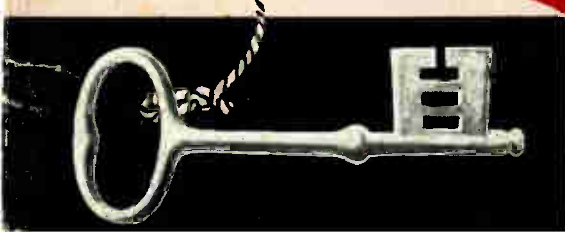
the KITE and the KEY

the story of radio, TV and electronics from a tiny spark to a great industry



CONTENTS

INTRODUCTION

THIS BOOKLET HAS BEEN produced by the Radio-Electronics-Television Manufacturers Association to tell the dramatic story of radio, television, and electronics.

The story is an important one. The science of electronics has had more impact on modern life than most of us realize.

In the field of radio and television alone, we have seen grow up within the memory of living men the greatest mass communications medium in the history of civilization.

This medium of communication is so swift that literally millions of people can be informed by it in less time than it takes a speaker's voice to reach the back rows of an auditorium. Travelling with the speed of light, radio communication can circle the globe before sound waves span that short distance from speaker's rostrum to hearer.

But the dramatic impact of communication, important as it is, is only a part of electronics development.

The scientists and the manufacturers of the electronics industry have pushed the science far beyond mere communication. They have, with their development and manufacture of almost incredible devices, revolutionized modern warfare. At the same time they have developed electronic instruments that have also revolutionized modern medicine—the science and art of healing.

They have brought electronics into our homes, too—in better telephones, music, intercommunications systems and electronic baby sitters, blankets and elevators.

They have pushed industry's mass production methods far beyond the peaks of other years. Without electronic devices, nuclear research itself could not exist.

Above all, the men and the companies of the electronics industry have made life easier and better for all of us—as well as more entertaining.

That is the story this booklet is intended to tell.

I the kite that sparked an idea

IT ALL BEGAN on a dark, thundery day in 1749. It began with a kite, bobbing and weaving high in the lightning-charged air. Down from the lashing kite ran a long cord. At the end of the cord, held in a portly man's hand, a key dangled.

The lightning flashed.

Down the kite's cord ran a charge of electricity—that force man had named for the Greek *electron*, or amber, which produced sparks when it was rubbed. It was still all but unknown then. It had only a name.

The spark jumped from the metal key to the knuckle of the man who held the cord—and the proof was delivered. Electricity was lightning. Lightning was electricity.

The man looked down at the small boy who was watching the experiment, and smiled.

You know the old story. The man with the kite was Benjamin Franklin, that almost unbelievably talented and versatile American who invented so many things—that man with the insatiable curiosity.

You might say that American radio and television—and the whole science of electronics—began with that kite and the ordinary door key that offered practical proof.

After Franklin, in many countries, came the pioneers who cut a road toward radio and television through the darkness.

In 1790, Volta made the first device for producing a continuous flow of man-made current through a wire—the simple battery. Sir Humphrey Davy found a way to use the battery to maintain a spark between sticks of charcoal, making a powerful arc-lamp that (like Franklin's spark) was one of the ancestors of Marconi's spark-gap wireless transmitter.

In 1821, Ampere discovered electro-magnetic induction. Faraday, in the same year, made a current spin a magnet—and then reversed his discovery to make a spinning magnet produce a current in a hollow coil of wire.

A basic theory. But the really revolutionary discovery came 46 years after Faraday. James Clark Maxwell, the theoretical physicist, working in England, published his proof that electro-magnetic energy travels through space in waves, at a definite rate—and that its speed is the speed of light, 186,000 miles a second.

That was the basis of radio and television as we know them now.

But much remained to be done. It was 40 years after Faraday's suggestion that ether waves existed—22 years after Maxwell's theory—that the German Professor Heinrich Hertz put both theories to the test. He actually created and detected wireless waves in his laboratory. Sir Oliver Lodge, at the University of Liverpool, improved on the test. In 1895, the Russian Professor A. S. Popoff, at the University of Kronstadt, duplicated Lodge's work.

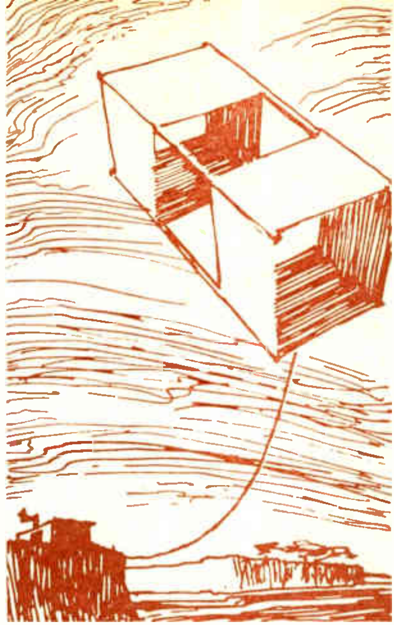
But now it was time for the second great development.

All these pioneers were theoretical men, working in laboratories. The commercial development that must follow, if any such discovery is to be made practical, was only to begin in the late 1890's.

In the United States, especially, where the telegraph was already spanning great distances with wires, these first theories led to deep interest.

Western Union was naturally curious about any theory that would eliminate wires. The American Bell Telephone Company also began research. The electrical manufacturing industry joined in the tests—Edison, General Electric, Westinghouse, Western Electric, and others. New companies, with new capital, were formed. The practical commercial research had begun.

II the kite that sparked a modern miracle



THEN, 152 YEARS after Benjamin Franklin, there came into the story another kite--and another key!

