting to note that since that date *all* of radio's expansion into new channels—international communications, ship-to-shore, VHF and UHF television, radar, etc.—has been in that short wave spectrum below 50 meters which McDonald so effectively demonstrated to the world.

In 1925 radio broadcasting was under jurisdiction of the Secretary of Commerce. McDonald told the then Secretary, Herbert Hoover, that this was too much power to be in the hands of one man, and then deliberately jumped a Canadian frequency. In the resulting court test, McDonald's position was confirmed. This led to establishment of the Radio Commission, which has since been superseded by the Federal Communications Commission.

Under McDonald's direction, Zenith's experimental work in television began in 1931. At that time, because of his conviction that advertisers would not be able to finance new motion pictures and other box office features on television, Zenith began research on finding a method of subscription television. He demonstrated Phonevision, the first such system, in 1947, conducted a limited commercial test in Chicago in 1951, and until his death, spearheaded the pro-subscription TV drive on this highly controversial issue.

On February 2, 1939, Zenith went on the air with W9XZV, the nation's first all-electronic television station built to then current standards.

In 1940-41, the first color TV broadcasts in Chicago were transmitted by W9XZV, using a VHF transmitter, receiver, and studio equipment, including direct pickup cameras, that were constructed in Zenith's laboratories. The colorcasts were used to test the company's receiver design.

In 1950 the station moved to the Field Building. There, under new call letters, K2XBS, it broadcast the experimental test of Zenith's Phonevision system of subscription television. The station later proved invaluable to the television industry during development of the NTSC system of color television.

McDonald's early interest in FM put Zenith on the air in February, 1940, with one of the nation's first FM stations, now operating under the call letters WEFM. Through the war WEFM created and broadcast special programs for industry which were put on the speaker systems of war factories to relieve worker fatigue, and act as a stimulus to production. From its beginning for over 26 years, this station was operated as a public service, presenting a program of fine music without the sale of advertising. On February 14, 1966, the station began broadcasting a new programming format from new Stereo FM facilities described by station engineers as "the most advanced in the country."

It was at McDonald's suggestion that most radio manufacturers granted the government a free license under all of their patents during World War II.

In April 1942, long before there was any talk of renegotiating war contracts, Zenith directors resolved

*(Continued on next page)*

## Comdr. E.F. McDonald, Jr.

*(Continued from preceding page)*

that the company would voluntarily return to the government any amount that it considered over and above a reasonable profit from war business. These refunds aggregated millions of dollars before the renegotiation act went into effect.

In 1943, McDonald launched a "crusade to lower the cost of hearing" by introduction of an efficient hearing aid for $40, about one-fourth the price of other good instruments then on the market. Within a matter of months Zenith became and has remained the world's largest manufacturer of hearing aids.

During World War II, Zenith was a 5-time winner of the Army-Navy E, as was its wholly owned subsidiary, the Wincharger Corporation of Sioux City, Iowa. During the war Zenith passed along to competitors, free of charge, many production technics that made for greater efficiency in war production, even though they represented short cuts that would have been valuable peacetime production secrets.

As president of Zenith, McDonald was insistent on quality, and stimulated the development of many new and novel features. From the company's laboratories came the industry's first all-electric receiver that eliminated storage batteries from the living room; the first automatic radio tuners; the first ultrasonic wireless remote control for home TV sets; a glare proof black-and-white TV picture tube; and many other advances.

As an explorer, McDonald participated in a command capacity on two Arctic expeditions, sought the original site of Stevenson's Treasure Island, and discovered the wreckage of what may have been LaSalle's lost ship *Le Griffon* which disappeared in the Great Lakes several centuries ago. During his lifetime he owned more than 30 boats, ranging from his first canoe to the 185-foot *Mizpah*, which was known throughout the world, and on which he lived for many years until the ship went to the Navy in World War II.

McDonald authored numerous magazine articles and a book, *Youth Must Fly*, published by Harper's in 1941. He played a leading role in having glider instructions given to our armed forces prior to U. S. entry into World War II.

McDonald was a Fellow of the Royal Geographic Society of London; member of the Racquet, Chicago Athletic, and Tavern clubs of Chicago; Mackinac Island Yacht Club; Royal Canadian Yacht Club; and Explorers Club of New York.

McDonald was born at Syracuse, New York, in 1886, the son of Eugene F. and Mary McDonald. From early childhood he was fascinated by things electrical and mechanical, and by the time he entered high school had developed a business installing and repairing electric door bells.

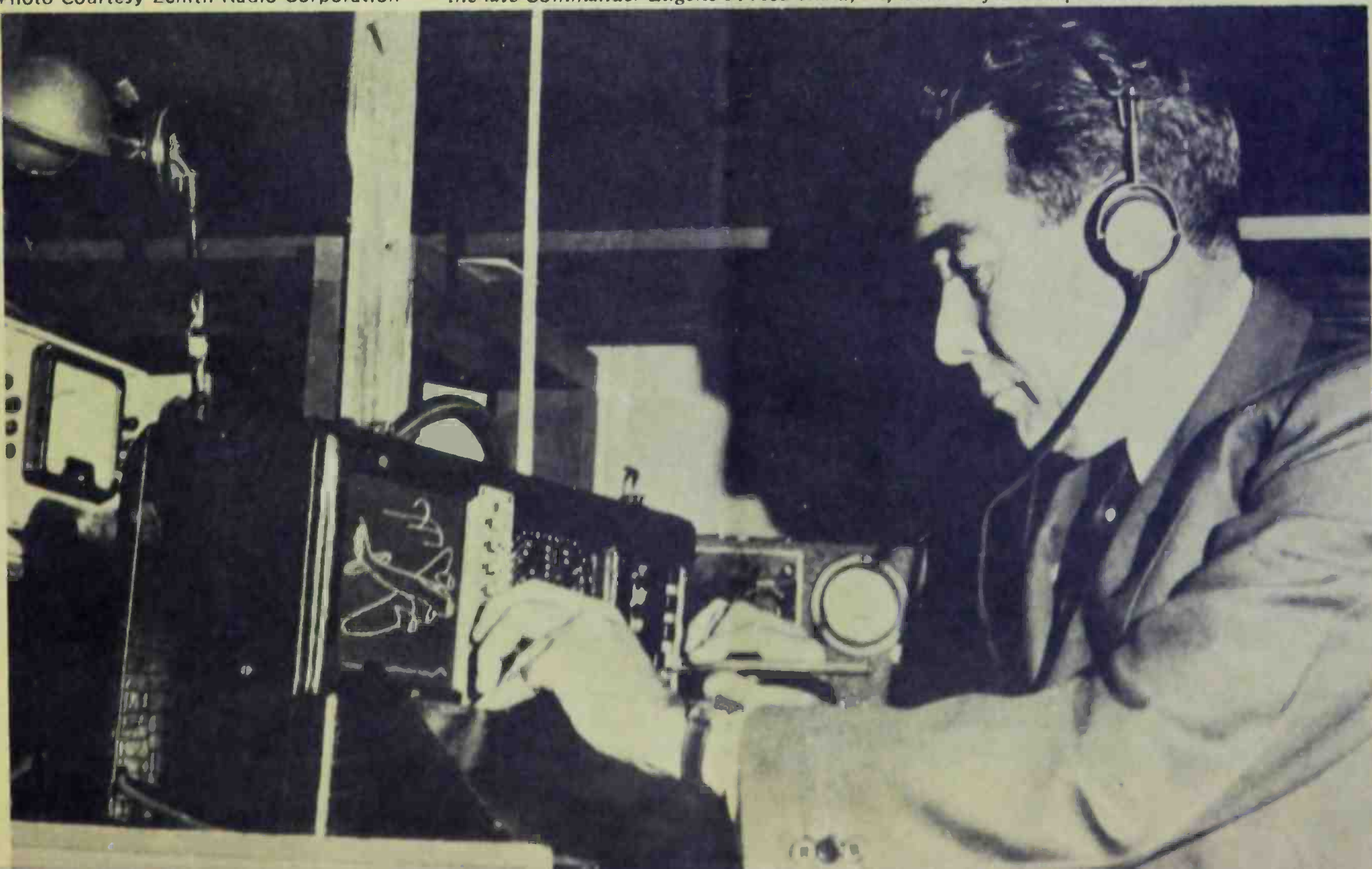
He left high school after two years to become a factory worker in the Franklin Automobile Company, soon became southern sales manager, and in 1910 became sales manager of the Imperial Motor Company. Then he moved to Chicago to distribute an automobile self-starter, and was soon in the automobile sales business.

