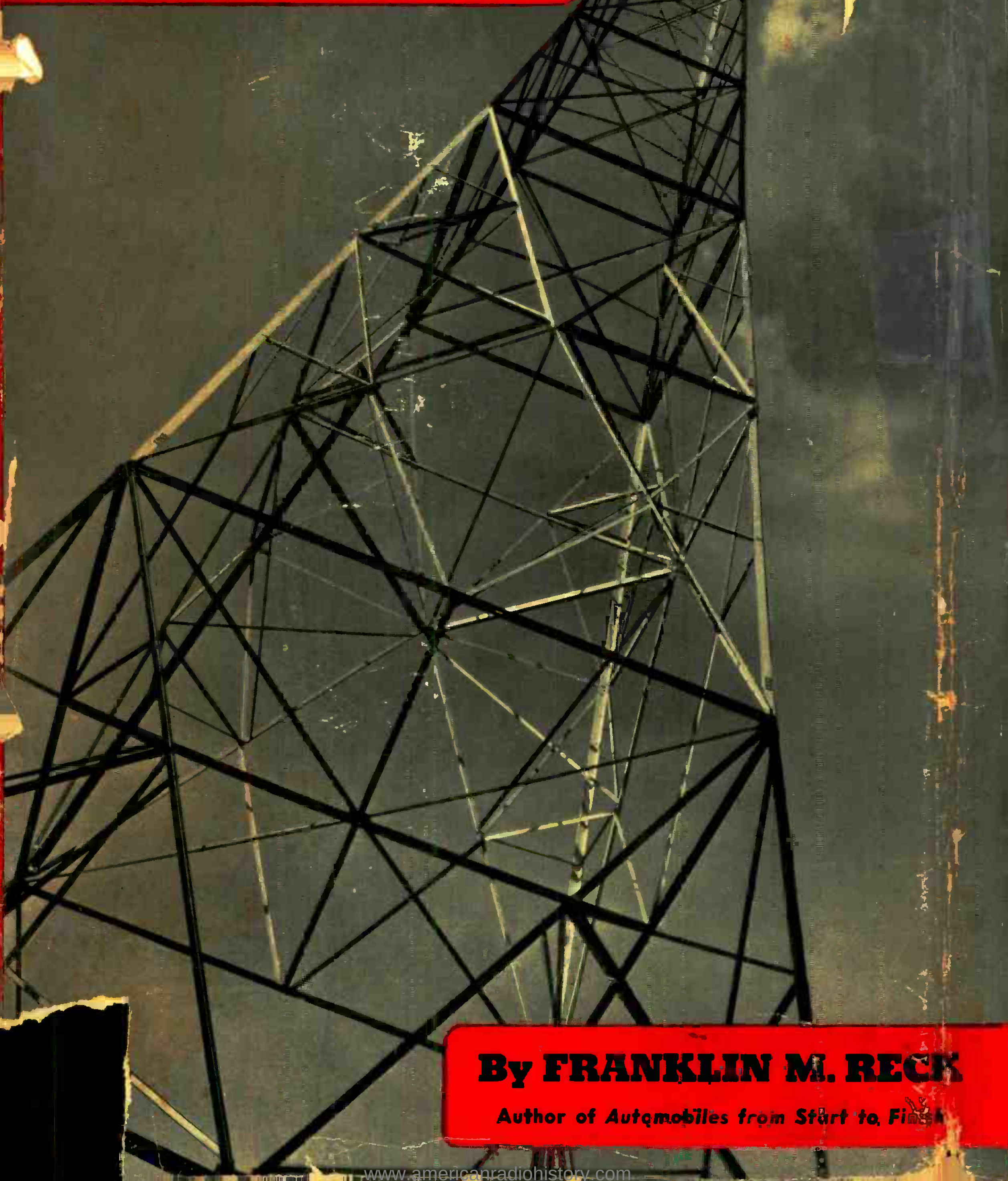
RADIO

FROM START TO FINISH



By FRANKLIN M. RECK

Author of Automobiles from Start to Finish

RADIO

FROM START TO FINISH

by FRANKLIN M. RECK

Author of **"Varsity Letter"** and **"Power, From Start to Finish"** former Junior Literary Guild selections

The Old World gave us wireless. The New World gave us radio. Marconi transmitted the first practical wireless messages across the Atlantic from Europe in 1895. A Canadian named Fessenden was the first to impress the human voice upon the ether waves. Then came radio's magic tube, the first broadcast from the garage of Dr. Frank Conrad's home, and radio's glorious future was in the offing.

This fascinating book gives you the whole picture of your own radio from the earliest days when scientists first began to think about it. It introduces you to the famous men who made it possible: Maxwell, who first formulated the laws that led to Marconi's invention; David Sarnoff, who foresaw musical and talking entertainment in radio; E. H. Armstrong, who developed frequency modulation—"FM"; and a score of others.

The author takes you on a personally conducted tour through a broadcasting station. He explains to you how FM and television work and describes how radio is used in war and aviation and what the future holds for radio.

Indeed, you will spend many absorbing hours with this book, and when you have finished it, you will find that you know a great deal about a subject of vast importance to all of us.

This book has been chosen for young people by Helen Ferris, Angelo Patri, Mrs. Franklin D. Roosevelt, and Mrs. Sidonie M. Gruenberg as an outstanding publication of the month for older readers (C Group).

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RADIO

FROM START TO FINISH

FRANKLIN M. RECK

Author of *Automobiles from Start to Finish* and *Power from Start to Finish*

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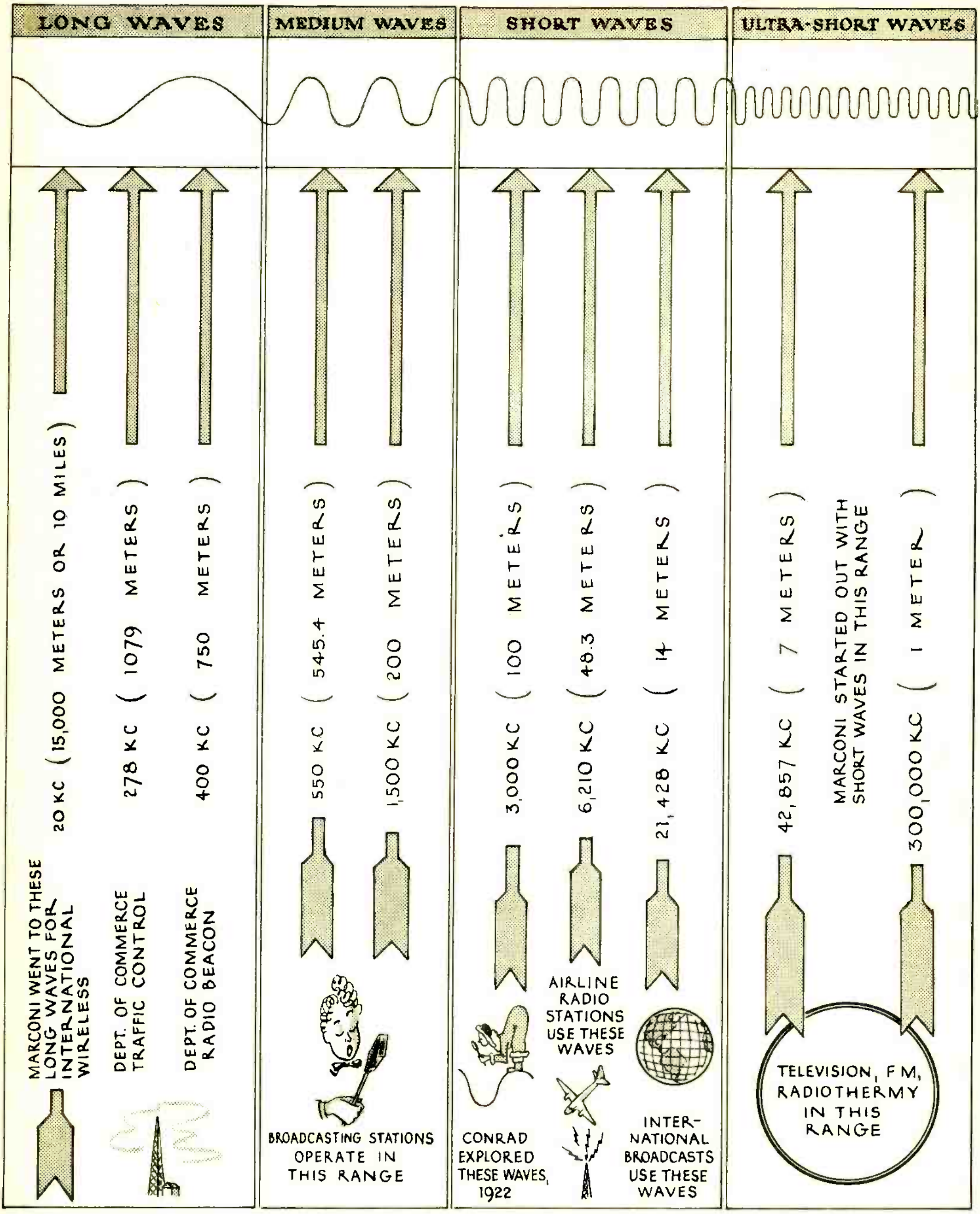
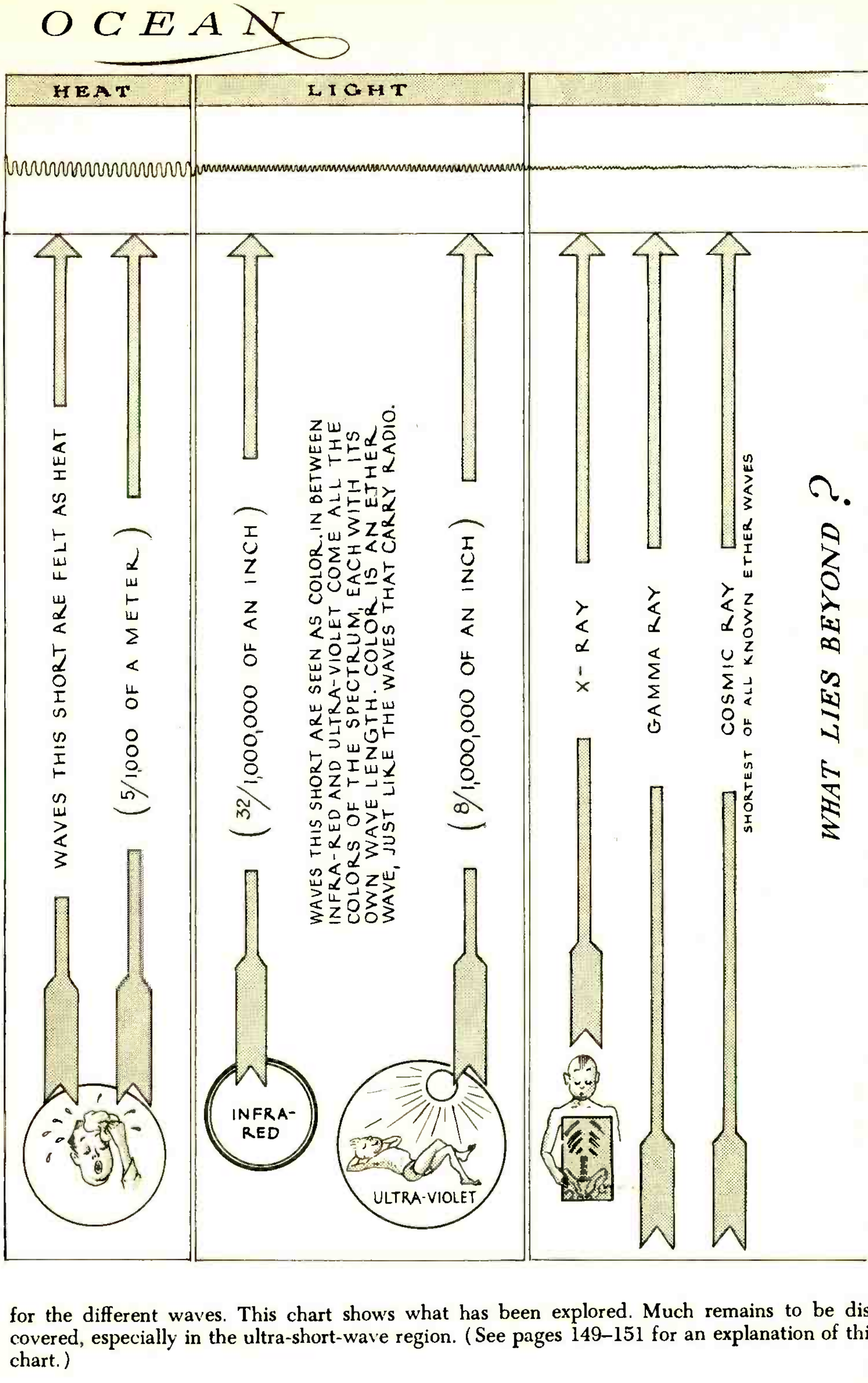
Contents