This kite flew in wintry winds over St. Johns, on the high cliffs of Newfoundland. But this time the key was 1,700 miles away, in Poldhu, in the British Isles. It was a telegraph key, modified to produce a spark in a gap when the key was depressed.

On December 12, 1901, an operator in Poldhu sat working the key steadily, making the spark in the gap spell out one letter in Morse code—the letter "S"—three dots. He had chosen it because it was a signal easily understood.

In Newfoundland, young Guglielmo Marconi had flown the kite, because his receiving antenna was not high enough to pull in the faint signal from across the Atlantic.

Hoisted high by the kite into the winter sky, the antenna at last picked up those weak waves from England—and the first trans-Atlantic wireless transmission and reception had been achieved.

Behind that simple, but epoch-making, event lay five years of astonishing work and progress.

Marconi's beginning. Reading in an Italian electrical journal, one day in 1894, an article on one of those early theories—on the German Hertz's work with radio waves—the young Marconi had set out to improve on it in his home workshop. After the dramatic trans-Atlantic transmission, contracts with Lloyd's of London and the British Admiralty, which recognized the safety value of wireless, followed.

But Americans were taking the same lines of development. The American De Forest Wireless Telegraph Company managed to make equipment cheaper than Marconi's—and sold it outright to the U. S. Navy, which had refused to lease Marconi's gear because it needed its own equipment.

Prof. Reginald Fessenden, of the University of Pittsburgh, became the first notable American experimenter in 1900, leaving the university to help the Weather Bureau devise means of using wireless telegraphy in weather forecasting.

It was in December of 1900 that Fessenden first transmitted *speech* by wireless. After Prof. Ambrose Fleming developed the "Fleming valve," a crude forerunner of the vacuum tube, development moved faster. With a new high-frequency alternator, Fessenden added more and more power to his new transmitter. And on Christmas Eve, 1906, he broadcast to ships at sea a program of music and speech that astonished every ship's wireless operator on the North Atlantic.

Fessenden also gave us the heterodyne circuit, a development often called "the second greatest in radio."

The vacuum tube. The first greatest, of course, was the vacuum tube invented and developed by Lee De Forest—the triode tube that made all modern radio and television possible.

Scientists and radio men have called this invention "so outstanding in its consequences that it almost ranks with the greatest inventions of all time."

Meanwhile, more of the great American companies were beginning to make their presence felt in radio.

American Telephone and Telegraph collaborated with Fessenden in 1906, as did General Electric. Westinghouse research began to loom large in the commercial field. Radio Corporation of America was formed in 1919, with Owen D. Young as its first president, and David Sarnoff—now its leader—as the first commercial manager. Sarnoff, incidentally, was the young wireless operator who had picked up the first dramatic distress signal from the sinking *Titanic.*

The most recent significant development in radio broadcasting came with the introduction of FM in the middle 1930's. While FM was almost as old as AM, or "standard" radio, in theory, its potentialities for broadcasting with a minimum of static and with wide-range fidelity of sound were not fully realized or put to use until Major Edwin H. Armstrong, an inventor and engineer, developed the first FM systems for commercial adaptation. Others followed his lead and offered varied FM circuits. For a time, FM experienced a mild boom.

The overshadowing public interest in television, plus economic factors and the strongly established position of AM stations, however, prevented or postponed the full flowering of this new service.

And then came television. Not suddenly, of course. It had begun developing as early as 1862, when the Italian priest, Abbe Caselli, devised a crude system of photo-telegraphy. By transmitting, over a wire, small segments of a picture until the complete photograph was put together at a distant point, very slowly, he invented the grandfather not only of modern television but also of the telephoto newspictures we now take for granted in our modern newspapers, as well as facsimile broadcasting that transmits whole newspapers.

This gadget was popular in France at the time, as a means of transmitting telegrams in the sender's own handwriting. Napoleon III backed the invention, but it was not practical at the time.

The German engineer, Paul Nipkow, in 1884, invented a scanning disc with spiral holes and cells that would transmit a moving picture by wire—but the receiving apparatus was never perfected.

Not until Ferdinand Braun developed the cathode-ray oscilloscope in 1897 did progress toward television really begin. This was a tube in which an electron gun squirted electrons at the back of a fluorescent screen, or tube-face, producing light patterns on the screen. This was the beginning of the modern television tube.

But a complete electronic television system was impractical until Dr. Vladimir K. Zworykin developed the first iconoscope—an amazing camera which could break down a picture into the smallest elements of light—and until Farnsworth developed his image dissector. These two developments led to the television camera as we know it now.

Early in the 1930's Dr. Allen B. DuMont, who now heads a manufacturing company and a television network, was engaged, along with other scientists and engineers, in transforming the cathode ray tube from a laboratory experiment to commercial practicality. This work led to the development of the picture tube for the all-electronic television receiver.

Commercial development. During the rapid development of television invention and research, before World War II, the old principle was again demonstrated: commercial possibilities were out of reach until the major companies began to push forward their own research on a large scale, based on laboratory developments.

But here a difference appeared. Television's development was faster, easier, broader and deeper because radio had preceded it. Decades of experiment with radio circuits had taught engineers what they would do, what vacuum tubes could be expected to do. So television grew faster.

Again companies large and small—some small in the beginning and great now—took part in the push forward. Their progress looked forward, for its fruition, to the day when television would be both practical and commercial, both inexpensive and widespread. It looked forward, in short, to our own time.