In 1912, McDonald launched an innovation in the automobile industry, the sale of commercial cars on time payments. At that time small business men could buy almost anything but cars on credit. McDonald set up a company to finance their purchases on time payments and was soon handling more than 20,000 cars a year.

When the United States entered World War I, McDonald sold his business and joined the Navy. He held the rank of lieutenant-commander.

Photo Courtesy Zenith Radio Corporation

*THE LAST TRANS-OCEANIC shortwave receiver produced before Zenith Radio Corporation converted all production to war work during the World War II era is put through its paces by the late Commander Eugene F. McDonald, Jr., Zenith's founder-president.*



# FROM AN ALBUM™

**PICTORIAL HISTORY OF ELECTRONICS**

## A Mobile Radio Broadcasting Station in 1925

Compare this portable radio broadcasting station with the compact, streamlined, systems used by today's radio and television stations, and you will agree that we "have come a long way in forty-six years"

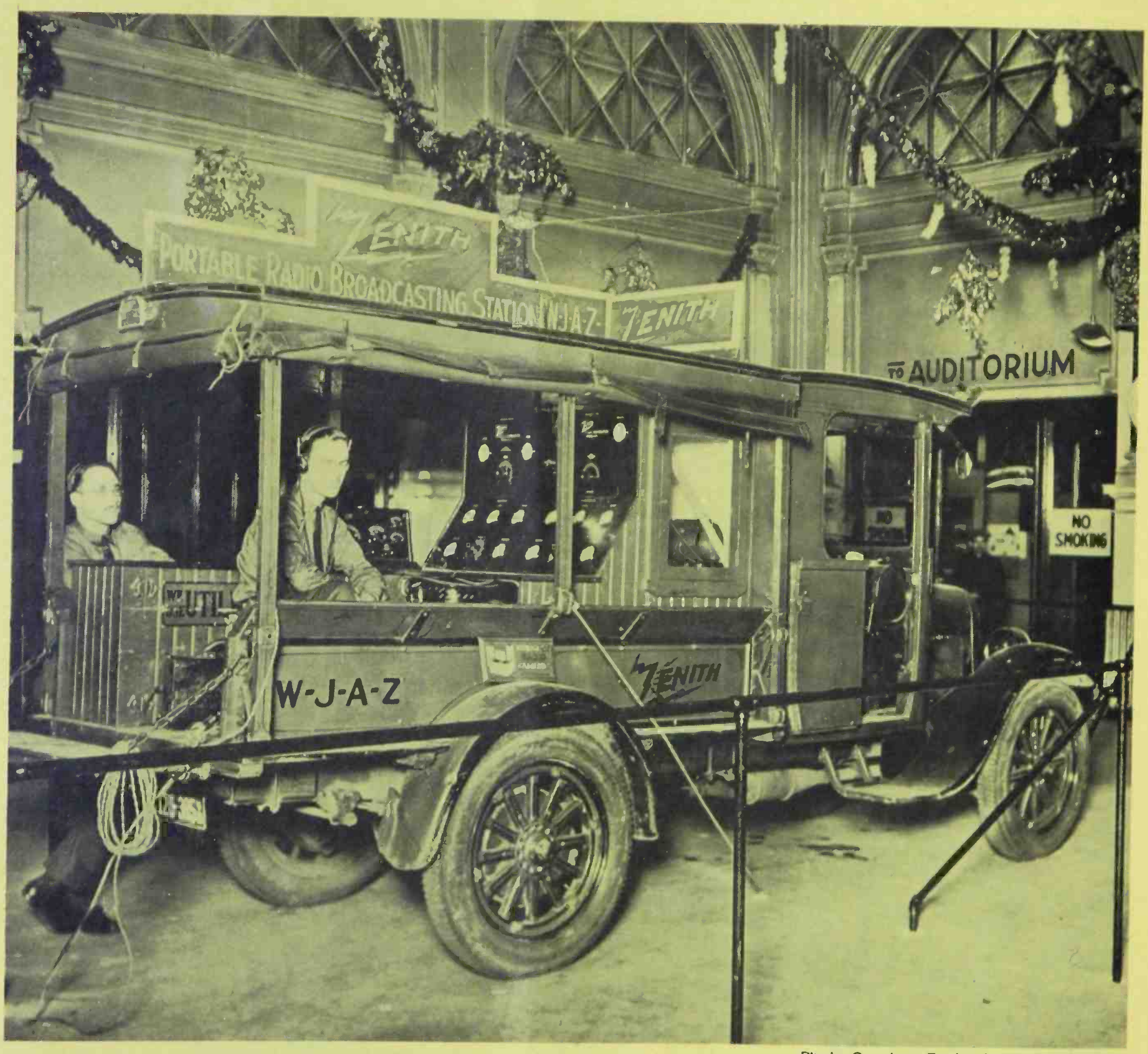



Photo Courtesy Zenith Radio Corporation

*This old photograph displays the very latest in portable radio broadcasting stations forty-six years ago. It is the Zenith Radio Corporation's mobile radio station, WJAZ, and the year was 1925. The base station studios were built in 1922 in Chicago's famous Edgewater Beach Hotel.*

# THREE-YEAR INDEX

ELECTRONICS DIGEST INDEX BY ISSUE AND BY SUBJECT

July, 1967 — June, 1970

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# INDEX BY ISSUE
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### A



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## SUBJECT INDEX

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## SUBJECT INDEX

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## SUBJECT INDEX

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*Editor's Note:*

*The Electronics Digest Three-Year Index is also available in an attractive 8-page booklet, size 8½ x 11 inches, drilled for standard three-ring binder. It may be placed in the Electronics Digest custom magazine binder which has a two-year capacity and offers an ideal way to protect individual issues of the magazine. The price of the index is $1.50 postpaid; and the price of the custom magazine binder is $3.50 postpaid.*

*A limited supply of annual bound volumes are available at $4.95 each postpaid. Volume One (July 1967 through June 1968); Volume Two (July 1968 through June 1969); Volume Three (July 1969 through June 1970). Please order by volume number.*

*All orders should be addressed to: Special Orders Dept. MJ-71, Electronics Digest, P.O. Box 9108, Fort Worth, TX 76107.*

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# SCIENCE NOTEBOOK™

## Programmed Lesson on Inductive and Capacitive Circuits

### This self-teaching lesson presents the basic theory necessary for understanding ac circuits using inductors and capacitors. Impedance, reactance, and resonance will become familiar terms

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

Inductance and Capacitance are important concepts in circuit theory associated with energy storage. Inductors and Capacitors are also practical circuit components just about as readily available as resistors. Most electronic circuits require the use of capacitors or both inductors and capacitors along with other components to perform their intended function. Therefore, an understanding of their characteristics is essential for those involved in electronics. In this lesson, voltage and current relations for inductors and capacitors will be discussed. From these relationships, practical circuit applications will be noted.