THE ETHER



The ether ocean is an immense and marvelous sea. An electric discharge can set it in motion, and the resultant waves will travel around the world. In the last fifty years man has explored much of the ocean. He has generated waves of varying lengths, all the way from waves fifteen or more miles in length down to waves a fraction of a meter long. He has found different uses



for the different waves. This chart shows what has been explored. Much remains to be discovered, especially in the ultra-short-wave region. (See pages 149–151 for an explanation of this chart.)

THIS book is about radio as it is operated today—about the men who run it, the desks they occupy, the things they do, and the rewards they receive. There is a brief history of radio's beginnings, so that the reader will know how the world of broadcasting came to be, and a quick glimpse into what lies just ahead. The book is written for the young man (and young woman, too) who is curious about what lies behind the dial of his home receiver and who may some day go to work for a local station or a network.

For exceptional cooperation the author wishes to thank Mel C. Wissman and Robert Kelly of WWJ, Detroit; Leo Fitzpatrick of WJR, Detroit; Frank Mullen, vice-president of NBC; Lewis Titterton, manager of NBC's Script Division; Miss Frances Sprague, NBC Librarian; and Leif Eid, NBC Press Division.

I

Radio's Beginning

THE President of the United States sits in the White House and talks into a microphone. His voice, transformed into tiny electrical signals, scurries over special telephone wires to five hundred radio stations. From these stations the signals climb tall masts and leap out into space, spreading outward in all directions until they find the aerials of your radio set. Inside the set, the signals again become voice, and you sit comfortably in your chairs and listen.

While this is happening, those selfsame signals are traveling to tall antennae along the coast, where they take off with the speed of light for Europe, Africa, South America, Australia, and Asia. Today, because of the high development of broadcasting, five continents may listen simultaneously to the voice of one man.

There are nine-hundred-odd radio stations in the United States, more than half of them members of four large networks. Other countries have similar webs, and continent is joined to continent by short wave. It is over this highly organized system that a President or a Prime Minister addresses the planet.

Radio today is an important part of our lives. We throw a switch and turn a knob and listen to a drama, an orchestra, a comedian. We tune in on a World Series ball game or a championship boxing match. We hear a radio reporter talking from half way round the world, bringing us first-hand information from a foreign capital.

We rely on radio to provide a part of our information and entertainment. Ships and airplanes depend on radio for weather information and flight instructions and Arctic explorers talk to their homelands by radio. Armies in the field maintain contact with headquarters, and ships of a fleet speak to each other over the invisible waves of the thing scientists call "ether."

Today, we know much about the invisible ocean called the "ether." We know that it fills all space, and even exists in solids such as earth and rock and wood. Ether can be made to undulate in waves, just as waves are created in a pond when a pebble is tossed into it, except that the "pebble" that sets the ether in motion is a discharge of electricity.

Ether waves vary in length, just as water waves vary all the way from great ocean swells to tiny ripples. There are ether waves ten or fifteen miles from crest to crest, once used for trans-oceanic wireless messages. There are shorter waves of a few hundred meters in length, used for commercial broadcasting, and waves fifteen or twenty meters long used for short-wave broadcasting between continents.

If ether waves are short enough we feel them as heat, and when they become a tiny fraction of an inch long they are manifest as light and color. Go even smaller and you have the X-ray, used to combat cancer. All of these are ripples in that substance called "ether," which is unseeable, yet is all around us.

So this book, while it is a story of men and their triumphs, of wireless and broadcasting, is really a story of the ether ocean. It is a map of the explored areas and a hint of the unexplored. The chart at the beginning gives you an idea of the immensity of the ocean and the many ways in which it serves mankind. A fuller explanation of what we know about the ocean will be found in Chapter Fifteen.

Guglielmo Marconi, with his homemade wireless sending device developed in 1895. From a contemporary photograph. *Photo from The Bettmann Archive.*

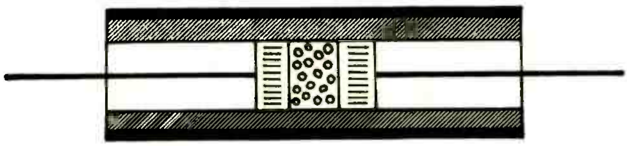
The story of Radio begins in 1895, in the gardens of an Italian banker near the pleasant city of Bologna. In that cheerful setting, the banker's son, a young man named Guglielmo Marconi, performed an experiment of considerable importance to all of us.

He stood by a strange-looking piece of equipment. From it a long wire extended into the air. Another wire connected the apparatus to the earth. Convenient to his hand was a Morse telegraph key, and when he pressed the key, a spark leaped across a small gap in a coil of wire.

More than a mile away was another apparatus, also with a wire extending into the air. Between the two sets there was no connecting wire. Only space. Yet, when Marconi pressed the key of the first apparatus, an electrical signal reached the wire of the second. It traveled down this wire into a small glass tube containing nickel and silver filings, and here an odd thing happened.

The filings, jumbled in the tube, arranged themselves in order. They "cohered," making the little tube a good conductor of electricity. It permitted a current to pass from a battery to a Morse inker, a device for printing dots and dashes on tape.

So, whenever Marconi, in his father's garden, pressed a key, code characters were imprinted on tape more than a mile away. The world's first practical wireless messages were taking wing.



Branly's coherer. Marconi used this to detect wireless signals. When wireless waves passed into the tube, the jumbled filings arranged themselves and permitted a current to pass through.

Guglielmo (Italian for "William") Marconi was born in Bologna, April 25, 1874. His schooling at Leghorn and the University of Bologna wasn't particularly technical, but he was living at a time when scientists everywhere were finding out new and startling things about the behavior of electricity.

In the Marconi home at Villa Griffone there was a large technical library. Guglielmo as a boy, because of ill health, received part of his schooling at home, and therefore had lots of time to spend in the library. Like another great inventor, James Watt, who also suffered ill health as a youth, Marconi substituted books and science for the normal outdoor sports of the average boy. He studied chemistry, steam engines, the life and work of Benjamin Franklin, and everything else of a scientific nature he could find.

One day he built a static aerial on the roof of the house, so wired that when enough electricity was collected a bell would ring. Marconi's father proudly encouraged his precocious son, and so did a famous friend, Professor Augusto Righi of the University of Bologna, who was an investigator into the ether waves by which wireless messages are carried.

So it is plain that Marconi was like any boy of today who tinkers in his basement with electrical and chemical sets. He was a boy indulging in a hobby. One day when Guglielmo was vacationing in the Italian Alps he came across an article in a scientific magazine stating that a German scientist had sent sparks across a room without the aid of wires. Marconi thought for a moment, and said:

"If you can send sparks across a room, why can't you send them across the Atlantic?"

From that moment on, Marconi dedicated his life to wireless. Famous men in Paris, London, and Berlin were also interested in the subject, but they weren't having any great luck with their experiments, probably because they were only devoting part time to it. Other and weightier matters claimed their interest. But that wasn't true of Marconi. Marconi was just young enough and ambitious enough to be interested in radio and nothing else. He had something the great men lacked. He had singleness of purpose.

So it was that this keen-eyed young Italian, just turned twenty-one, was the first man to put wireless telegraphy on a practical basis.

Of course Marconi wasn't the "inventor" of wireless any more than James Watt was inventor of the steam engine or Robert Fulton inventor of the steamboat. No invention springs to life overnight. What we call an "invention" is the final advance in a series of hard-won battles fought silently and patiently by many men in many places.

Before Marconi, there was a Scotchman named James Clerk Maxwell, born in Edinburgh on June 13, 1831. Clerk Maxwell was a precocious youngster, nicknamed "Dafty" by his schoolmates at Edinburgh Academy. At the age of fourteen he was writing papers that commanded the respect of scientists. From the very beginning of his schooling he took an intense interest in such subjects as chemistry, magnetism, and light.

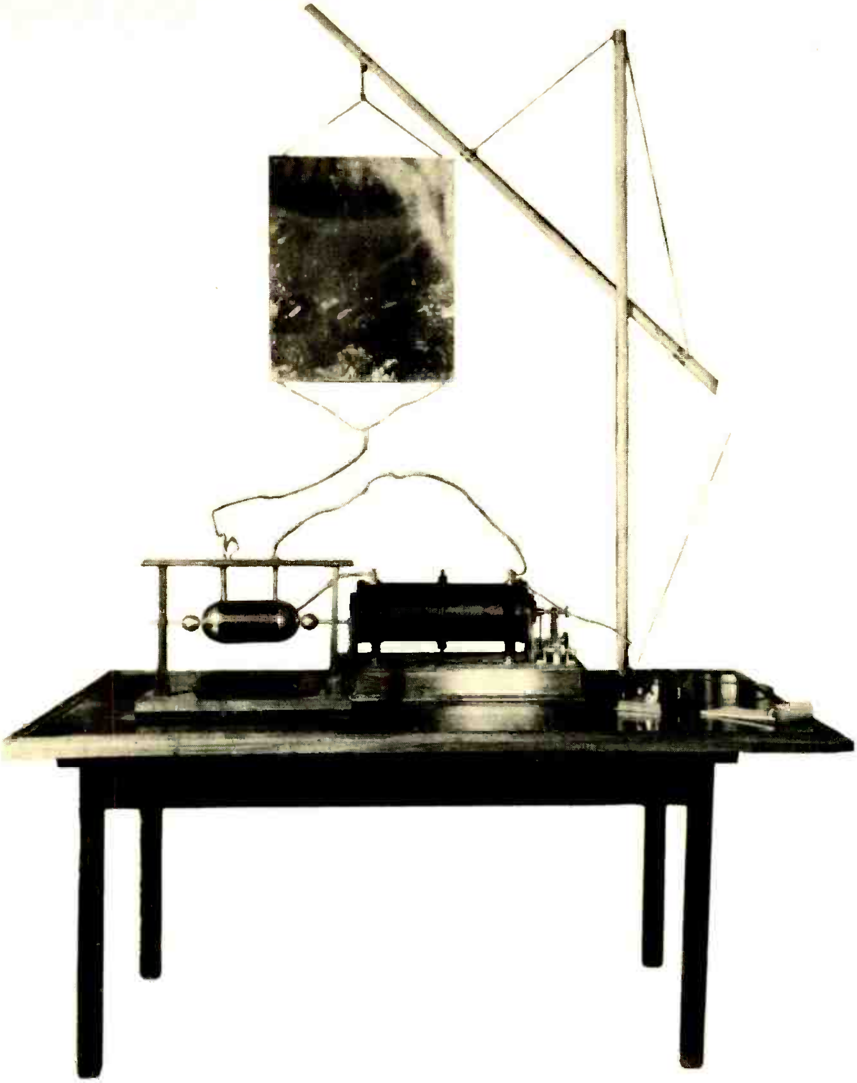
He went on to Cambridge, won honors, and became a lecturer at Trinity College. When he was only twenty-five he was appointed professor of natural philosophy at Marischal College in Aberdeen, and his tireless mind busied itself with such varied matters as color and vision and heat, and what the Rings of Saturn are made of. Apparently there wasn't any behavior of nature that Dafty Maxwell wouldn't investigate. You and I are likely to take for granted the fact that we can see colors. Not Maxwell. He wanted to know the "how" of all things. In 1871 he was appointed professor of experimental physics at Cambridge, a high honor for a man of forty.