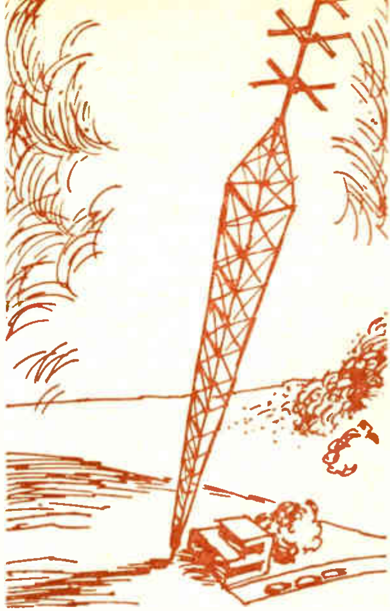
The broad commercial development of television began to show itself about 1947, when slowly spreading broadcasting stations began to make their impact felt.

This spread was delayed when the Federal Communications Commission, soon after, "froze" station construction and the grants of new licenses for television stations, to develop a plan for the allocation of new frequencies.

These new channels had been opened by more research—in the very midst of television's growth. All in the ultra-high frequency ranges, they multiplied many times the number of television stations possible in the nation.

The commercial development had only begun, but it was already a long way from the crude kites of Franklin and Marconi.

III sounds and pictures in the air



RADIO Radio and television are miracles of modern science. But it is significant of the high standard of living in modern America that we mostly take these miracles for granted.

Fifty years ago, the average American would have called you crazy if you had suggested that in the short span of half a century he would be listening to a symphony orchestra more than 2,000 miles away—or watching a comedian slapped in the face by custard pies an equal distance away.

How do these miracles work? How is it that sounds and light waves can be picked up by microphones and cameras, turned into some kind of energy that will travel great distances through wire and air, picked up by distant antennas and turned back into sounds and sights by tubes and wires?

Let us look at the strange and wonderful things that must happen to sight and sound in the broadcast process.

How the microphone works. Sit at a piano and strike the A above middle C. The sound you hear is produced by a piano string vibrating 440 times a second. This vibration produces corresponding vibrations in the air, which in turn produce corresponding vibrations in your ears.

The radio microphone—and the television microphone, too—is modern electronic science's substitute for the human ear. It responds to those 440 vibrations a second much as your ear does. But there its resemblance ends.

Inside the sensitive microphone, a tiny ribbon is set to vibrating 440 times a second when you strike that A on your piano in the studio.

These vibrations are instantly translated into electrical current that also pulses 440 times a second. This current, moving along the microphone cable, passes into the complex instruments of the radio control room.

Here powerful amplifiers build up the current (and its 440-cycle vibration). Complicated instruments shape it into the quality the control engineer wants it to have for the best broadcasting.

Thus built up in strength and quality, the vibration passes along more cables, beyond the studios of the radio station, to the transmitter, where it will be put on the air.

The transmitter. Here another kind of vibration gets into the picture—the steady, fixed vibration of the transmitter's "carrier wave." This wave must itself vibrate at a frequency assigned by the Federal Communications Commission, which acts as a technical "traffic cop" of the radio waves, so that stations will not interfere with each other. Let us say the station you are listening to is assigned a frequency of 600 kilocycles. That means you will find it at 600 on your radio dial (or 60, if your dial is calibrated briefly). The carrier wave, which carries the sound through the air to your radio receiver, must pulse at 600 kilocycles or 600,000 cycles per second.

This has nothing to do with the sound waves vibrating 440 cycles per second, of course. One is sound, the other is the electro-magnetic energy that carries through the air.

This carrier wave is of such a kind of electro-magnetic energy that it can be modulated (or altered) into patterns that will match any sound frequency we wish to superimpose on it. This carrier will then transport these sound frequency patterns, transformed into electro-magnetic energy, through many miles of space, ready to be picked up by any radio receiver tuned to the same frequency as the transmitter's carrier wave.

Waves in the air. So the sound, translated into vibrations of electro-magnetic energy, gets into the air (or aether, as the scientists call it), travelling along the carrier wave of energy from the transmitter. These waves, of course, may be of two kinds—the kind we know as "standard" radio (AM, or amplitude modulation) and the kind we call FM, or frequency modulation.

One principal difference between the two is the frequency at which the waves vibrate. FM waves are higher in frequency, lying in the area between 88 and 108 megacycles—or much faster than ordinary radio waves vibrate. A megacycle, by the way, is 1,000 kilocycles, or 1,000,000 cycles.

Another principal difference lies in the way in which the waves are modulated to carry the sound after it has been turned into energy. Ordinary radio waves are modulated in amplitude, or size. In FM, frequency, or speed of oscillation, is modulated. This means, among other things, that FM can carry wider ranges of sound—so wide a range, in fact, that its highest notes may be well above the top-most range of human hearing. FM could transmit the squeak of a bat, but only a few people with abnormally acute ears could hear it, even if most home receivers would reproduce it. FM also has the advantage of being resistant to many kinds of static interference—the noise made by electrical appliances, lightning storms, and the like. AM stations can transmit high frequencies and a wide range of sound under the best conditions, but they are prevented from doing so by insufficient channel space. Because of congestion in the AM band, the Federal Communications Commission has restricted its capacity in this respect.

However, FM has a limitation not shared by ordinary radio waves. Theoretically, FM transmissions are limited in range to the practical horizon of the earth. This is true because, being high frequency signals, very near the frequency of light waves, they are what physicists call "quasi-optical." That means they behave as light waves do. They will not bend around the curve of the earth unless they are reflected or refracted, as light waves may be. When they reach the horizon, they go off into space in a straight line. They are so short, also, that they pass through the Heaviside-Kennelly layer (an ionized layer about 20 to 25 miles up), without being reflected, as are radio waves of the older kind. Actually, we now know that FM waves frequently are received far beyond the horizon, sometimes at very great distances under special conditions.