As with previous programmed lessons, start by reading frame 1 and then examine the answers to the question at the end of the frame. Choose an answer you think is correct and go to the frame indicated. Then proceed through the lesson as directed.

---

**1** Inductance can be described as the ability of a wire or conductor to produce induced voltage when the current varies. This voltage, resulting from electromagnetic induction, appears across the conductor similiar to an IR drop across a resistor. A coil of wire has more induced voltage than an equivalent length of straight wire. Therefore, practical inductors are just coils of wire around a suitable core, manufactured to have a definite value of inductance. The schematic symbol for an inductor resembles a coil as shown in Figure 1.

The voltage induced across an inductor is calculated from the expression, $e = L\frac{\Delta i}{\Delta t}$, where L is the symbol for inductance in henries. The $\frac{\Delta i}{\Delta t}$ factor represents the time rate of change of current. Induced voltage is also called the counter e.m.f. or back e.m.f. If the applied voltage increases or decreases, the back e.m.f. opposes this change. Thus, an inductor in a circuit opposes any change in the current.

The magnetic field associated with an inductor stores energy. This energy, usually expressed in the unit of joules, is equal to $\frac{1}{2}LI^2$.

QUESTION: What is the value of the back e.m.f. induced across a coil of 0.3 henry, when the current increases from 80 ma to 100 ma in 10 μsec?

1) 0.6 volt . . . Go to frame 5

2) 30 volts . . . Go to frame 15

3) 600 volts . . . Go to frame 10

---

**2** Your answer is incorrect. You forgot to carry along the units when finding the stored energy, $\frac{1}{2}CE^2$. For this problem, C is equal to $1 \times 10^{-6}$ farad. Return to frame 10 and choose another answer.

---

**3** Your answer is incorrect. The $\frac{\Delta E}{\Delta t}$ factor equals $\frac{25}{1 \times 10^{-6}}$ volts/sec. Multiply this factor by the capacitance in farads to obtain the charging current. Note that 200 pF equals $200 \times 10^{-12}$F or $2 \times 10^{-10}$F. Return to frame 6 and choose another answer.

---

**4** Your answer is correct. How do we account for voltage and current relationships in circuits that are not purely inductive or purely capacitive? After all, most circuits contain combinations of resistors with capacitors or inductors, or contain all three components. In ac circuits, the term "impedance" is used to describe RLC combinations that impede current. The capital letter Z is used to represent impedance, which is specified by both magnitude and phase angle. Admittance, designated Y, is the reciprocal of impedance. For RC or RL series circuits, the magnitude of the impedance is found using the expression, $Z = \sqrt{R^2 + X^2}$. In this expression X represents either the capacitive or inductive reactance. Using impedance, Ohm's law is stated as E = IZ or e = iZ since small letters are usually used to represent ac quantities. Phase angles between voltage and current lie somewhere between 0° and plus or minus 90°, depending on the relative magnitudes of reactance and resistance. The exact angle may be found from the trig function for the tangent, where $\tan\theta = \frac{X}{R}$. In an RL series circuit, current lags the voltage and the phase angle lies between 0° and minus 90°. In an RC series circuit, current leads the voltage so that the phase angle lies somewhere between 0° and plus 90°. In both circuits the exact angle is determined by using the above formula.

*(Continued on page 28)*

QUESTION: For the circuit shown in Figure 6, does the amplitude of the output increase, decrease, or remain the same as the frequency increases?

1) output amplitude increases . . . Go to frame 9

2) output amplitude decreases . . . Go to frame 17

3) output amplitude remains the same . . . Go to frame 13

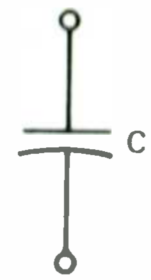



FIGURE 2
SCHEMATIC SYMBOL FOR A CAPACITOR, CAPACITORS ARE SOMETIMES REFERRED TO BY THEIR OLD NAME "CONDENSERS".

**5** Your answer is incorrect. The units must be changed to amps and seconds before using the formula, $e = L\frac{\Delta i}{\Delta t}$. For this problem, current changes $20 \times 10^{-3}$ amp in $10 \times 10^{-6}$ sec. Recalculate the back e.m.f. using powers of ten notation and choose another answer to frame 1.

**6** Your answer is correct. Note the similarity for calculating energy storage in capacitors and inductors. In a capacitor stored energy is found from $\frac{1}{2}CE^2$ whereas, stored energy in an inductor equals $\frac{1}{2}LI^2$.

Capacitors and inductors produce opposite effects when used in circuits. Remember that an inductor opposes changes in current due to its counter e.m.f. The capacitor on the other hand opposes changes in voltage by maintaining circuit current. Capacitive current is found using the expression, $i = C\frac{\Delta E}{\Delta t}$. Actually, current does not flow through the capacitor but allows current to flow in a circuit when it charges or discharges.

QUESTION: What amount of capacitive current flows when the voltage across a 200 pF capacitor charges 25 volts in 1 μsec?

1) 500 ma . . . Go to frame 3

2) 50 ma . . . Go to frame 19

3) 5 ma . . . Go to frame 12


FIGURE 1
THE SCHEMATIC SYMBOL FOR AN INDUCTOR RESEMBLES THAT OF A COIL, ILLUSTRATING THE BASIC CONSTRUCTION.

**7** Go directly to frame 21.

**8** Your answer is incorrect. Reactances in series can be added but capacitors in series are calculated in the same manner as resistors in parallel. Thus for capacitors in series, use the formula $\frac{1}{Cs} = \frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3} + \ldots$ For two capacitors in series, this formula reduces to $Cs = \frac{C1 \times C2}{C1 + C2}$. Conversely, capacitors in parallel are added similarly to series resistors, so that $Cp = C1 + C2 + C3 + \ldots$ Apply the above formulas and choose another answer to frame 12.

**9** Your answer in incorrect. Consider the expression for capacitive reactance where $Xc = \frac{1}{2\pi fC}$. As the frequency increases the reactance decreases. At any particular frequency we can treat the magnitude of Xc as a resistor of so many ohms. As the frequency increases this resistor gets smaller and smaller. From voltage divider principles the output then decreases.

The RC circuit in Figure 6 is known as a low-pass circuit, or low-pass filter, since low-frequency signals are relatively unattenuated. Higher frequency signals become attenuated and may be blocked from appearing in the output. Go to frame 17 and begin reading with the second sentence.