Maxwell exercised the same kind of intelligent curiosity on electricity and magnetism. He proposed the startling idea that electricity was like light. Both, he said, traveled through space at the rate of 186,000 miles per second. They traveled in waves, like the waves that ripple outward on a pond, when you toss a stone into it. The "pond" in which these waves traveled he called "ether."

He thought of the universe as an immense ocean of ether in which all the heavenly bodies are swimming. Ether wasn't air. It existed outside of air; it existed in a container from which air had been exhausted. It was of such a nature that it existed in walls and other solid objects in the earth.

The light that reached us from the sun was nothing more nor less than successive ripples of this unseeable ether, said Maxwell. And electricity, traveling through space from one electrical device to another, was also waves in ether.

Maxwell didn't originate these ideas completely out of the blue. Others had believed in the wave theory of light. Maxwell



Replica of Marconi's first radio transmitter operated on his father's estate at Bologne, Italy, in 1895. *Photo from Monkemeyer Press Photo Service.*

was indebted to all the experimenters who came before him. But Maxwell summed it all up. He reduced it to mathematics and presented the world with formulas by which men could predict the behavior of electricity in space. He said, for instance, that electrical waves could be reflected just as light could, and later this was found to be true. His work clarified the understanding of people, eliminated false theories, and brought together many seemingly unrelated happenings into a single system.

But Maxwell didn't have time to prove his ideas by experiment. His revelation was given to the world in 1873, and a few years later, when he had reached the age of forty-eight, his great mind was stilled.

The man who was to prove Maxwell's theory of electrical waves in ether was a young German high school teacher named Heinrich Rudolph Hertz.

This thoughtful, unassuming young man, whose experiments were to mean so much to the future world of radio, was born in Hamburg on February 22, 1857. His father was a successful lawyer, a man who spoke many languages well, and who loved to read classical literature. Young Heinrich Hertz was brought up in a tolerant, intellectual home that was friendly to the spirit of inquiry.

What is even more important, Heinrich's grandfather, a prosperous merchant, had a well-equipped physical laboratory in his home. Heinrich was introduced to the fun of laboratory work at an early age.

At that time, Germany was in a period of great industrial growth, and like most of his friends Heinrich planned on a career of engineering. He attended the Hamburg grade schools, spent a year with an engineering firm at Frankfort, another year in the army, and in November, 1877, went to Munich to study surveying and construction. All this time, he had been carrying on an inward struggle between engineering and pure science, and at Munich he made his decision. There were laboratories in Munich, and the sight of them was too much for him.

James Clerk Maxwell, who proposed the theory that light and electricity travel in waves through ether. *Photo by Brown Brothers.*

He wrote his parents that he wanted to study mathematics and physics. His parents, who undoubtedly wanted him to be a successful engineer, one of the builders of the new Germany, wrote back that if he wanted to study physics, then that was what he should study. It was lucky for the world of radio that they let him have his way.

With high enthusiasm, Hertz plunged into the maze of mathematics that is the foundation of all science. After a year in Munich he went to the University of Berlin, where he studied under the great Hermann von Helmholtz, one of the formulators of the law of the conservation of energy. He became von Helmholtz's assistant, and it was at this time that his thoughts were directed toward the startling ideas of Clerk Maxwell.

What was the nature of electricity? Did it travel in waves? Was it similar to light as Maxwell said? These thoughts he carried with him to the university of Kiel where he lectured in physics, and in 1885 to Karlsruhe, where he became professor of experimental physics at the technical high school. At that time he wrote in his diary: "Thought about electromagnetic rays. Reflected on the electromagnetic theory of light. Hard at Maxwellian electromagnetics in the evening. Nothing but electromagnetics."

The high school laboratory at Kiel had two coils of wire, each with a small spark gap in it. One of these coils was connected to a source of current. One day Hertz noticed that when a spark leaped across the gap in the one coil, a similar spark appeared at the gap in the other, even though there was no wire connection between the two.

For the next two years, Hertz followed up this interesting behavior. In the school laboratory, with homemade equipment, he caused wireless waves to travel a distance of forty feet. This was the experiment that Marconi later read about, in the Italian Alps.

By means that we could understand only if we were trained scientists, Hertz showed that these waves actually did travel with the speed of light through the "ether." He built curved mirrors six feet high and showed that electrical waves could be reflected, exactly as Maxwell had predicted. He built large prisms made of pitch, passed electrical waves through them, and showed that the waves were refracted, much as light is refracted.

Hertz brought the ether waves of Maxwell down into the real world. He verified Maxwell's laws and added more laws of his own. He built the first transmitter and first receiver. When Hertz finished his work, it was only a question of time before wireless and broadcasting would become a part of our lives.

Hertz himself had no idea that this would happen. When someone asked him if his waves would ever be used for wireless telegraphy or telephony he replied that he didn't believe it would be practical.

He didn't live long, or he might have seen for himself the marvelous future in store for his discovery. On January 1, 1894, when he was only thirty-six, yet the recognized equal of such great men as Maxwell and von Helmholtz, Heinrich Rudolph Hertz died.

So, when Marconi, on his father's estate near Bologna, sent wireless waves a distance of more than a mile, in 1895, he owed much to those who went before. He was employing waves defined by Maxwell and demonstrated by Hertz. His detector, that little tube of filings that obligingly cohered under the influence of ether waves, was the work of Professor Edouard Branly of the Catholic Institute of Paris, and his telegraph key and inker were Samuel F. B. Morse's. Marconi inherited the findings of all these men and every other scientist who had advanced the cause of electricity.

But for the rest, Marconi owed much to his own resourceful mind. Until he hit upon the idea of connecting transmitter and receiver to the ground and raising antennae into the air, his range was limited. After these significant improvements, wireless was to stretch out its invisible feelers, year by year, until one day the Atlantic would be conquered.

2

Marconi Spans the Ocean

THE story of how Marconi established wireless as an international service in a half dozen years is the story of a week-by-week struggle for distance, more distance, and yet more distance.

In the summer of 1896, with his invention far enough advanced to merit attention, he went to England. Marconi's mother was Irish, and the boy himself had received part of his education in England, so that the country and its language weren't unfamiliar to him. England was the world's money capital. English scientists, among them Sir Oliver Lodge and Sir William Crookes, were working on the problem of wireless. Marconi felt that England, rather than his native land, would give him the backing he needed.

He went directly to Sir William Preece, technical director of the British Post Office, and demonstrated his wireless in the rooms of the London Post Office. Preece himself had experimented with wireless, and what Preece saw in this first demonstration convinced him that this unruffled young Italian, just old enough to be finishing college, was working along the most practical lines so far known.

Marconi and his assistants, G. S. Kemp (left) and P. W. Paget, on the day they received the "S" signal, the first wireless message to be sent across the Atlantic, from Poldhu, Cornwall, to St. John's, Newfoundland, in December, 1901. *Photo by Brown Brothers.*

Under the supervision of the British Post Office Marconi set up his equipment at Salisbury Plain, and that first year attained a distance of almost two miles. The battle for distance had begun.

The following spring he filed a patent for "signaling through space without wires." The word *wireless* wasn't yet in use. At that time, by painstakingly improving his equipment, he had sent messages four miles over land and nine miles across the Bristol Channel.

Progress was swift. In June, 1897, he returned to Italy and installed a shore wireless station at Spezia that successfully communicated with a warship twelve miles at sea. Also in June Sir William Preece reported the progress of wireless to the Royal Institution in London, and his words, reprinted in the *London Engineer*, announced to the world that a new age in communication was under way.

On July 20, 1897, the Wireless Telegraph and Signal Company was formed in England with Marconi as chief engineer, and now the new form of message sending began to find its commercial uses. Lloyd's Corporation of London asked Marconi to install equipment in two lighthouses on the North Irish Coast, seven and one-half miles apart. The equipment was put in, the keepers taught to operate it, and the first practical use of wireless was successfully launched.

Up until this year, 1897, when a ship put out to sea it was swallowed up in a vast, mysterious unknown until it arrived at a port. There was no way on earth of getting in touch with it. If it sank, nobody knew how or why.

So it was natural that ships should eagerly welcome the new invention and become its first customers. Marconi wireless sets were installed in ships and at shore stations throughout 1897 and the years following.

One battle Marconi had to win before his wireless could become reliable, and that was the battle of tuning. This meant, simply, that the transmitter had to be so devised that it would send out waves of a single length, rather than jumbled waves of varying lengths. If that could be accomplished, then distance and clarity would be improved, and nearby stations would not interfere with each other.

Marconi called it "syntony." In his struggle for syntony he was helped greatly by Sir Oliver Lodge, and on April 26, 1900, he applied for a patent covering this important development.

Everyone is familiar with tuning now. When we turn a dial on our radio sets to get a certain station, we are tuning the set to receive a certain wave length. Tuning permits several stations to broadcast from the same town without interfering with each other. So this indispensable phase of broadcasting goes back to the earliest days of wireless. It goes back, in fact, to the first experiments of Hertz in the high school laboratory at Karlsruhe, for at the beginning Hertz discussed the matter of tuning.

Meanwhile, the struggle for distance went on. Antennae climbed higher and higher into the air. Circuits were changed and improved, and the range increased to twenty, twenty-four, and thirty miles. Yacht races and regattas were reported by wireless from tugboats following the races to stations on shore. A wireless set was put up for Queen Victoria's personal use.

On March 27, 1899, Marconi sent wireless messages across the English channel from Dover to Boulogne, and France and England were connected by the rapid vibration of waves in ether.