Your home receiver. Whatever kind they may be, these waves of energy are now ready to strike the antenna of your home receiver. Or, to put it another way, they are passing through the air, ready to be picked up by your antenna—whether your antenna be wires high above the house or merely a built-in loop inside your radio set.

When the waves strike this antenna, they set up in its wires a current having the same character as the carrier waves. This current is passed along to the so-called "radio-frequency" portion of the receiver. Here condensers and wire coils "tune" the set to the same frequency used by the station transmitting these waves of energy and sound translated into energy.

The detector portion of the set separates the sound-energy from the carrier wave energy. The portion of the energy carrying the modified sound is passed along to the audio (sound) amplification parts of the set.

Here sensitive vacuum tubes build up this tiny energy in an amplifier. The powerful amplifier passes along the built-up energy to the loudspeaker.

Until it reaches the loudspeaker, this energy is still in the form of an electrical current, vibrating at the same frequency of the original sound wave. You will remember that the sound we saw being transmitted was the A above middle C on the piano—so that the energy being transmitted was vibrating at that frequency, 440 cycles per second.

This vibrating electrical energy, reaching the magnets of the loudspeaker, causes them to push and pull, backward and forward, the diaphragm of the speaker. This diaphragm, vibrating 440 times a second, translates the energy back into sound waves, which move out into the room and produce the sound of the piano which was struck in the radio studio.

TELEVISION Generally speaking, the waves that bring television into your home, with its combination of sound and pictures, are transmitted and received in the same way.

But there are vast differences in the picking up of the pictures by the television station, and in the receiving of the pictures by your television set at home.

First, television waves are of very high (and ultra high) frequencies, some higher than FM waves. All television sound, too, is transmitted by FM. Television sight or picture waves theoretically behave much as FM waves do, being limited to the practical horizon—travelling in a "line of sight"—though they too are often received beyond the horizon.

How the camera works. When a television camera is focused on a scene to be picked up, it looks much like a motion picture camera. In the way its lenses pick up and concentrate the light, the television camera *works* in the same way a movie camera does, too. But there real resemblance ends. The television camera uses no film.

Instead, the lenses concentrate the light patterns they pick up on the face of a special tube—known as an iconoscope or image orthicon. This tube has on its face about 367,000 microscopic dots, each of which reacts to light as a photoelectric cell does. If light strikes one of these dots, it sets up in the dot an electrical charge in proportion to the *amount* of light. The brighter the light that strikes the dot, the greater the charge. No light, no charge. So the light-and-shadow pattern of the scene being picked up forms an identical light-and-shadow mosaic on the tube's face. Other kinds of tubes vary slightly in operation.

While this is going on, a tiny beam of electrons is "scanning" the inner face of the tube. This beam sweeps from left to right, then returns and sweeps from left to right again—just the way your eyes follow the words on this page, but much faster. In fact, this beam scans 525 lines, from top to bottom of the tube face, 30 times each second.

As the beam sweeps over each dot, it picks up its current (light or dark), and then wipes the dot clean for the next impression. Thus the beam itself takes on a pattern of electronic energy matching that of the dots.

This pattern is passed along to amplifiers and to the transmitter, where it is put into the air on a wave of energy.

Your home receiver. After travelling through the air to your receiver, this pattern of energy goes through a reversed process. Each dot pattern, as it is received, is passed into a streaming beam of electrons inside the big picture tube. This beam is sweeping back and forth across the inner face of the tube, just exactly as the scanning beam did in the camera's tube.

The inner face of your picturc tube is fluorescent. It is coated with a material which glows when bombarded by electrons. So the pattern —now light, now dark—is superimposed on the inner face of your picture tube, so that you see on the face of the tube the same picture the camera "saw" in the studio.

This picture is thus made up of "lines" and "dots" of light and darkness, much as a newspaper reproduction of a photograph is.

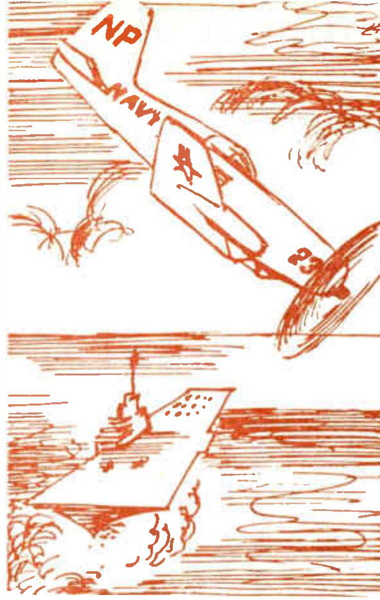
You never see a complete, static picture at any given instant, of course, since the scene in television is moving. But the habit of your eye in retaining such a picture for a fraction of a second—known as "persistence of vision"—keeps the picture from looking jerky.

*

So it is that sound and pictures are transmitted through the air to your home receivers—radio or television.

Only fifty years ago, people were saying it was impossible. But the pioneers, who had been working toward it ever since Benjamin Franklin flew his history-making kite, knew better.

IV exploring the unknown



WE HAVE SPOKEN OF the "frequency" of the carrier wave which transmits the modulated sound-energy through the "aether." These two terms need a little more explanation, to be perfectly clear.

Actually, "aether" or "ether," in the physicist's sense, cannot be defined exactly. Even the best simple definitions refer to it simply as a medium filling all space—a medium in which electro-magnetic waves may be set up and transmitted. You may imagine it, if you like, as being a very thin element, in which ripples and waves will travel.