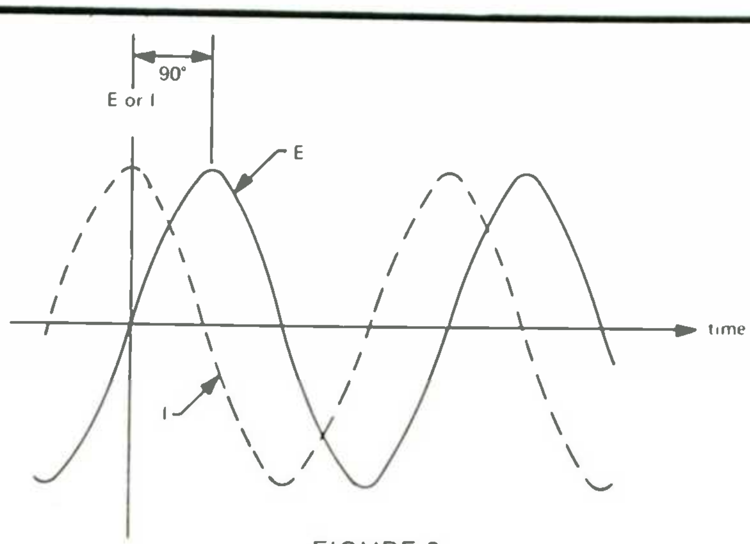



FIGURE 3
IN AN AC CIRCUIT CONTAINING ONLY CAPACITORS, THE CURRENT LEADS THE VOLTAGE BY 90°.

**10** Your answer is correct. A capacitor is formed when two metallic plates are separated from each other by a thin layer of insulating material called a dielectric. The schematic symbol for a capacitor is shown in Figure 2. If a battery is placed across the capacitor plates, current cannot flow due to the dielectric material. However, the potential across the capacitor will equal the battery voltage. An electrostatic field exists across the capacitor plates and the capacitor is said to be charged. If the battery is removed, the parallel plates remain charged until an external circuit allows the plates to discharge. The charge on the plates is expressed using the relationship $Q = CE$, where Q represents the charge in coulombs. In this expression, C denotes the value of capacitance in farads and E is the voltage across the capacitor plates. The farad is such a large value of capacitance that microfarads ($\mu F = 10^{-6}F$) and picofarads ($pF = 10^{-12}F$) are more common units. A capacitor stores energy in its electrostatic field and is calculated using the expression $\frac{1}{2} CE^2$.

QUESTION: How much energy is stored in a 1 $\mu$F capacitor charged by a dry cell to 6 volts?

1) $1.8 \times 10^{-5}$ joule . . . Go to frame 6
2) 18 joules . . . Go to frame 2
3) $3 \times 10^{-6}$ joule . . . Go to frame 16

---

**11** Your answer is incorrect. The power factor is always less than 1. Review the formula for power factor in frame 14 and choose another answer.

---

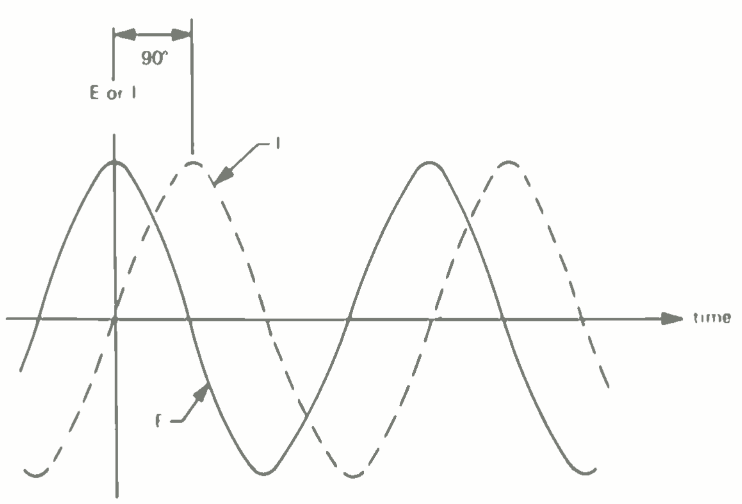



FIGURE 4
CURRENT LAGS THE VOLTAGE BY 90°
IN PURELY INDUCTIVE CIRCUITS

---

**12** Your answer is correct. Opposition to the flow of alternating current in capacitive and inductive circuits is called reactance. For sinusoids, capacitive reactance is expressed in ohms using the formula, $Xc = \frac{1}{2\pi fC}$. Capacitive reactance has a different value for each frequency and decreases as the frequency increases. For purely capacitive circuits, reactance is treated similar to resistance. Thus Ohm's law can be applied as $E = IXc$ and the reactances added in series or parallel like resistors. Note that reactance is treated like a resistance, not the capacitor. An important difference exists, however, between resistive and reactive circuits. For reactive circuits, current and voltage changes are not in step and the two are said to be out of phase. In a circuit containing only capacitors the current leads the voltage by 90°. Waveforms illustrating the leading phase angle are shown in Figure 3.

For purely inductive circuits, the opposition to changes in current is called inductive reactance. For a given sinusoid frequency, the reactance in ohms is found from $XL = 2\pi fL$. Again we can apply Ohm's law as $E = IX_L$ or treat the inductive reactance as resistance, adding in series or parallel combinations. In purely inductive circuits the current lags the voltage by 90° as shown in Figure 4.

The reciprocal of reactance is called susceptance designated by B. For capacitors $Bc = 2\pi fC$, and for inductors $B_L = \frac{1}{2\pi fL}$.

QUESTION: For the circuit in Figure 5, what is the total series capacitance and equivalent parallel inductance?

1) $Cs = \frac{1}{2}\mu f$, $Lp = 1mh$ . . . Go to frame 4
2) $Cs = 2\mu f$, $Lp = 1 mh$ . . . Go to frame 8
3) $Cs = \frac{1}{2}\mu f$, $Lp = 4mh$ . . . Go to frame 20

---

**13** Your answer is incorrect. From Ohm's law, the magnitude of the output voltage is $e_0 = \frac{Xc\, e_{in}}{\sqrt{R^2 + Xc^2}}$

Consider how Xc varies as the frequency increases and choose another answer to frame 4.

---

**14** Your answer is correct. At resonance, current and voltage are in phase since only resistance is left in the series circuit.

In ac circuits, power is dissipated only by resistors since, as was previously mentioned, capacitors and inductors both store energy. Power dissipated by