Then, the following month, there happened what was certain to happen sooner or later. In a fog off the English coast, the steamer *R. F. Matthews* got off course and rammed the Goodwin Sands lightship. There was a wireless set on the lightship, and the operator began tapping out messages for help. They were received on shore. Men put out in boats, rowed twelve miles to the scene of disaster, and saved all lives. It was the first marine disaster in which wireless had come to the rescue, and if there had been any public resistance or skepticism before the event, it disappeared now.

"Do you think?" a newspaper man asked Marconi at this time, "that New York, say, and Paris can ever be connected by wireless?"

'I see no reason to doubt it," the twenty-four-year-old Italian replied. "What are a few thousand miles to this wonderful ether which brings us light every day across millions of miles?"

Light, reaching us from the sun as vibrations in the untouchable ether. Electricity, traversing the world as vibrations in ether. A new concept. A dazzling one, filled with magnificent promise. Marconi by now was sending messages over a hundred miles and he saw no reason why the distance might not be two thousand miles, just as well as a hundred.

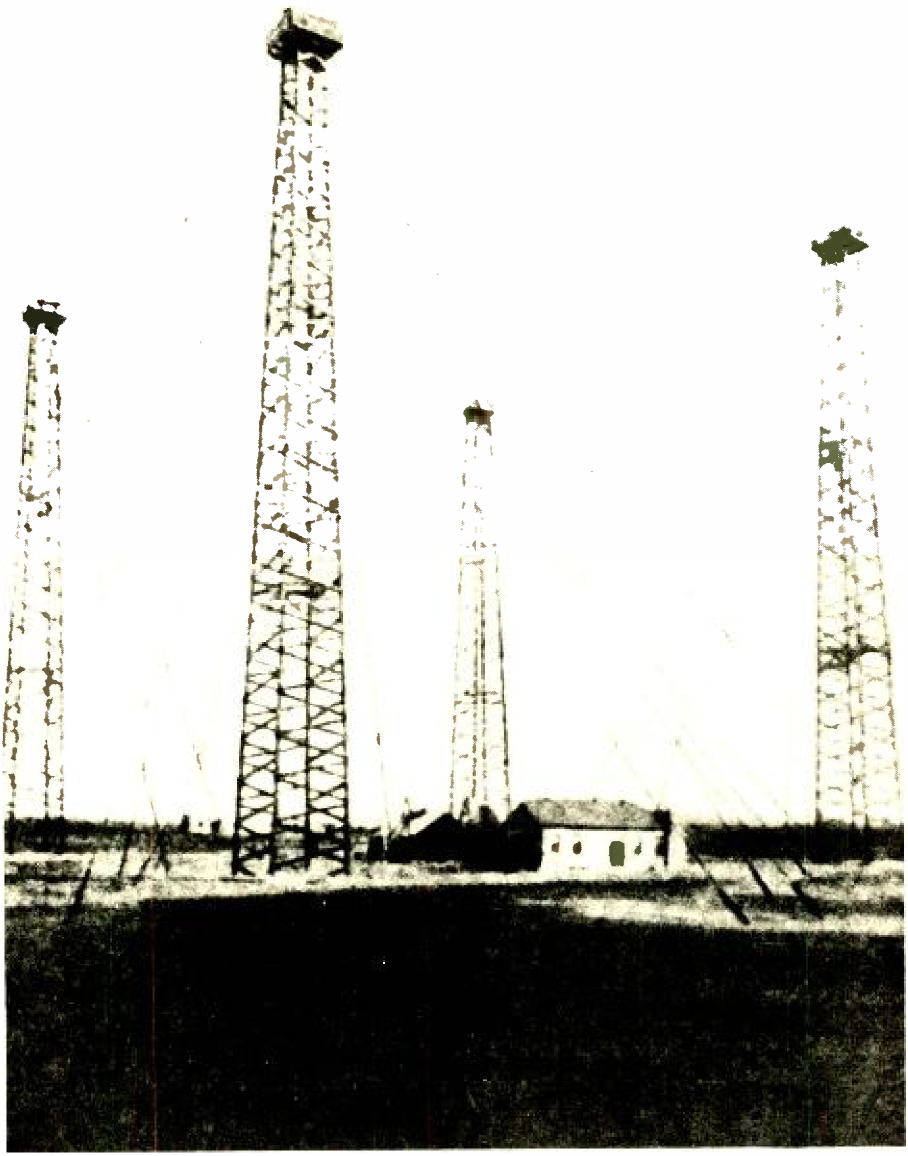
In 1901 Marconi decided to try to send signals across the Atlantic. At Poldhu, Cornwall, on the southwest tip of England, he erected a ring of twenty masts, each 200 feet high, to support an immense aerial from which his transatlantic signals would be launched. But before he could put his equipment to the test, a gale wrecked the aerial.

When Marconi looked at the wreckage he showed no despair, no sign of irritation. He merely said to his assistant, P. W. Paget: "Well, it shall be put up again."

With the new aerial he had no difficulty in sending messages to Ireland and there seemed no reason to wait longer. With his helpers, Paget and G. S. Kemp, he sailed on the *Sardinian* for Newfoundland and arrived at St. Johns on Friday, December 6.

For this first experiment, the trio didn't want to go to the expense of erecting permanent aerials at the receiving end. The important thing was to get a wire high into the air, and they felt that a kite would do this satisfactorily. Since height was important, they selected the old military barracks on the rocky eminence of Signal Hill, outside the city, for their station.

Finally, on December 12, the pioneers succeeded in raising a



Marconi's station at Poldhu, from which the "S" signal was sent. *Photo by Brown Brothers.*

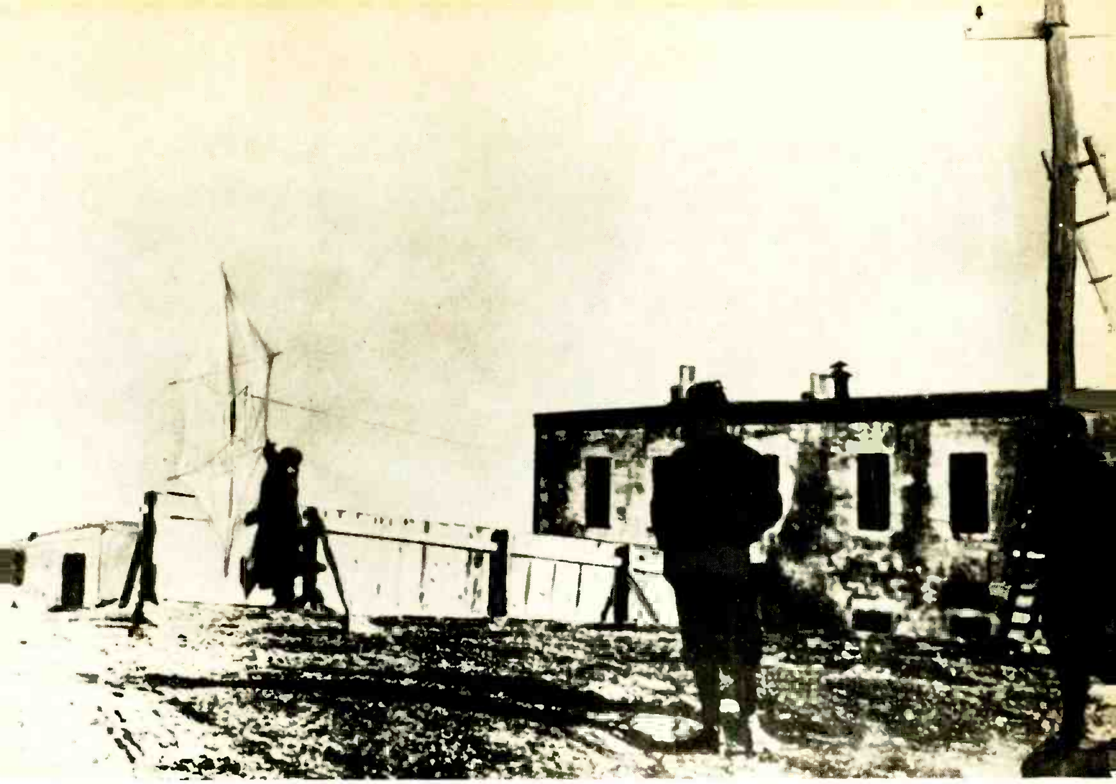
kite-borne aerial four hundred feet into the air. Marconi had already arranged for Poldhu to send signals at specified times each day. The signal was to be the letter "S," which in the Morse code was three dots. The sound, if it reached Newfoundland at all, would be something like: "dit—dit—dit." Each day, for three hours, from 11:30 until 2:30, St. Johns time, Poldhu was to send this signal.

Poldhu went into action. The dynamo whirred and began producing current. An operator pressed down a three-foot-long wooden lever three times. Sparks leaped from the knobs of big Leyden jars, the room flashed with light, and the powerful 20,000-volt current surged up the aerials and went leaping into the ether.

In Newfoundland, Marconi sat with headphones on his ears, waiting for those invisible signals to reach the thin wire dangling from his kite. If all went well, those signals, grown a little weak from the long trip, would travel down the wire to his little glass tube of silver and nickel granules. These granules, under the influence of Hertz's waves, would obligingly arrange themselves in order and permit a current to pass into Marconi's headset, giving him three short buzzes.

For an hour Marconi listened in patience, but nothing happened. We know now that Marconi didn't pick the best time of the day. Night would have been better, because wireless signals travel farther at night, when they are not weakened by daylight. We know that his sending current was not of the best kind. It was a spark, which started out strong and died away. One day, it would be replaced by a steadier kind of current that maintained its strength evenly, but Marconi had no such current then. Nor was his detector, the little glass tube that he had adapted from Branly's coherer, the most sensitive of detectors. Far better ones were to be invented, some day.

But luck was with Marconi. The variable and capricious conditions that govern radio reception must have improved, because at



Marconi's "Flying Antenna," at Newfoundland. The kite (left) was used to raise the aerial four hundred feet into the air. *Photo from Monkemeyer Press Photo Service.*

12:30 Marconi heard three faint clicks. He handed the headphones to his assistant, and said:

"Can you hear anything, Mr. Kemp?"

Mr. Kemp heard them, and for the first time in history messages had been sent without wires across an ocean. Starting from a point in Cornwall they had broadened out in all directions, growing weaker as they traveled, until they found a thin wire hanging from a kite in Newfoundland, 1700 miles away.

Not until the next day, Friday, December 13, after he had again heard the signals, did Marconi announce his triumph to the world. People everywhere were thrilled. Sir Oliver Lodge felt that the world was on the verge of some great universal discovery that would unlock the treasure chest of all knowledge.

But the Anglo-American Cable Company wasn't exactly

Wireless room on the *Republic,* from which the first SOS was sent out. *Photo by Brown Brothers.*

pleased. This firm, which had exclusive rights for telegraphic service from Newfoundland to all points outside, was afraid of this upstart competitor. Its directors warned Marconi to stay out. Rather than go to court, the twenty-seven-year-old inventor decided to establish his first New World station at Glace Bay, Nova Scotia.

From this first transatlantic conquest, the growth of international wireless was rapid. Small stations with high antennae became a familiar sight along many coasts. Ships were equipped with wireless rooms and operators were added to their crews, and space messages were to save lives in such sea disasters as the sinking of the *Republic* and the *Titanic.*

Marconi lived to see wireless grow into radio, and radio grow into the worldwide broadcasting of voice and music. He bought a yacht that he named *Elettra* and used it for a floating laboratory. He was decorated and honored by many governments and universities.