The frequency of these waves—the rapidity with which they vibrate or pulsate through the ether—is what makes them capable of being separated from one another, so that many transmissions may go on at the same time.

The frequency spectrum. Radio and television are only a small part of the total range of frequencies possible in the whole spectrum. And commercial radio and television are only a very small part of that small part of the whole spectrum. The total range of frequencies stretches from vibrations below the range of human hearing—subaudible frequencies used for power—to the incredibly high frequencies of cosmic rays. They are arranged in the spectrum according to their wave lengths. Large areas of this spectrum are still virtually unknown—exciting fields for the explorer.

The radio and television portion of the spectrum is the only part that need concern us here, however. The frequencies used in this radio spectrum for communication are measured in kilocycles and megacycles. One cycle is one complete electrical vibration. A kilocycle is one thousand cycles, a term used for brevity and convenience. A megacycle (a similarly convenient term) is one thousand kilocycles —or a million cycles. "Kilo" means thousand, as you know, and "mega" means million.

Before the second World War, the radio spectrum ranged from 10 kilocycles to about 300 megacycles. During the war, for instance, fighter and bomber aircraft used frequencies as high as 300 megacycles, for static-free communications. Navy ships used similar frequencies for security, since such short-wave transmissions cannot readily be picked up at great distances by an enemy. Thus a new use was found in a frequency's very limitation.

Since the end of the second World War, new developments have pushed the useful range of radio communications up beyond 30,000 megacycles. Hitherto unknown spectrum space is still being explored.

The broadcast portion of the spectrum, in which we listen for news, entertainment and information on commercial radio stations, lies between 540 kilocycles and 1600 kilocycles. Below 540 are frequencies used by radio aids to air and sea navigation. Above 1600 kilocycles, stretching upward, are frequencies used for long-distance short-wave communication, FM, television, experimental and developmental work, radar, and other aids.

The standard broadcasting band is only one thirty-thousandth of the entire known spectrum!

The radio channels. Within this radio "band," for instance, segments allotted to radio stations are called "channels." Each standard radio channel is 10 kilocycles wide. Since this width would allow only a few stations to broadcast between 550 and 1600 kilocycles, if each channel were allotted to one station only, a careful system of allotment is necessary.

This allotment is the work of the Federal Communications Commission in the United States—and of other governmental agencies in other nations. The FCC "polices" the air, so that stations do not interfere with each other. There are now about 2,500 standard radio stations using the frequencies in this band, as well as about 600 FM stations, in the United States. In the television band, growth is still going on.

In the case of standard radio, directional antennas are used to reduce interference between stations.

To prevent international interference, frequency international conferences are held all over the world. In these meetings, treaties are drawn up to parcel out the available spectrum space among the nations of the world. This, obviously, does not always prevent interference. But world radio would be chaos without such agreements.

Many other services must also share this spectrum of radio and television frequencies. Among them are:

International broadcast: not merely the Voice of America, but also the Armed Forces Radio networks, commercial short-wave stations, and the like.

EDUCATIONAL BROADCAST: stations assigned to schools.

MISCELLANEOUS BROADCAST: remote pickup stations for FM, sports, television, etc., and developmental stations.

GOVERNMENT RADIO: about 35,000 allocations, including all military (Army, Navy, Air Force and Marine Corps).

SAFETY AND SPECIAL RADIO: includes marine radio, aeronautical radio, police, fire, forestry, railroad and public utilities radio.

MISCELLANEOUS SERVICES: include geological radio for oil exploration and other uses, provisional radio for construction projects, relay press radio for newsgathering, motion picture radio for use on location, and state guard radio.

EMERGENCY RADIO: special services for time of disaster, operated by the Red Cross, utilities, American Legion, National Guard, and other organizations engaged in relief work.

EXPERIMENTAL RADIO: for research into new fields.

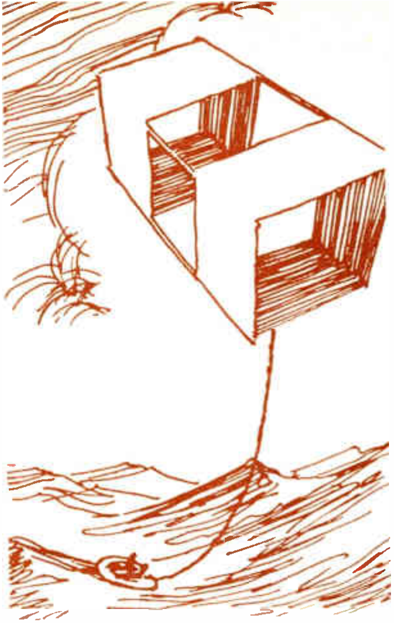
Mobile Radio, Industrial Radio, Citizens Radio, Common Carrier

Radio for commercial messages, and many others round out the vast picture.

Perhaps the largest and most vital of these types, of course, is military radio. Modern warfare is wholly dependent on instantaneous communications. New techniques for the use of television, to allow commanders to see the battle at a great distance, are being developed also.

Amateur operators, the so-called "hams", occupy large areas of the spectrum. Like frontiersmen and pioneers, they have blazed trails for many commercial services by proving the practicality of many unused frequencies for communications.

V the man-made brain



HERE ANOTHER KITE and another key enter the continuing story of electronic communications, for radio and television in your home are only a small part of the field of electronics.

This kite flew for the first time during World War II. It flew first in the clear blue air of the Pacific Ocean—that unbelievably clear sky in which visibility is sometimes a full 75 miles—a far cry from the murky sky of Franklin's kite and the dark winter air of Marconi's kite.