*(Continued on page 30)*

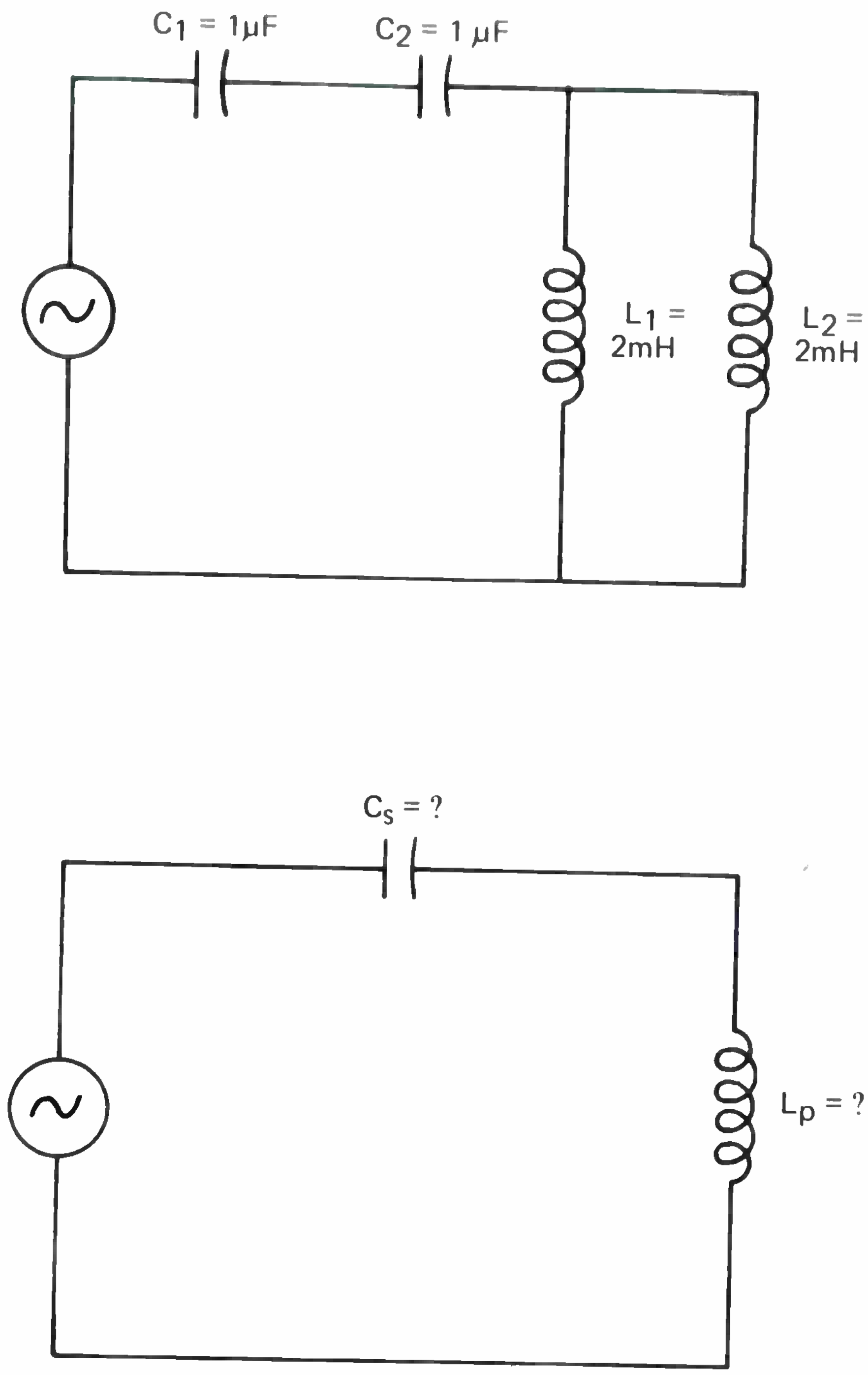



FIGURE 5
FIND $C_S$ AND $L_P$ FOR THE EQUIVALENT CIRCUIT — FRAME 12

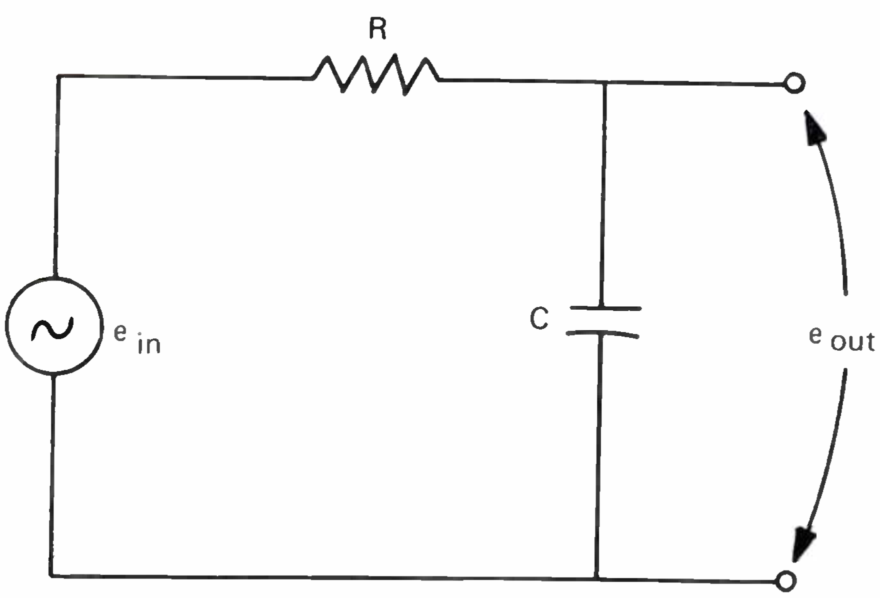



FIGURE 6
RC CIRCUIT FOR FRAME 4

the circuit resistance is called "real power" and is calculated as $I_{rms}^2R$ or $E_{rms}^2/R$. Another formula for real power is $E_{rms}\ I_{rms} \cos\theta$, where the RMS values for current and voltage are multiplied by the cosine of the phase angle. The $\cos\theta$ factor is called the power factor and has a numerical value between 0 and 1. For series circuits:

$$\text{Power factor} = \cos\theta = \frac{R}{Z}.$$

If a circuit is mostly resistive, the power factor is close to 1. At the opposite extreme, a purely reactive circuit has a power factor of 0.

QUESTION: What is the power factor of a circuit containing a 300 resistor in series with an inductive reactance of 400?

1) 0.75 . . . Go to frame 18
2) 1.33 . . . Go to frame 11
3) 0.60 . . . Go to frame 22

---

**15** Your answer is incorrect. Current changes 20 ma in 10 μsec. The $\frac{\Delta i}{\Delta t}$ factor equals $\frac{20 \times 10^{-3}}{10 \times 10^{-6}}$ or $2 \times 10^3$ amp/sec. Multiply this value by 0.3 henry and choose another answer to frame 1.

---

**16** Your answer is incorrect, you forgot to square the voltage term. Recalculate the stored energy and choose another answer in frame 10.

---

**17** Your answer is correct. RC and RL circuits can be used as either low-pass or high-pass filters. The four possible configurations are shown in Figure 7 along with graphs of magnitude versus frequency. A high-pass filter passes high frequencies but attenuates lower frequencies. Alternately as we saw in the previous frame, a low-pass filter passes lower frequencies but reduces the amplitude of higher frequencies. The frequency where the voltage output is reduced 0.707 or 3db (decibels) from its midrange value, is called the cutoff frequency. The "time constant" of the particular circuit determines the cutoff frequency as shown in the figure.

For series RLC circuits, the impedance is found from the expression $Z = \sqrt{R^2 + (X_L - X_C)^2}$ and $\tan\theta = \frac{X_L - X_C}{R}$. If $X_L$ is greater than $X_C$