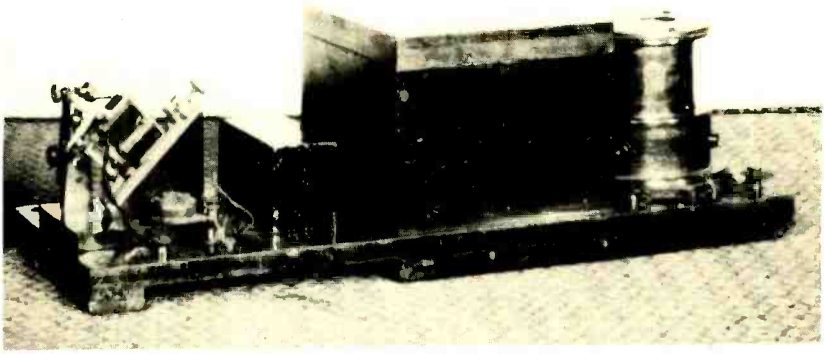
Through it all he remained quiet and unassuming, never more distressed than when his Poldhu wireless blew down, never more triumphant than when, in Newfoundland, he handed the earphones to his assistant to listen to the first transatlantic signal, merely saying: "Can you hear anything, Mr. Kemp?"

Marconi died in 1937, leaving behind him a world of radio, and instant worldwide communication.

But at the time his wireless sets were being installed in ships, early in the century, voice radio was impossible. Before there could be such a thing as broadcasting, new discoveries would have to be made. Marconi's equipment was able to send and receive the simple dots and dashes of the Morse code. A short burst of power sufficed for a dot, and a longer burst of power for a dash.

Before the inflections of voice and the tones of music could be transmitted through the ether, something besides intermittent bursts of power would be needed. There would have to be a constant, uniform stream of ether waves.

Transmitters capable of carrying voice and detectors capable of capturing it would have to be invented.



Marconi coherer, the first detector. About 1898. *Courtesy of Radio Corporation of America.*

3

The Human Voice Takes Wings

THE Old World gave us wireless.

The New World gave us radio.

The first man ever to impress the human voice on ether waves was Canadian-born Reginald A. Fessenden.

In the late nineties, when Marconi was stretching his dot-dash wireless signals to ten, fifteen, and twenty miles, the tall, rugged Fessenden was professor of electrical engineering at Western University in Pittsburgh. He had never had a technical education himself, but in the library of Bishop's College in Lennoxville, Quebec, he had come across the scientific magazines in the college reading room, and these had turned his mind toward electricity. After college, as a young man of twenty, he had worked in Edison's laboratory in Llewellyn Park, New Jersey. To make up for his lack of engineering training, he had spent his nights studying electrical theory and analytical mechanics. So thoroughly did he educate himself that he was to become one of our foremost electrical inventors.

Fessenden's contribution to radio was two-fold. First, he knew that if anything beside dot-dash was to be transmitted through space, something better than a spark transmitter would be

Reginald A. Fessenden, the first man to transmit the human voice by wireless. *Photo by Brown Brothers.*

needed. To understand this, we must discuss for a moment just what sets the ether in motion.

The current that performs this service is not direct current, but alternating. In all radio transmission, alternating current is the carrier.

A spark, leaping across a gap, creates alternating current, but it is of the unsteady kind. It starts with a surge and dies away. Engineers call it a "damped" wave. It is a poor chariot for conveying speech.

We're all familiar with the alternating current in our electric lights at home. We know that it alternates (call it oscillates if you wish), or goes from negative to positive and back again 120 times per second.

Fessenden wanted this kind of a current for his radio transmitter, but he wanted it much faster. Hertzian waves are oscillations, but they're extremely rapid. They alternate from negative to positive twenty thousand to many billions of times per second.

So, if Fessenden was to find the kind of current that would carry speech, he had to get away from spark. He had to have a current that would oscillate rapidly and steadily.

He set his sights at 100,000 oscillations per second. He wanted to build a generator that would produce this kind of current at a steady, even pace. He planned to connect this generator to the antennae, let the rapidly vibrating current climb the wires and leap into the ether. Given this kind of horse—strong and constant and swift—he felt sure that speech could be carried through the ether without the distortions and fading that a spark transmitter would cause.

The trouble was, that no such generator—or alternator—had ever been built. The fastest alternator of the day would only produce around 5,000 oscillations per second. Much of Fessenden's labor was to be devoted to the production of the kind of current he wanted. It was to be heart-breaking, disappointing, tireless labor.

Fessenden's second contribution to radio was at the receiving end. He wanted to improve on the crude coherer. He wanted a sensitive detector that would snare Hertzian waves out of the air and so modify them that the tiny speech currents would be made manifest in a telephone receiver.

Fessenden, then, was the persistent pioneer who was to start wireless on its way from telegraphy to telephony.

He achieved his detector first. While still at Western University he did much experimenting with many kinds of detectors, and he finally perfected a device that he called a "liquid barretter." This was a glass bulb containing a wire. The end of the wire was in contact with a solution of nitric acid. It was the acid that had the ability to so modify the rapidly vibrating signals from the ether that speech would come through.

This was not to be the final detector. A vastly better one was to come along later. But the liquid barretter was much the most sensitive device to date. Part of Fessenden's battle was won.

His struggle for a sending current was much sterner. By this time his devotion to wireless resulted in an appointment as wireless research head for the United States Weather Bureau. He left Pittsburgh and went to Cobb Island, Maryland, where he set up experimental stations.

There, he won his first minor victory in the sending of speech. He transmitted voice between two fifty-foot masts a mile apart. This was in 1900, just five years after Marconi had sent dot-dash a distance of a mile on his father's estate in Italy.

The result was imperfect. A loud buzzing noise almost drowned out the voice. His transmitter was of the spark variety. But men, listening keenly with earphones at the receiving end, distinctly heard the inflections of voice. For the first time, human speech had been sent through space, without wires.

By this time, Fessenden's fame was such that a company was formed around him called the National Electric Signaling Company. Its twin objectives were to compete for the rapidly growing wireless business, as well as to develop wireless telephony.

So, with ample financial backing, Fessenden renewed his quest for a high-speed alternator. He went to various companies. He suggested his own designs and modified the designs of others. He tore down and build up, only to meet with one disappointment after another.

Meanwhile his company had built a wireless station at Brant Rock, Massachusetts, and another at Machrihanish, Scotland, and on January 1, 1906, conducted a two-way exchange of dot-dash messages across the seas. This was the first conquest of the ocean since Marconi. All this time, Fessenden's liquid barretter was being installed on many ships in place of the coherer, and the stage was being set for the first actual broadcast in history.

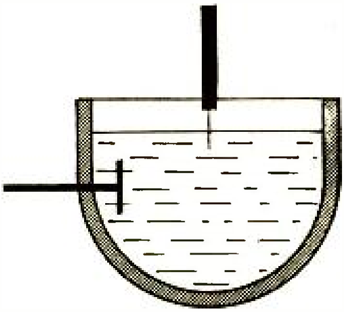
Finally Fessenden's hunt for a sending current was rewarded with partial success. In the fall of 1906, General Electric delivered to Brant Rock an alternator capable of delivering 50,000 cycles. This was just half what Fessenden wanted, but in the light of his previous disappointments he was content. The machine was the work of Dr. Ernst F. W. Alexanderson.

With this new kind of sending current, Fessenden experimented with wireless telephony between Brant Rock and Plymouth, eleven miles away. He also sent conversations to a radio-equipped fishing schooner a dozen miles offshore.

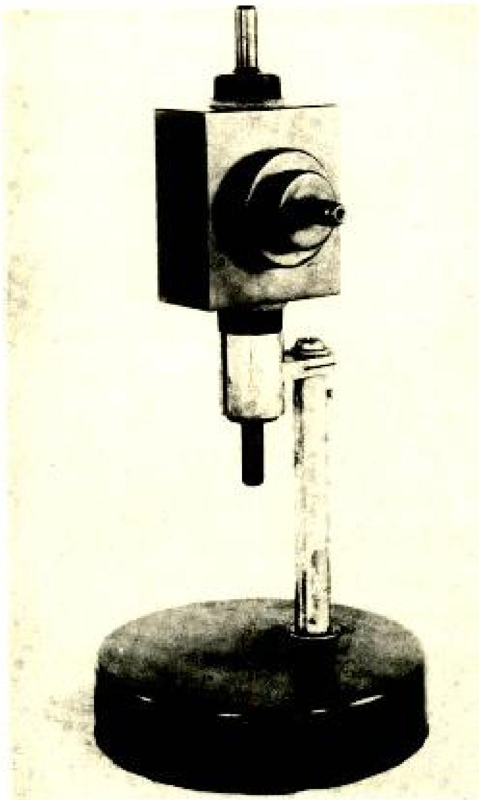
By December, 1906, he felt that his equipment was reliable enough for a demonstration. He sent a letter to the editors of a telephone journal and such foremost scientists as Dr. A. E. Kennelly and Professor Elihu Thompson, inviting them to hear a demonstration of wireless telephony.

The demonstration—the first real broadcast in history—took place on Christmas Eve. In the small station at Brant Rock notable men gathered, eager and interested, but entertaining a healthy doubt.

In the small room they saw Alexanderson's alternator. The microphone was an ordinary telephone transmitter. It would turn



Fessenden's liquid barretter. This first sensitive detector of radio signals consisted of a fine platinum wire dipped into a dilute acid solution. It could reduce the high-frequency radio waves to low-frequency waves within the range of the ear.



A later Fessenden barretter. *National Electric Signaling Company Photo, Courtesy of RCA.*

Fessenden's voice into electrical signals and these signals, borne on his steady, swiftly oscillating current, would travel in widening waves to the world's first broadcast audience.

This audience, Fessenden knew, would be small. Here and there, ships at sea were equipped with his liquid barretter. In radio rooms, behind the bridges of freighters and liners, radiomen would be sitting with headsets covering their ears. Here and there, on land, were amateurs at their homemade receivers, listening for anything that might arrive through the ether. Most of them would expect nothing but Morse code signals from ships and shore stations.