The cord of this kite was an antenna, like Marconi's. It led downward to the sea's heaving surface, where a small yellow life raft of rubber floated, bearing two men.

This raft carried the key, too. It was an automatic key, inside a compact, water-proof transmitter called a "Gibson Girl" by the castaway pilots and aircrews who had to use it in emergency.

As the man on the raft cranked a handle on the side of the "Gibson Girl," the key inside transmitted a continuous automatic distress signal.

Many miles away over the sea, ships and aircraft picked up the signal, triangulated on it for bearing and range, and turned to steam and fly toward the castaway aircrew, bringing rescue.

Symbol of progress. Not an important modern development of electronics—except that it saved many men's lives during that war.

But it was a kind of symbol. It stood for the vast contribution of the electronics industry to a war which could not otherwise have been won. That was the war they called "the electronic war"—and with good reason.

Remember those dark days of 1940, when the German Luftwaffe was striking at England with all its strength? When Winston Churchill said that "never in the history of human endeavor have so many owed so much to so few"—the Royal Air Force's fighter pilots? When convoys punched relief and supplies through the Luftwaffe-dominated Mediterranean sea to Malta and Egypt?

Survival was possible then only because radar directed the fighters to the Luftwaffe's bombers, because skilled "fighter directors" watched the enemy on radar screens and controlled pin-point interceptions.

Remember when a small force of American carriers in the Coral Sea defeated a great Japanese task force—and then turned north to Midway to annihilate a Japanese fleet moving to invade the island and bring our fleet to battle?

We had radar, and fighter directors. The Japanese had only crude surface radar—and no fighter direction. The difference was victory.

Radar's simplicity. Radar, the miraculous device that sees through clouds, fog, or the blackest night, at great distances, is actually very simple—once you know how it works. A high frequency radio transmitter sends out brief (a fraction of a microsecond) pulses of tremendous energy, so tremendous that it can be transmitted only in such short pulses. These pulses strike an object to be detected (an airplane, a ship, a shoreline, or anything else), and bounce back to their source, where a radio receiver picks them up.

Transferred to a screen much like a television screen, but much simpler, these pulses tell how far away the object is and in what direction—direction and range.

It is from the initial syllables and letters of these words that radar gets its name: **RA**dio **D**irection **A**nd **R**anging. During the final years of World War II and in Korea, radar also allowed precision bombing through heavy layers of cloud, through which no human eye could see.

Radar was only a small part of the victory in that war. The "magic" machine that broke the Japanese Navy's codes and told us what they were planning was an electronic "brain." The proximity fuse was a tiny electronic brain carried by anti-aircraft and artillery shells, to detonate them and destroy their targets without contact. It saved London from the buzz bombs. Our Navy called it the second most important weapon of the war.

Analogue computers with electronic brains directed gunfire. Electronic brains helped make the atomic bomb possible. Aircraft, then and now, carried electronic equipment worth 30 to 40 percent of their total value.

In 1944-45, when electronic production for the war hit its peak, over four and a half billion dollars worth of such equipment was turned out by American industry alone.

But most of these devastating weapons and equipment have since turned to peacetime uses, too. Even while other military emergencies have brought them back into use, their uncanny skills have served us peacefully.

In your home. Beyond the millions of radio and television sets in American homes, electronics goes a long way. About 95% of American homes now have at least one radio set. Television is approaching that figure as rapidly as it moves into new areas.

But that is only the beginning.

Your telephone would not be possible in its modern form without electronics. Music would be reproduced mechanically from scratchy records—not the high-fidelity long-playing vinylite recordings you now play through fine instruments.

Apartment buildings now use electronic controls for elevators. So do some office buildings. Some are experimenting with television to announce visitors. The future is unpredictable.

Industrial electronics. In modern industry, electronic devices control motors and other machines; sort, test, measure and count products of all kinds; prevent accidents. Printing presses rely on electronic controls to insure exact register and ink distribution.

Steel mills use electronically operated cutters to shear sheet steel accurately, while it travels through the rolling process at 2,000 feet a minute. Electronic devices pilot airplanes over great distances, or bring them safely into landings when pilots cannot see at all. Electronic controls sort steel bearings accurately within one twenty-thousandth of an inch; count pills at a rate of 15,000 a minute; package buttons, screws, nails, and many other small objects. Electronic testing machines find flaws in steel rails, textiles, foods, and other items.

Electronic heating has speeded up hardening of metal parts—gears, cutting tools, shafts. It aids soldering, welding and brazing operations.

Electronic devices vulcanize foam rubber mattresses; mold plastic articles, make furniture plywood. They sole shoes; sterilize packaged food products; thaw frozen fruits; and melt chocolate for bakeries.

The chemical industries could not flourish without the electronic tubes that rectify current—especially for the making of aluminum.

Television electronics make possible the watching of otherwise dangerous atomic and radioactive materials in the manufacturing and experimental processes. Large businesses and industries use television for conferences between groups many miles apart.

Computers, which are electronic machines, solve problems for engineers and scientists that would require hundreds of years of mathematical calculations—and come up with correct answers in a matter of seconds. These machines are so close to the human brain in power and complexity that they have long memories—and are subject to nervous breakdowns.

Research and medicine. Nuclear research could not exist at all without electronics. The cathode-ray oscilloscope, the spectrometer and the electron microscope are the primary tools of this kind of research. Electronic computers, or "brains," are also used in this research to shorten long and laborious calculation.