*(Continued on page 32)*

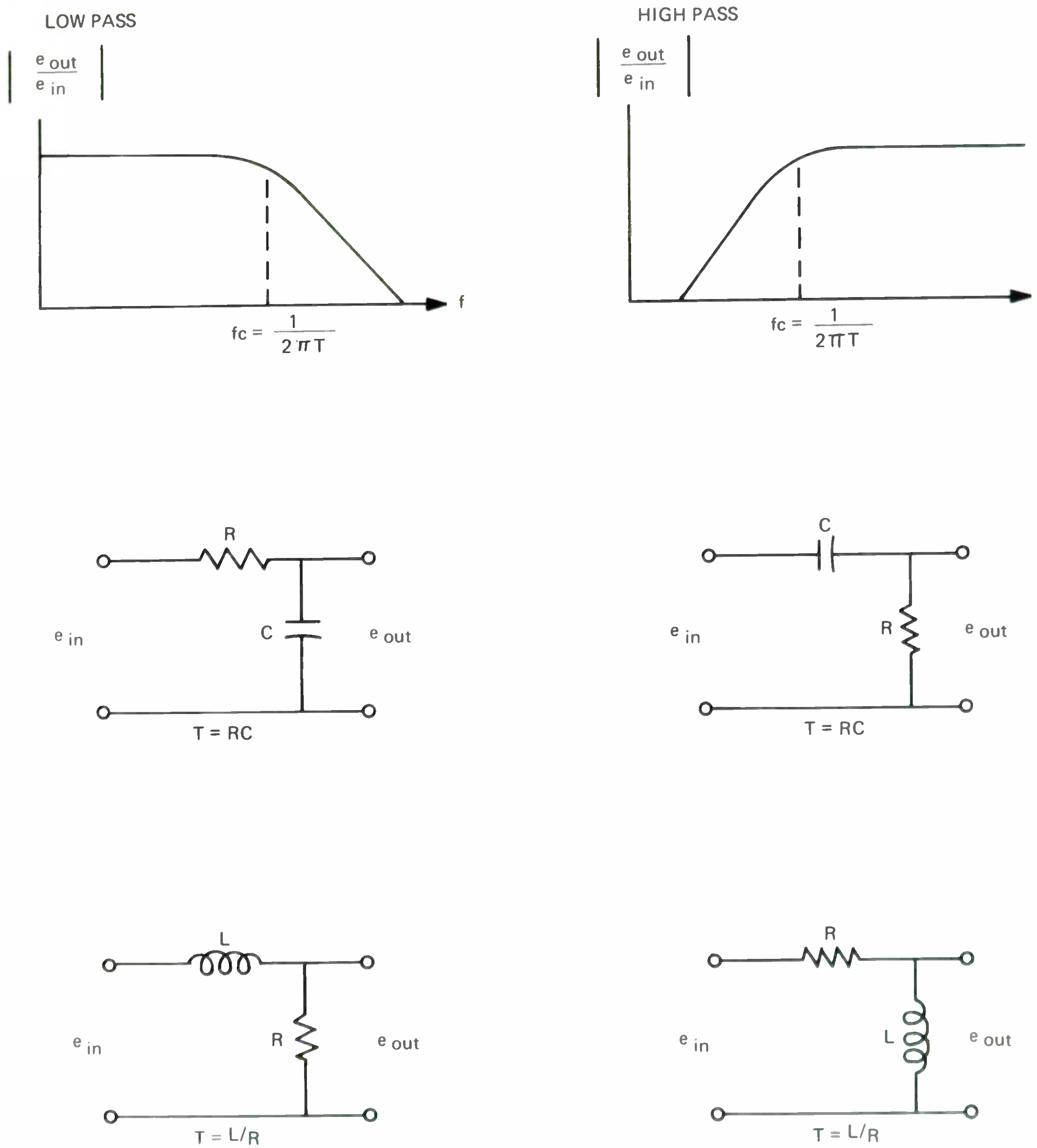



FIGURE 7

SIMPLE RC AND RL FILTERS

the RLC circuit has an impedance which is inductively reactive. When Xc is greater than $X_L$ the impedance "looks" capacitive. At one particular frequency $X_L$ will be equal to Xc causing the reactive terms in the impedance formula to cancel one another. This frequency is known as the resonant frequency and in a series circuit, current will be a maximum. The series components act like a bandpass filter as shown by the frequency versus amplitude graph in Figure 8.

QUESTION: What is the resonant frequency for the circuit in Figure 8?

1) 5 Hz . . . Go to frame 21

2) 1.6KHz . . . Go to frame 14

3) 100KHz . . . Go to frame 7

---

**18** Your answer is incorrect. Note that the power factor is the ratio of resistance to impedance not reactance. The impedance for the series circuit is determined from the expression $Z = \sqrt{R^2 + X^2}$. Find this impedance and recalculate the power factor. Then choose another answer to frame 14.

---

**19** Your answer is incorrect. The numbers used in this problem are typical values encountered in electronics, illustrating the need for the use of powers of ten in calculations. For multiplication, powers of ten are added, for division they are subtracted. The 200 pF capacitor can be expressed as $200 \times 10^{-12}$F or $2 \times 10^{-10}$F. Likewise, 1 µsec equals $1 \times 10^{-6}$ sec. The $\frac{\Delta E}{\Delta t}$ factor is equal to $25 \times 10^{6}$ volts/sec. Multiply this value by the capacitance to obtain the charging current. Then select another answer to frame 6.

---

**20** Your answer is incorrect. Inductors in series and parallel combinations can be reduced in exactly the same manner as resistors. For series inductors $L_s = L_1 + L_2 + \ldots$, and for parallel inductors $\frac{1}{L_p} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \ldots$ For two inductors in parallel, the above expression reduces to $L_p = \frac{L_1 \times L_2}{L_1 + L_2}$. Find the equivalent parallel inductor for Figure 5 using the above formula and choose another answer to frame 12.

---

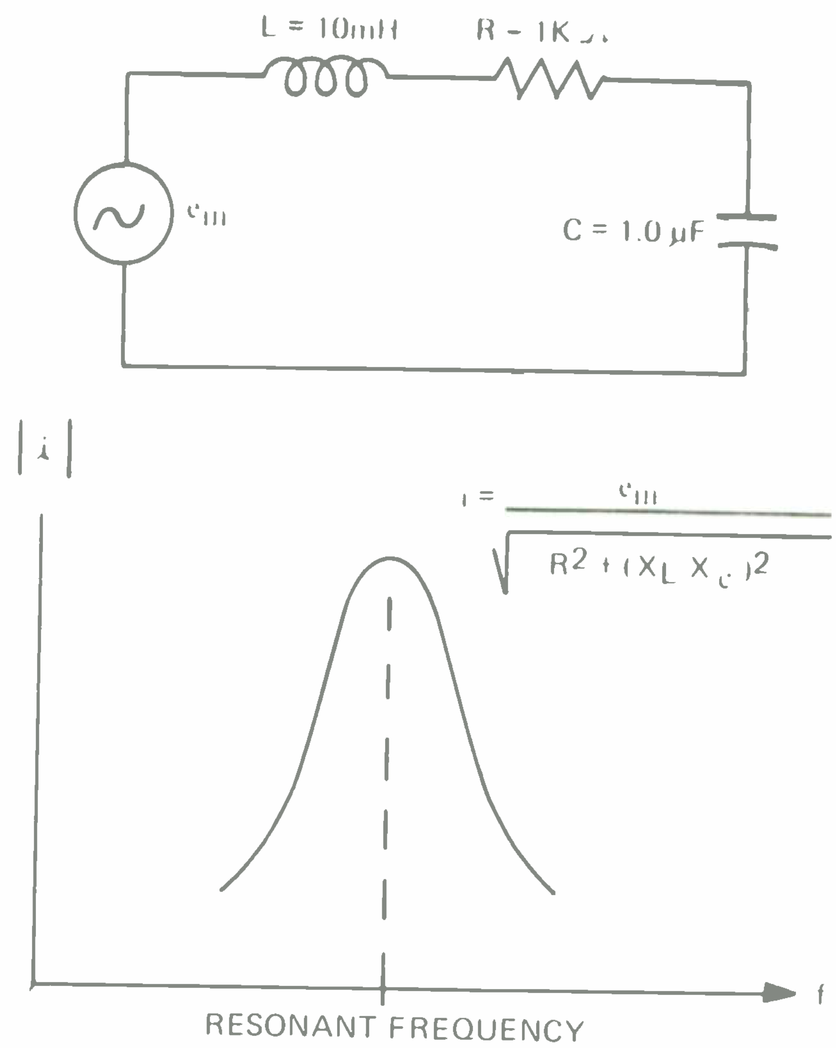



FIGURE 8
SERIES RLC CIRCUIT FORMS A BANDPASS FILTER — FRAME 17

---

**21** Your answer is incorrect. The resonant frequency occurs when $X_L = X_C$. Substituting $2\pi fL$ and $\frac{1}{2\pi fC}$ for $X_L$ and Xc respectively, and then solving for frequency results in an expression for the resonant frequency as $f = \frac{1}{2\pi\sqrt{LC}}$

Use this formula and the values for L and C from Figure 8 to find the resonant frequency. Then choose another answer to frame 17.