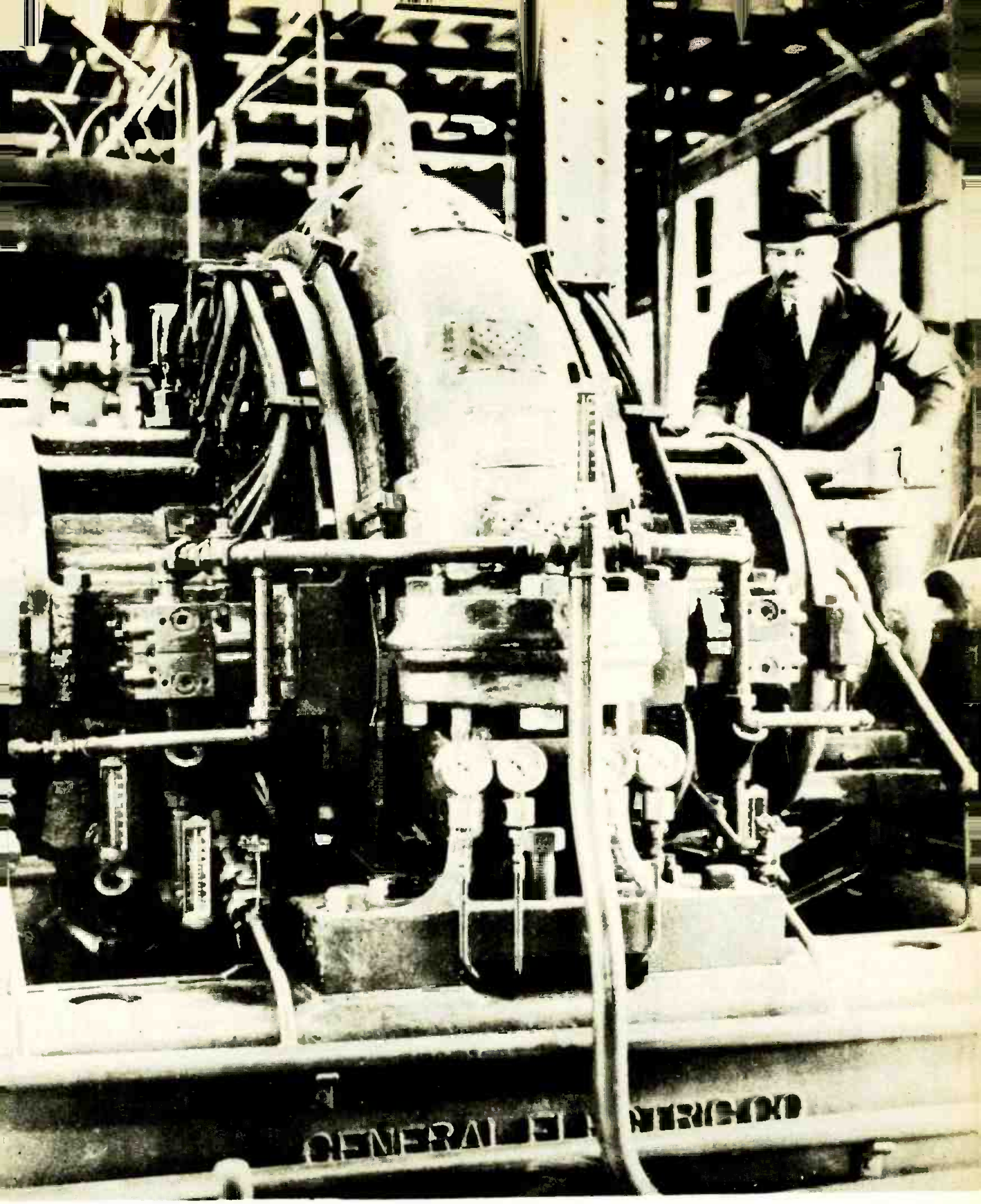
Early in the evening, Fessenden began his program by sending out the "CQ CQ" of the Morse code. Wireless operators at sea and on shore, hearing the familiar buzz, listened for the code that normally would follow. But something far different from code was to come through.

The tall scientist at Brant Rock began speaking into his microphone. He gave a brief talk, identifying himself and telling what was to follow. When he had finished, an assistant started up a phonograph record of Handel's Largo, aiming the horn at the telephone transmitter.

A violin solo played by Fessenden himself followed—Gounod's "O, Holy Night." Says Fessenden: "I played it through, then sang one verse, though the singing wasn't very good." The program ended with the words, "Glory to God in the highest and on earth peace and good will to men."

A few of the intended listeners had been warned, and these men weren't surprised. But the others, those who expected perhaps a distress call in dot-dash, were unnerved. The sound of voices and music, coming faintly and clearly to them through their earphones, was an uncanny experience.

A man's voice. Music! The sound of a violin! These things, arriving out of invisible space, were a miracle. Operators, forgetting rank and salutation, yelled to ship's officers to come and lis-



Dr. Ernst Alexanderson watching the operation of his alternator, which was capable of creating the rapidly oscillating Hertzian waves. *Photo by Brown Brothers.*

ten. Headsets were passed from man to man. Little groups stood crowded around radio tables, silent and awed.

That first broadcast of history, a typical little variety show of the air, was received hundreds of miles from Brant Rock. Letters trickled in to Fessenden reporting the reception of his program. Encouraged by his success, the scientist repeated his broadcast on New Year's Eve, and in the following months succeeded in establishing wireless telephony between Brant Rock and New York, about two hundred miles distant; and later with Washington, five hundred miles away.

Fessenden wasn't thinking of any such a strange art as broadcasting at that time. He was thinking only of establishing a telephone system without wires. He visualized two-way conversations for a fee. Perhaps he thought the telephone company would find a use for his service between island and mainland, or between wilderness points where it was inconvenient to lay wires. Or as a sort of branch service leading off from the main routes of the telephone lines. He had no idea of establishing a studio where a few people would entertain and millions would listen. Nobody at the time had any such notion.

It's a little strange, when you think of it, that after such a promising start, broadcasting was to wait fourteen years more before making its bow.

But the fact is that Fessenden's sending current was still inadequate to the job. His alternator did this: it created a carrier wave with a frequency of 50,000. Perhaps at times he achieved as high as 80,000 oscillations per second.

But if you will look at the newspaper listing of stations in your locality, you will notice that one station is rated, say, at 750 kilocycles. This means that the carrier wave of that station oscillates not a mere 80,000 times per second, but no less than 750,000 times! Farther down the list you'll find a station operating at 1400 kilocycles. Its carrier wave vibrates at 1,400,000 times per second.

Each station has a different "wave length" or "frequency," which permits all of them to broadcast at the same time without interfering with each other.

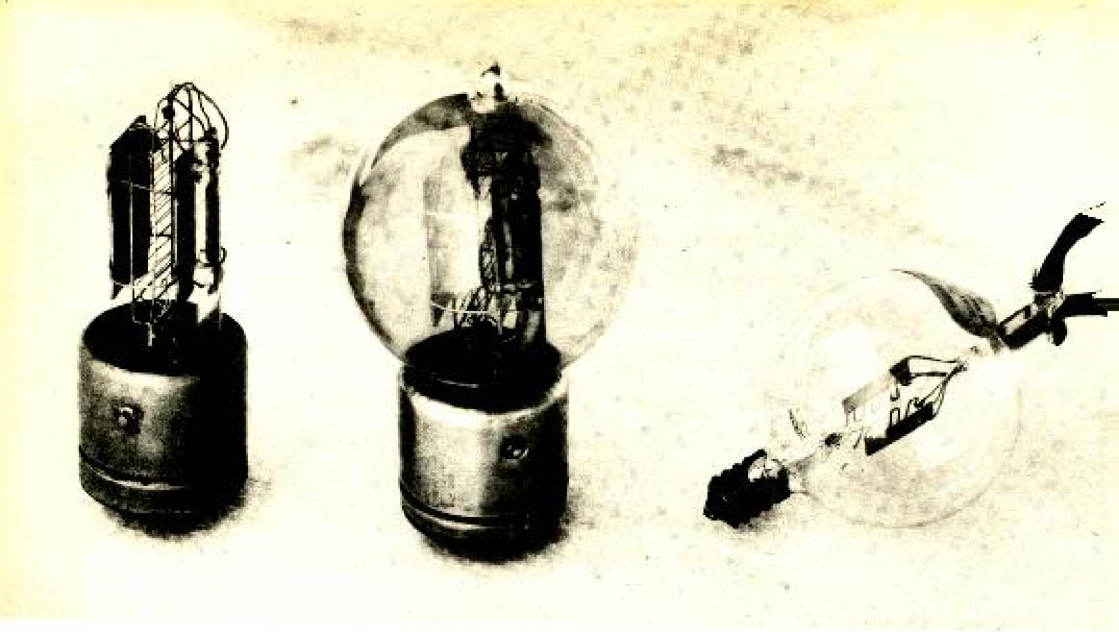
Nobody in the wireless world of 1906 had equipment that would conveniently create currents of this kind. Some new device had to come along. A key mechanism that would obligingly generate waves of any frequency desired.

The alternator wouldn't do it. There is a limit to which mechanical rotating devices can be made to whirl. There was nothing on the horizon that would do it, as far as anybody knew then.

Fessenden's great service to radio was in outlining what needed to be done before voice could be transmitted. He had created a sensitive detector, capable of reproducing voice tones. He had made a start toward developing a steady, high-frequency transmitting current. He had gone as far as he could.

Until a magic something came along, broadcasting would have to wait.

And that brings us to the story of Lee DeForest.



The Lee DeForest audion tubes. *Photo by Brown Brothers.*

4 · Radio's Magic Tube Appears

THE little device that was to act not only as the ideal receiver but also the perfect transmitter for voice is known as the audion, or the vacuum tube. This simple combination of glass and wire, a literal jack-of-all-trades of radio, was developed by Lee DeForest.

DeForest was born in Council Bluffs, Iowa, August 26, 1873. When he was six years old, his father, a Congregational minister, was made president of a school for Negroes in Talladega, Alabama. Young Lee, a Northern boy in the South during the bitter generation following the War Between the States, was both taunted and shunned by white boys of the town. Left to himself, he turned to "invention." He "invented" model windmills, steamships, even an airship. He made a crude play locomotive out of a barrel, and he even constructed a farm gate that a driver could open without getting down from his wagon.

His father wanted him to become a minister, but Lee was eager to be nothing less than a great scientist. He wanted to keep on "inventing." He was a strange youngster, fiery, poetic, eager for fame and riches. The world was full of new and exciting things. Railroads. Gas engines. Dynamos, telephones, electric lights. DeForest was thirteen when Hertz demonstrated his ether waves. By the time he was ready for college, scientists everywhere were experimenting with these waves. Lee wanted to be in the forefront of the marvelous scientific age, a leader in the parade.

Lee won his point with the family, and after working his way through Mount Hermon Preparatory School in Massachusetts, entered the Sheffield Scientific School in Yale.

His grim determination to let nothing swerve him from his chosen career showed itself in 1896, during his senior year at Yale. That year, his father died from a fall. His mother came to New Haven to run a rooming house for students, and Lee was faced with the decision of whether to get a job to support his mother or take postgraduate work. After a night or two of struggle, he decided, with his mother's consent and encouragement, to continue his education.

In his graduate work, DeForest specialized in wireless waves. The years immediately following graduation were up-and-down years for the ambitious young doctor of science. He held a job with Western Electric in Chicago at eight dollars a week, and taught school part time. At night, in lunch hours, and even during his working hours, he fought with the problems of wireless. At that time Marconi was making his fight for distance, and DeForest knew, just as Fessenden knew, that wireless needed a better detector than the Branly coherer.

DeForest developed an arrangement called a "responder," and later another detector involving the use of a liquid, much like Fessenden's liquid barretter. In those days men with money were eager to invest in wireless. It was an era of wireless promotion. So, in the first year of the new century the DeForest Wireless Telegraph Company was formed.

Like all companies that attempted to compete with Marconi, this one was due to fail. After some four or five years of disappointing progress, a new kind of detector called the crystal detector arrived on the radio scene. DeForest's backers decided to have done with DeForest's inventions. They adopted the crystal detector and got rid of DeForest.