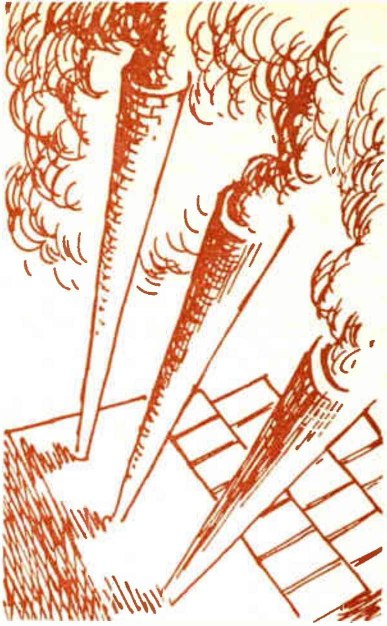
Your doctor has used X-rays for many years. He knows well, too, the electrocardiograph that diagnoses heart ailments, the electroencephalograph that probes the brain, the electronic machines that test paralyzed muscles, the diathermy machines that heal with heat and short waves, the phototubes that study internal organs. And there are many others.

For pure research that may lead to inter-planetary travel, the most dramatic of all electronic devices are those that ride on the huge rockets now being shot high into the void outside the earth's atmosphere. These send back information of every conceivable kind—data no man could collect himself in those empty spaces.

In short, man has made of electronics, in the brief half century of progress, an extension of his own brain. He has come very close to making another brain.

VI

the industry behind the science



ONE OF THE MAJOR reasons for America's great industrial development is that scientific developments have been quickly translated into products of practical use to our citizens.

The radio-television and electronics industry is an excellent example. First came the lonely, theoretical scientist who developed the theory. Franklin, for all his practical mind, was such a man. So was Hertz. Then came the applied science. Men like Marconi applied the theory to wireless communication.

But it was not until industrial ingenuity realized the commercial possibilities of this new mode of communication in the form of radio broadcasting that the electronics era began. The applications engineer, while he did not entirely replace the theorist, took over the job of making radio a household word.

The beginning. The radio industry—as distinct from the electrical industry which pioneered wire communications—made its appearance early in the 1920's as the first radio broadcasting stations came on the air. Some of its pioneers began as home producers of crystal sets and grew as the industry moved from the battery operated to the electrically powered radio.

In April, 1924, the Radio Manufacturers Association was formed in Chicago by a small group of men who sensed and believed in the future of this infant industry. Twice in recent years it has expanded its name to include "Television" and "Electronics".

Spurred by such broadcasting achievements as the coverage of the 1924 political conventions, public interest in radio multiplied set sales so that in 1925 manufacturers produced and sold 2,000,000 receivers. Just as this fledgling industry seemed well on the way to prosperity, the recession of the late twenties and the depression of the thirties slowed it down to a walk. Consequently, it was not until 1939 that its annual net production passed the 10,000,000 mark. Then came World War II and a cessation of the manufacture of radios for civilians until late 1945 after V-J Day.

The industry expands. While World War II temporarily halted the radio boom, it brought about a rapid and extensive expansion of the radio industry. Electronics devices soon proved their efficacy in navigation of planes and ships, in detection of enemy targets, and finally in timing the explosion of shells as well as in communication.

From a civilian output valued at $250 million at the factory, the industry rose to a peak annual production rate of $4.5 billion in 1944-45. Between 1942 and 1946 manufacturers produced $7.5 billion worth of radio, radar, and electronic equipment and components for military use. Employment multiplied several times and reached a peak of 550,000.

In his war-end review, J. A. Krug, Chairman of the War Production Board, said: "All in all the communications and electronics industry need make no apologies, even to atomic power, for the magnitude of its contributions to the pre-invasion signing of the surrender terms in Tokyo Bay."

Post-war reconversion. With the world at peace again—for a time—the radio industry turned quickly to peacetime production and the problem of utilizing its greatly expanded facilities.

Because no radios had been built for civilians for almost four years, there was a ready market for a time. Technical improvements and the development of a staticless transmission—frequency modulation (FM)—stimulated the public appetite for the post-war radio, as did the long-deferred public desire for new sets.

But the big boom was yet to come. Television, which had made its commercial debut just a few months before Pearl Harbor, was ripe for development. While TV broadcasting and manufacturing were closed down during the war, research for the military services, especially in cathode ray tubes, advanced television even then. However, time was needed to build TV stations and for manufacturers to tool up for a much more complicated device than radio had ever been, and so it was not until 1947 that volume production of TV sets got underway. Within three years the annual output of these new entertainment devices had reached 7,400,000. Then came the Korean War.

War and Peace. When the United Nations moved into Korea to stem the Communist invasion of South Korea, the radio-television industry boom was at its peak. But the industry recognized its responsibility and immediately made a substantial share of its facilities available for the production of military electronic equipment and components.

The Armed Services had learned the value of electronics in World War II. But by mid-1950 technical advances had shown it to be vital to modern warfare. General Carl Spaatz, who directed the nation's military aircraft in World War II, warned that in the next world conflict superior electronics would be decisive.

For a while it seemed that shortages of critical metals might curtail radio-TV set producton sharply. But the industry, always resourceful, worked out a conservation plan which permitted a high rate of civilian production and fulfillment of all military obligations.

By 1952 the industry which in 1941 was manufacturing at the annual rate of a quarter of a billion dollars had achieved a combined military and civilian production of over $4 billion.

The scope of the industry. The radio-television-electronics industry may be roughly divided into three major groups. They are: (1) manufacturers of radio and TV sets and phonographs, (2) manufacturers of industrial, commercial, and military electronic equipment, and (3) manufacturers of the tubes and other components, such as capacitors, resistors, and transformers, used in the end equipment.