---

**22** Your answer is correct. In this lesson we have concentrated primarily on series circuits. Parallel and series-parallel RLC combinations are of course possible and often used in circuit applications. In general, impedances may be combined following the same rules as for resistors. However, calculations become cumbersome and exact expressions for impedance and phase angle may be difficult to obtain. Handbooks are available which show various RLC combinations with expressions already determined for impedance and phase angle. One particularly good basic reference is Allied Radio Shack's, "Electronics Data Handbook." This handy and inexpensive handbook has condensed formulas, trig tables, and other commonly used electronic data.

## TRAPPED MINERS

*(Continued)*

water, and medical supplies.

The portable shelter is also equipped with a hand-cranked atmosphere conditioner to provide fresh oxygen to the interior of the shelter or directly to breathing masks until the shelter interior is cleared of smoke or carbon monoxide. Each of the modules weighs about 4,100 pounds and can be wheeled into place by small, electrically powered vehicles or by several men.

The large, permanent shelter is designed as a 75-foot-long tunnel in rock with reinforced concrete blast walls on each end. The shelter design calls for an 8-inch pipeline to the surface to provide a channel for fresh air, communications, and additional supplies.

The pipeline would link the survival chamber with a small building housing a compressor and heating equipment to provide conditioned air. As a precaution, the shelter is also outfitted with equipment to make it self-sufficient for five days - - time enough to make the pipeline usable again.

The permanent shelter is designed to provide much more in comfort and convenience than the smaller shelter. The Design calls for such things as more comfortable bunks, better lighting, and temperature control.

### COMMUNICATE AND LOCATE

Once the coal miner has survived the dangers immediately following an explosion and has found safe refuge, the focus shifts to the surface where rescue operations have begun. The Coal Mine Rescue and Survival System could put tools in the hands of the rescue team that were not available before.

Westinghouse Electric Corporation

*A Voice Through the Earth*

One of the most valuable tools is a newly developed emergency communications system. Communications is not only the key to locating trapped miners, but a means of providing information that could enable them to survive.

The emergency communications system developed by the Westinghouse Georesearch Laboratory in Boulder, Colorado, consists of two different types of equipment. One system permits through-the-earth transmission of voice or beacon messages and the other enables rescuers to detect seismic vibrations set off by a thump from a pick, a sledge hammer, or a heavy timber.

Through-the-Earth Communications - last year several Westinghouse Georesearch engineers sat in a passageway of the Eagle Coal Mine in Colorado and listened to some raspy rock music coming from their receiver. What made the incident unusual was that the music was being transmitted through 270 feet of earth, rock, and coal from equipment on the surface directly above.

Anyone who has been confronted with the sudden silence of a car radio on entering a tunnel knows that radio waves cannot travel through earth. Yet research has shown that very low frequency waves, not much different from the frequency range of the human voice, can be transmitted through the earth.

The electromagnetic communications equipment developed by Westinghouse calls for each miner to be equipped with a miniature receiver attached to his headlamp battery case. The receiver is no larger than a transistor radio and has a retractable ear plug.

In case of an emergency the miner would immediately turn on the receiver and begin listening for instructions. The tiny unit is a receiver only, so the miner would have to use the other means provided to send messages back to the surface.

Miners who reach survival areas will have a more powerful receiver and a push-button beacon transmitter at their disposal. Those trapped elsewhere in the mine can use any heavy object available as a transmitter by slamming it against the mine wall to communicate by the seismic technique described later.

The electromagnetic transmitter sends beacon signals rather than voice to conserve its two-week battery power supply. This unit is equipped with six buttons marked "yes," "no," "unknown," "repeat," "good," and "bad."

When one of the buttons is pushed in response to a question from above, the underground transmitter sends a signal to the surface receiver where it is decoded and a corresponding indicator lights up on a display panel.

The shelter transmitter is also equipped with a manual key to answer questions by a number of pulsed responses. The manual key might be used to indicate such things as the number of men in the shelter or how many are injured.

Seismic Communications - the seismic communications system developed for the Coal Mine Rescue and Survival program is similar to equipment used to measure and locate the origin of earthquakes. In this case, however, the tremor being detected is man-made, perhaps by no more than a miner's pick.

The devices used to detect these tiny man-made tremors are called geophones and are capable of sensing vibrations and converting the energy into electrical signals. By installing a number of geophones on the surface, enough information can be fed into the system's small computer to analyze the location of the signal's origin from below.

The seismic signaling system is doubly effective when an isolated miner is also equipped with the miniature portable voice receiver - - enabling him to both transmit and receive. The seismic system serves still another purpose when used in conjunction with receivers and beacon transmitters located in refuge areas.

Once communications are established with a shelter and its occupants are safe, rescuers might call on them to install a geophone from their cache and connect it to their transmitter and receiver. The geophone would provide an underground sensing station to detect and relay vibrations from miners who might be trapped nearby.

### THE RESCUE DRILLS

Trapped coal miners most often come out the way they came in - - through the mine shaft. However, fires or cave-ins sometimes prevent reopening the mine shaft and tunnels.

An alternative is to drill a hole from the surface down to the miners and pull them out. As part of the Coal Mine Rescue and Survival program, two drills have been designed and built for this purpose using advanced techniques developed for the petroleum industry and the Atomic Energy Commission's underground test program.

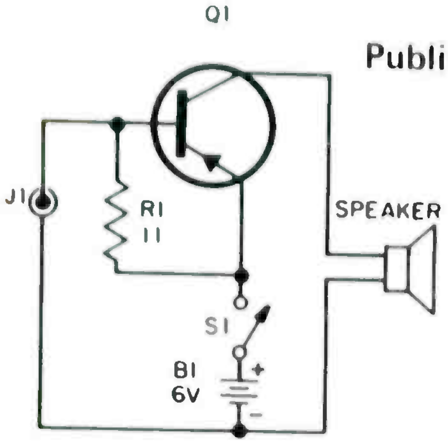
One of the drills is designed to rapidly bore a hole nine inches in dia-