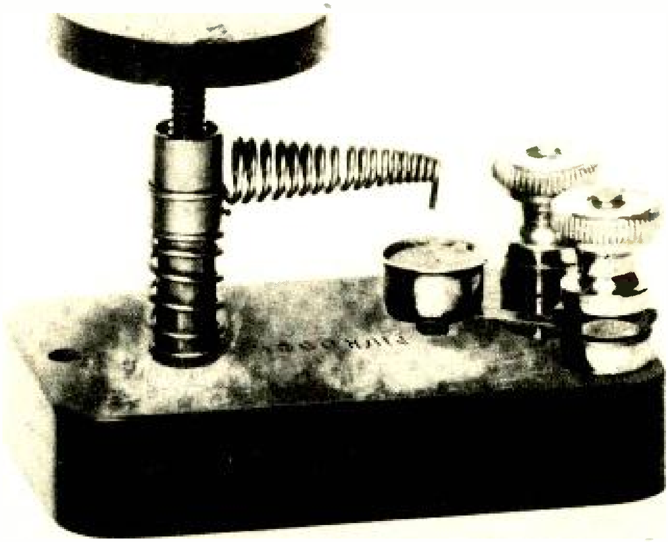
The crystal detector was a sort of magic stone. In 1906, General H. C. Dunwoody of the United States Army discovered that carborundum, when connected to an aerial, had the ability to catch silent signals out of the air and convert them into sound. At the same time G. W. Pickard learned that other substances such as galena and silicon could do the same thing.

For many years, amateurs were to use these small pieces of crystal for their radio sets. They would move the point of a wire over the surface of the stone until they found exactly that part of the surface that would give the clearest signals. Well into the 1920's, thousands of amateurs relied on crystal sets. Students would study Mathematics and English in college, wearing earphones, while faint signals from the ether scurried down their aerials, passed through their crystals, and were translated miraculously into the tiny but clear tones of a piano or an orchestra.

The crystal was never to be entirely satisfactory because there was no feasible way to amplify or strengthen the signals that came through it. Yet its arrival was providential because it set the footloose DeForest on a new line of study.

The thirty-three-year-old scientist fitted up a small laboratory and went hunting again for a better detector, but this time along a different path.

Two years before, in England, J. Ambrose Fleming had patented a detector that came to be called the Fleming valve. It looked very much like an ordinary electric light bulb. It contained a wire filament that glowed and became hot when the switch was turned on, like any light.



An early crystal detector. *Courtesy of Radio Corporation of America.*

But in addition to a filament, the bulb contained a metal plate. Many years before, Thomas Edison had discovered that some kind of an unknown current would pass from the filament of his early lamps to the side of the glass, darkening it. He didn't understand what it could be, so out of curiosity he sealed in a small metal plate. When he turned on the light and the filament began to glow, his gauges showed that current was passing through the vacuum inside his bulb from the negative filament to the positive plate.

This was something new. As far as he knew, the current should merely travel around the filament and out again. Instead, a side current of some kind was leaping across space.

Edison couldn't define it, because the science of electricity wasn't far enough advanced. Later, when experimenters discovered that an electric current was a stream of fast-traveling particles called electrons, each electron $\frac{1}{1800}$ the mass of a hydrogen atom, they knew what happened inside Edison's bulb. They knew that the hot metal was throwing off a stream of electrons, and that this stream was traveling over to the plate.

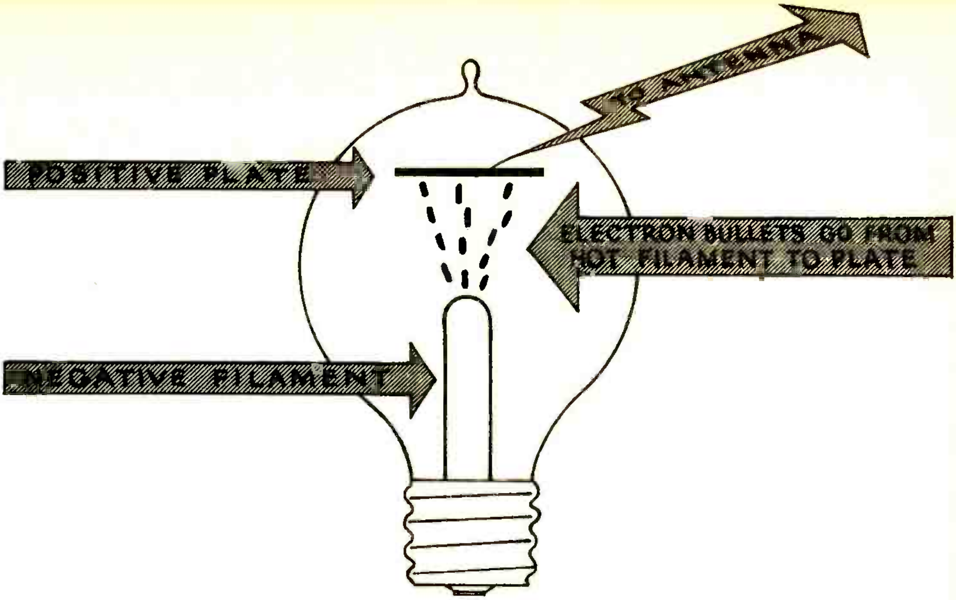
When wireless came along, Fleming wondered if this Edison bulb couldn't be used to detect wireless signals. So he attached the plate to an aerial and the filament to the ground. His hopes were realized. The convenient little glass tube performed as he hoped it would. (See diagram for explanation.) He called it a "valve" because by means of the tube, the waves from the ether had the power to control a local current, just as a tap controls the water in a pipe.

This is the detector that DeForest turned to in 1906. It wasn't good enough as it stood, so DeForest set about improving it.

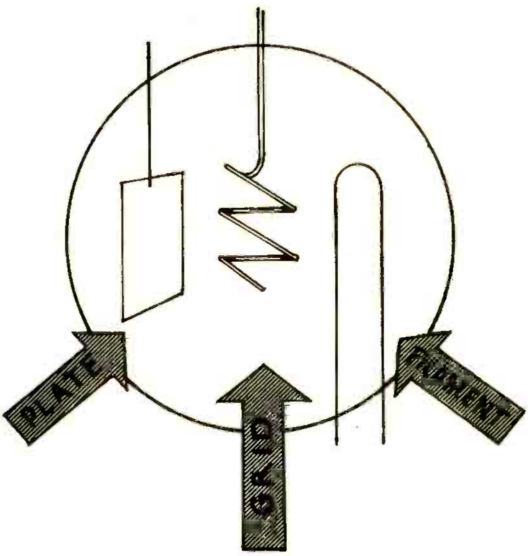
He tried various things, but one day in December he bent a piece of wire into the shape of a tiny gridiron and inserted it in the bulb as a third element. This "grid" he attached to the antenna. So now he had, inside his glass tube, a negative filament that became hot and threw off electrons. He had a positive plate on the receiving end. And he had a "grid" in between.

This little grid acted as a sensitive control of the stream of electrons going from filament to plate. The grid took its orders from the antenna. It imparted these orders to the tube current. No matter how strong the tube current, the sensitive grid could control it.

DeForest called his invention the audion and applied for a patent on it January 29, 1907. When the talents of the audion were fully explored, here's what men discovered it could do:



Fleming's valve. Fleming adapted Edison's bulb to act as a detector of radio signals. Edison had learned that a hot filament throws off a stream of electrons to a plate sealed inside a bulb. So Fleming attached the plate to the antenna. Thus the alternating impulses of the Hertzian waves (successive positive and negative charges) came down the wire to the plate inside the bulb. The negative Hertzian charges tended to stop the flow from filament to plate. The positive charges increased the flow. Thus the valve eliminated half the charges (the negative), reducing the frequency of the Hertzian waves by half. A bulb that does this is a detector of radio waves. Upon Fleming's adaptation of an old discovery of Edison's, the entire development of modern vacuum tubes and the broadcast industry depended!



DeForest's audion was Fleming's valve with a bent wire, called a "grid," placed between filament and plate. The grid, connected to the aerial, sensitively controlled a current passing from filament to plate.

It could detect radio signals better than any device ever invented.

It could amplify these signals to any volume required, millions of times if necessary.

It could change alternating current to direct current.

It could—and this is most important for the future art of broadcasting—*generate* high-frequency current of the kind needed to agitate the ether.

In Chapter Three we mentioned the kinds of carrier wave used by your local stations—radio waves vibrating with frequencies of 750,000 per second, or 1,400,000 per second. This marvelous tube could generate these frequencies. In fact it could generate frequencies of five or ten millions if necessary.

DeForest's audion does all the above duties for us now. It provides the ether-borne vehicle that brings us all our radio programs. It is found in all our home receivers, detecting these signals, and amplifying them so that they will actuate our loud speakers.

It does more than that. It has found a useful place in talking movies, long-distance telephoning, airport radio beacons, and wirephotos. In fact wherever electric current needs to be sensitively controlled, or amplified, or changed from alternating to direct current, the audion is the vital element. Someone has said that the audion has fathered billions of dollars of new industry and it has only made a start. This is true.

The marvelous abilities of the tube weren't discovered all at once, nor did DeForest himself know what a miracle he had performed. All he knew was that he had a better detector.

The fact that the audion could not only detect radio waves but could also generate them was the work of Edwin H. Armstrong.

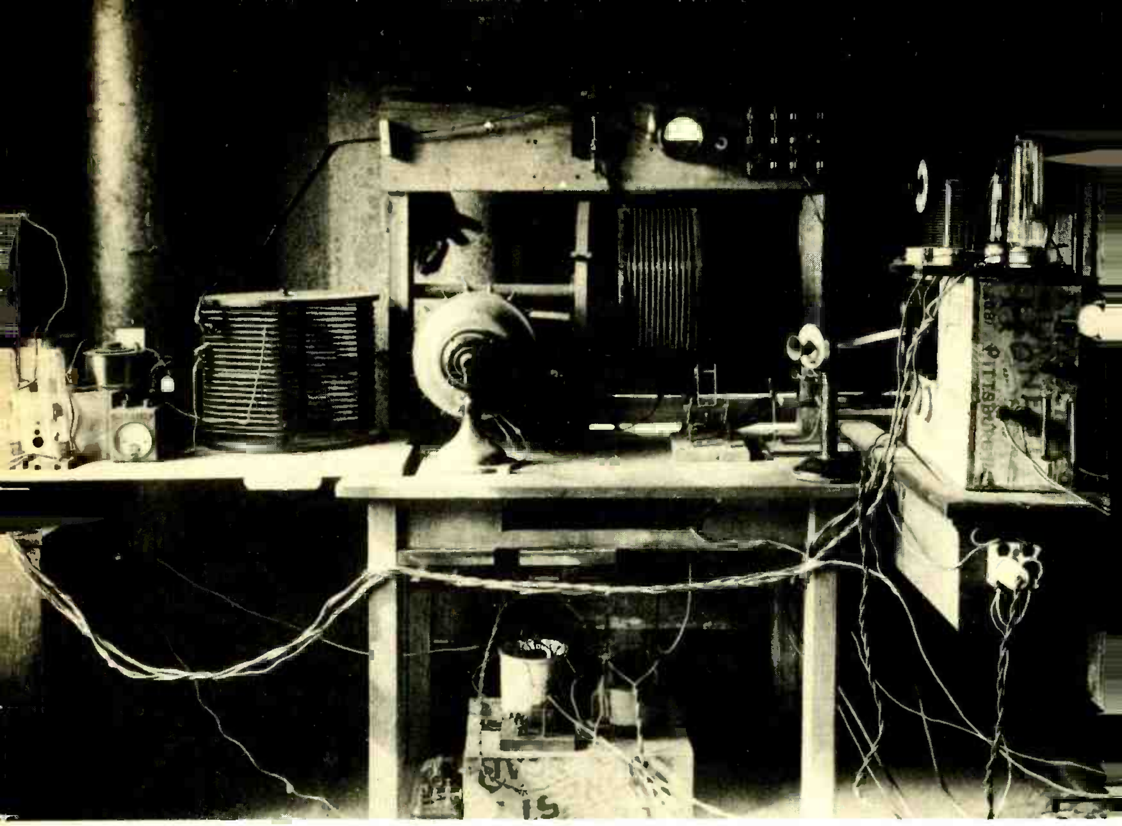
In 1910 Armstrong was a student at Columbia under the noted Professor Michael Pupin. Already, as an amateur tinkering with a homemade radio set, he had hooked up Fleming valves and later DeForest audions. With unusual curiosity and persistence, he tried to discover just how the audion worked. He didn't believe that the inventor himself fully understood it.