As might be expected, there is considerable over-lapping within these three categories. Some manufacturers operate in all three, others in two, et cetera.

Major production centers are: (1) the eastern seaboard states, (2) the middle west centering in Chicago, and (3) the Pacific coast with the heaviest concentration in Southern California.

Because many electronics producers are also engaged in the manufacture of other consumer or industrial products, accurate figures on employment, plant investment, and the like are difficult to come by. However, industry estimates indicate there are close to 2,000 manufacturers of widely varying size engaged in some form of electronics production and employing more than 500,000 skilled and semi-skilled workers. Plant investments run into hundreds of million dollars.

In addition, the industry's merchandising outlets throughout the nation provide jobs for hundreds of thousands of salesmen, service technicians, and jobbers and dealers.

While the leaders of the industry are large corporations employing thousands of workers, the majority of manufacturers are relatively small. For instance, more than 70 percent of the membership of the Radio-Electronics-Television Manufacturers Association comes from "small business"—a manufacturer employing less than 500 workers.

Industry-wide standardization of components through the RETMA Engineering Department has made possible mass production and assembly techniques by end equipment manufacturers and the utilization of thousands of products of the parts and tube manufacturers. The large producer is often dependent on small manufacturers for his components just as the small producer is dependent on the large manufacturer for his market.

While the growth of the industry in little more than a quarter of a century has been phenomenal, even in America, there is no indication that it has become stagnant or that it has reached its peak. As military expenditures decline, thousands of new uses of electronics in industry and in the home—as well as the continuing expansion of radio and TV set ownership—will keep the plants and employees of radio-TV and electronics manufacturers busy for the foreseeable future.

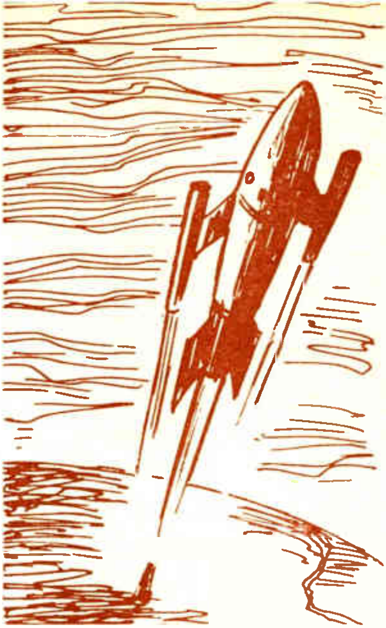
Research goes on. The industry is not composed of production and merchandizing facilities alone. Its engineers and its research laboratories are still its life-blood.

For instance, the National Television System Committee developed the transmission standards which made monochrome television a practical reality in 1941. In recent years another group of industry engineers under the same name has developed color television signal specifications which will permit an orderly transition from black and white TV to a combination of monochrome and color telecasts without obsoleting the millions of television receivers in use.

Industry engineers are constantly bringing out new devices and improvements in old devices which both broaden the industry's horizon and add to the efficiency of its products. The transistor, which offers many challenging possibilities, is an outstanding example of such research.

The greatest possibilities of electronics in war and in peace are still in the future.

VII *kites without strings*



IT IS A LONG TIME since 1749, when Benjamin Franklin and his young helper flew the kite that sparked the whole idea of electrical communication, and later electronics.

But men are still flying kites, in a very real sense.

Every time an experimental rocket roars into the air from a desert proving ground, soaring beyond the earth's atmosphere into the black void of space, man flies such a kite.

There are no strings leading downward from these modern kites. No *visible* strings. But the same communication of energy and information that came from Franklin's kite flows downward from these rockets.

It flows by radio and television from precise measuring instruments. It brings to earth vital information about conditions in that black void, among the cosmic rays. It brings back information that will help man to pass through those now unknown and dangerous regions—to the universe outside.

Rockets, truly, are kites without strings. Like Franklin's simple kite, they are opening up the future.

Not all the future's developments will have the drama of a flight into outer space, or a visit to Venus.

The truly dramatic fact about epoch-making electronic developments—from Marconi's wireless to the giant man-made brains that solve intricate problems—is that we tend to take them for granted as they come along.

The future of electronics probably holds many more such miracles that we will take for granted—accept as a natural part of the better life discovery has opened up for us.

The transmission of heat and power by way of the ether may well be one of these historic achievements. Communication with other planets of our solar system—even with other universes outside our reach—may be commonplace.

In the last analysis, communication is one of the tremendous achievements of the past half century or so.

As Thomas Mann once said: "Speech is civilization itself. The word—even the contradictory word—preserves contact. It is silence which isolates."

But the experimental kites that will lead to the miracles of the future are already being flown. In thousands of small experimental laboratories—in the research laboratories of great manufacturers—the exploring kites of man's mind are constantly probing the unknown, bringing back to the hand and brain of man the ideas that spark the future.

*

Suggestions for further reading

DUNLAP'S RADIO AND TELEVISION ALMANAC, by Orrin E. Dunlap, Jr. Harper & Brothers, 1951.

INVENTION AND INNOVATION IN THE RADIO INDUSTRY, by W. Rupert Maclaurin. Macmillan, 1949.

ELEMENTS OF RADIO, by Abraham Marcus and William Marcus. Prentice-Hall, 1943.

ESSENTIALS OF RADIO, by Morris Slurzberg and William Osterheld. McGraw-Hill, 1948.

TELEVISION PRINCIPLES, by Robert B. Dome. McGraw-Hill, 1951.

Radio-Electronics-Television

Manufacturers Association

Suite 800, Wyatt Building
777 Fourteenth Street, N.W.
Washington 5, D. C.