*(Continued on page 34)*

# SCIENCE PROJECTS

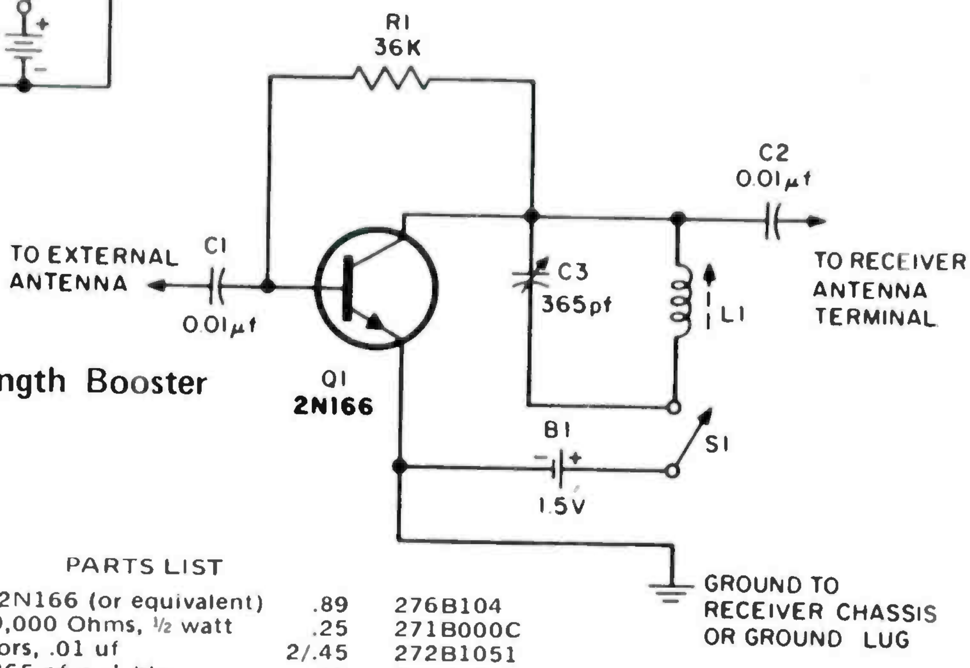
**For Students and Hobbyists**

## Public Address System




PARTS LIST

| | | |
|---|---|---|
| Q1, Power transistor, 2N174 (or equiv.) | 1.69 | 276B105 |
| R1, Resistor, 10 Ohms, ½ watt | .25 | 271B000C |
| J1, Phone input jack | .99 | 274B346 |
| S1, Toggle switch, SPST | .39 | 275B602 |
| B1, Four "D" cells | .19 ea | 23-466 |
| Battery holders (2) | .39 ea | 270B439 |
| Speaker, 2¼", permanent magnet | .98 | 40B246 |




Signal Strength Booster

PARTS LIST

| | | |
|---|---|---|
| Q1, Transistor, 2N166 (or equivalent) | .89 | 276B104 |
| R1, Resistor, 39,000 Ohms, ½ watt | .25 | 271B000C |
| C1, C2, Capacitors, .01 uf | 2/.45 | 272B1051 |
| C3, Capacitor, 365-pf variable | .59 | 272B134 |
| L1, Ferrite-Loopstick antenna | .79 | 270B1430 |
| S1, Switch, SPST | .39 | 275B602 |
| B1, Battery, 1.5 volts, "D" cell | .19 | 23-466 |
| Battery holder | .39 | 270B439 |

### Public Address System

This miniature public address system (PA) can be built right into a speaker enclosure, including power supply and other components.

The system operates when the power supply switch, S-1, is turned to the "ON" position and microphone input is supplied at "J-1", the input jack.

In operation, the power transistor, 2N174, is connected directly to the 6-volt battery power supply which in turn drives the speaker. A carbon mike of good sensitivity should be used for best results.

A low-cost speaker enclosure may be built from plans featured in the January/February, 1969, issue of Electronics Digest, "Easy-to-Build Speaker Enclosure." Reprints of that project may be obtained for fifty cents postpaid by writing to: Reprints, Electronics Digest, P.O. Box 9108, Fort Worth, TX 76107.

### Signal Strength Booster

This low-cost preamplifier circuit can give a small AM radio receiver a sufficient "boost" in signal sensitivity to allow tuning in of many distant stations. It is also a useful gadget for the experimenter to have at hand.

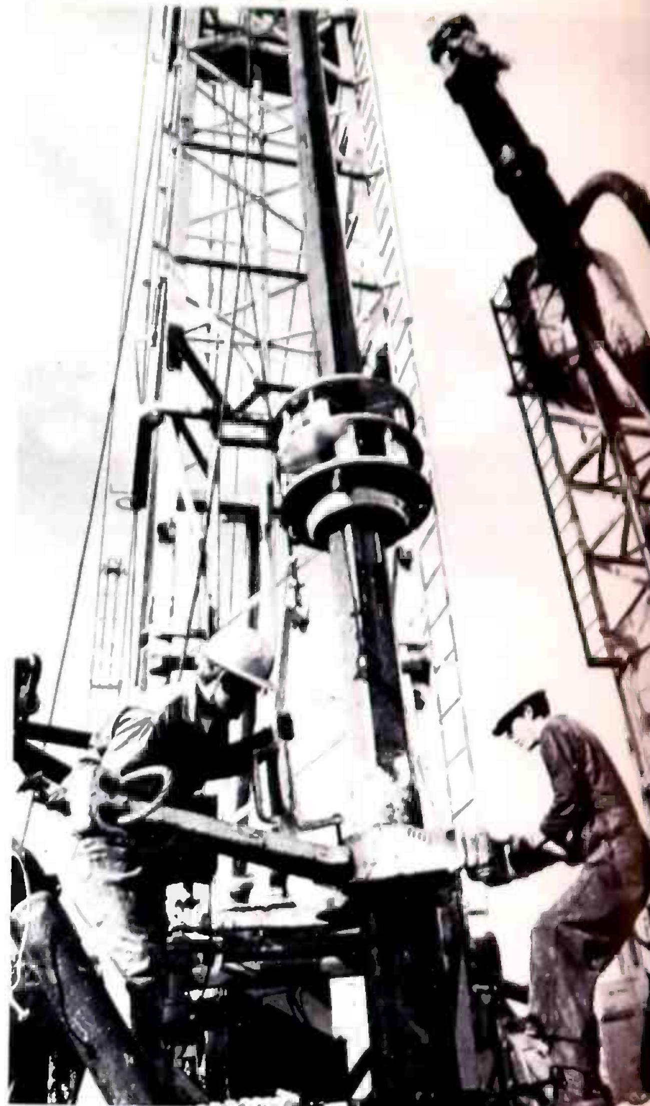
The entire circuit, which can be assembled in about one hour, can be built into an aluminum mini-box (Allied Radio Shack Cat. No. 270-235 @ .99) and attached to the back of the radio set.

For best reception, the ferrite-loopstick, L1, and the 365-pf variable capacitor, C3, should be peaked at the center of the band for regular listening, or at any particular frequency you wish to tune in with greater sensitivity.

*NOTE: Catalog numbers are Allied Radio Shack Electronic Parts Accessories and Kits, Spring/Summer, 1971, No. 212, available at their stores throughout the U. S.*

## TRAPPED MINERS

*(Continued from page 33)*



Westinghouse Electric Corporation

*Drilling Rigs for Rescue*

meter through to the trapped miners. Such a hole would provide a means of supplying fresh air, food, medical supplies, and wire communications.

Following this, crews would put the second drill into operation but proceed at the slower pace required to drill a 28½-inch-diameter hole for pulling the miners out in a personnel capsule.

The smaller drill, called a search and probe unit, can bore as fast as 100 feet every hour. The larger rescue drill operates up to 17 feet per hour.

The primary differences between the coal mine rescue drilling rigs and similar rigs in use by the petroleum industry are portability and versatility. All of the complex heavy equipment requires 22 trucks for transportation.

But the units can be broken down into modules and flown by C-130 to a nearby airstrip and carried in by heavy-lift helicopter. When transported in by truck, the drills can be put into operation in a few hours.

The drilling systems were designed and developed by Rowan Drilling Company of Houston, Texas. Rowan is also under contract to operate the drilling rigs during the evaluation test to be staged in West Virginia in January of 1971.

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