While trying various hookups and alterations, he noticed one day a curious whistling noise that made him think that the tube was not only receiving high-frequency waves, but also generating them. Careful experiment proved that he was right. By his discovery, he had revealed the audion as the ideal broadcasting transmitter.

Other men, too, contributed to the perfection of the audion. Dr. H. D. Arnold of the research department of American Telephone and Telegraph Company, and Dr. Irving Langmuir of General Electric worked independently on it, and discovered that the tube would work better in a high vacuum. DeForest had left a certain amount of gas in his audion under the mistaken idea that the gas was necessary to make it function properly. Today, the gas or air is removed. The tubes are vacuum tubes.

DeForest sold his audion to the American Telephone and Telegraph Company in 1913, for $50,000, reserving the right to make and sell them himself. He equipped the United States Navy with the audion for telephoning from ship to ship.

He went to Paris and staged a broadcast from the Eiffel Tower and his voice was heard as far away as Marseilles, a distance of five hundred miles. Back in New York, in 1910, from a little room in the Metropolitan Opera House, he put the famous tenor, Enrico Caruso, on the air, and a scattering of listeners heard it. Amateurs bought the audion and incorporated it into their sets. The stage was slowly getting set for broadcasting.



Station 8XK, the first broadcasting station, in the home of Dr. Frank Conrad in Pittsburgh. Later 8XK became the famous KDKA. *Photo by Brown Brothers.*

5 · Broadcasting Begins

WE begin to see, now, how a new art like broadcasting takes shape. First, there is a scientist like Maxwell to gather the existing knowledge about electricity and organize it into a set of laws. Then a great experimenter like Hertz to test those laws. After that, a whole series of venturesome, resourceful men like Marconi, Fessenden, and DeForest to take hold of a discovery and harness it to the use of mankind.

When World War I came along, the United States was ready for broadcasting. The equipment was far enough advanced so that the voice could be sent and received. There was a growing body of amateurs eager to pick up anything that came to them from the air.

Men's minds, too, began to envision broadcasting. In 1916, a young man named David Sarnoff, a rising executive with the American Marconi Company, proposed to his superiors that regular musical and talking entertainment be given by the company. He felt confident that a "radio music box" could be manufactured for seventy-five dollars, complete with amplifying tubes and a loudspeaking telephone. He was certain that in a few years' time several million of these sets could be sold. Far-seeing men were dimly sensing that something new in public entertainment was just over the horizon.

During the war years, the government had to take all amateurs off the air, since it wasn't advisable to permit irresponsible people with their own transmitters to send out messages that might conflict with Army or Navy wireless messages. Even receiving sets were sealed up for the duration, so that any development toward broadcasting had to wait.

Yet World War I advanced the art of radio. The United States communicated with the American Expeditionary Force in France by means of wireless. Edwin H. Armstrong, who had become an officer with the Signal Corps in France, developed the most sensitive receiver yet invented, in his effort to catch the weak signals of German wireless.

One day a German submarine, its crew dead, was washed up on the beach in England. In the submarine was a German code book, giving the British the ability to translate all German wireless instructions to her fleet. In a German cruiser sunk by the Russians another code book was found. So the British, instead of attempting to prevent German orders by setting up "interference," calmly allowed the enemy to send out messages with utmost freedom—

and then translated those messages to discover the movements of undersea raiders.

After the war, something else happened to set the stage for nation-wide broadcasting. The government didn't like to think of a foreign company having a monopoly on wireless communication. President Wilson and his advisers knew that the Marconi Company, British controlled, might own all facilities for sending space-borne messages.

So, with government urging, the General Electric Company bought out the American branch of the Marconi Company and set up the Radio Corporation of America. Then General Electric's chief rival, the Westinghouse Company of Pittsburgh, bought up all the wireless patents that were still available, and set up its own company to engage in wireless.

Neither company was thinking of broadcasting. They were thinking of code wireless and radio telephony. They were thinking of selling phone calls and messages between private parties.

But sometimes what the managers plan and what the public wants are entirely different. The war produced thousands of radio fans. Operators off ships, wirelessmen in the Signal Corps, discharged from the service, went back to their homemade sets. Some of the venturesome ones built transmitters as well as receivers. Every such amateur sender was a broadcasting station in the making.

Take for instance Lester Spangenberg whose story is told in Alfred P. Morgan's *The Story of Electricity*. After a year as radio expert in the U. S. Navy, Spangenberg set up his own station, W2ZM, in Lakeview, New Jersey. Within reach of his transmitter were several hundred amateurs with receiving sets. He talked to them and they replied with postcards and letters. Early in 1920, entirely for the fun of it, Spangenberg and his friends sent out piano music, phonograph records, and banjo solos. They did this night after night. Their telephone microphone was in the living room near the piano, their transmitter tubes on the second floor, and their aerial on the roof of Spangenberg's home.

Out in Detroit, an amateur sender in 1920 was building up listeners and laying the groundwork for what was to become WWJ, the first newspaper-owned radio station.

The most important step came in East Pittsburgh, where the Westinghouse Company was doing laboratory work in telephony. The man in charge of this work was Dr. Frank Conrad.

Dr. Conrad set up one station at the East Pittsburgh plant, and another in the garage of his home, several miles away. Between the two he sent code messages and voice conversations. His two sons, Francis and Crawford, helped him.

As we have stated, Conrad and his chiefs weren't trying to develop broadcasting. Westinghouse intended to inaugurate a regular service from shore to ships, whereby ships would get the day-by-day news of the world. This, the company thought, might yield enough revenue to justify money spent in experimentation.

So Dr. Conrad and his helpers talked at one station and listened at the other, changed hookups, redesigned parts, and did all the things experimenters do to improve their equipment. Letters came in from amateurs in the Pittsburgh area. Some of these writers asked Dr. Conrad to go on the air at regular intervals, so that they would know when to listen. Because their reports were valuable to him, he promised to broadcast for an hour on Wednesday and Saturday evenings, starting at 7:30.

Mostly he played phonograph music. Now and then he gave out baseball scores and newspaper headlines. His sons brought in neighborhood talent to fill the time with piano music, songs, and recitations. Experimental Station 8XK was building an audience.

In the summer of 1920, a Pittsburgh department store offered ready-built receiving sets to people interested in listening to Dr. Conrad's broadcasts. With the publication of this advertisement, the Westinghouse officials began to see which way the wind was blowing.

Harry P. Davis, vice-president of the company, realized suddenly that radio wasn't a matter for private conversations. Rather it was a way of spreading publicity from a single point to a wide audience. It was a means of tossing out news or entertainment in

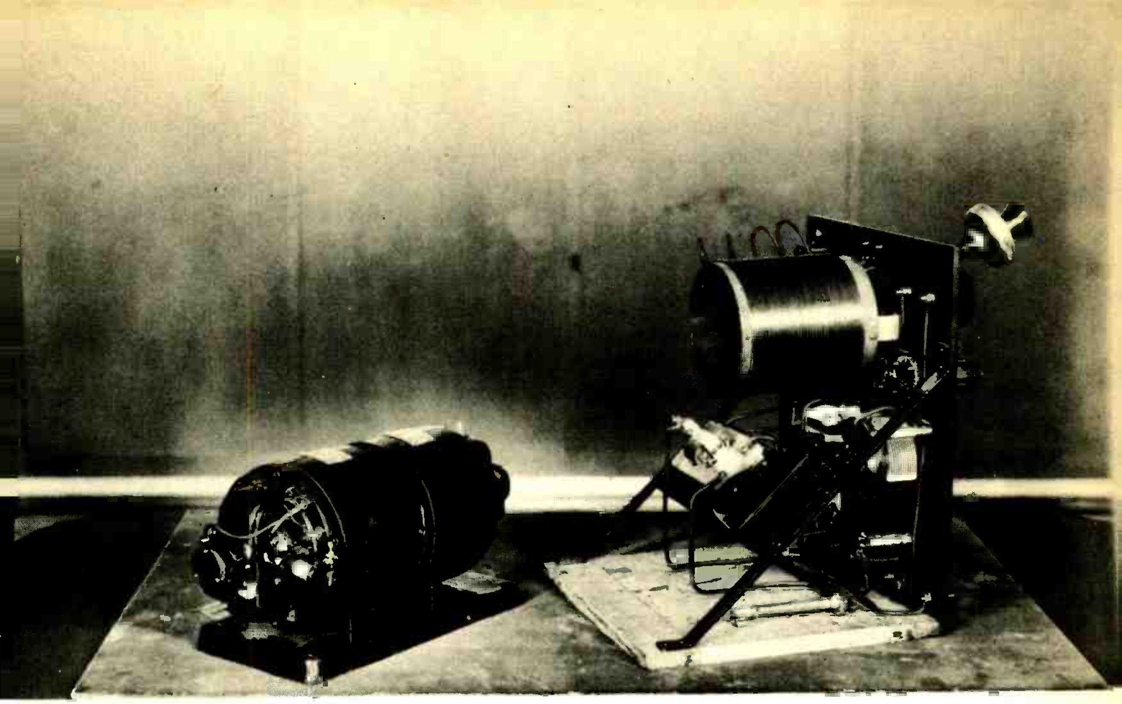
The first important broadcast: station KDKA reporting the Harding-Cox election returns, November 2, 1920. *Courtesy of Westinghouse Electric & Manufacturing Company.*

all directions, to anyone who would listen. And judging by the demand for radio parts, many people wanted to listen.

So Mr. Davis called a meeting of department heads and proposed that Westinghouse broadcast the returns of the 1920 Presidential election. Station 8XK went to Washington for a license and became KDKA. A shack was erected on the roof of the factory's tallest building. Inside were the transmitter equipped with a half dozen DeForest tubes to provide the radio waves, and a telephone mouthpiece for microphone.

The company hastily built and distributed inexpensive receiving sets to a selected audience. A Pittsburgh newspaper was enrolled to telephone election returns to the studio.

So it was that on November 2, 1920, for the first time in history, men and women gathered round radio sets and listened to a radio announcer giving out election bulletins. Out of invisible space came the returns from Maine and California, telling that Warren G. Harding was defeating Governor Cox of Ohio for the presidency of the United States. Probably somewhere between five hundred and a thousand listeners heard this first important radio program. The broadcasting era was begun.



A small generator and a transmitter mounted on a board. That was enough, in the early 1920's. Compare this with the equipment of a broadcasting station today! *Courtesy of The Detroit News.*

6 · Broadcasting Grows

IMMEDIATELY after the election broadcast of November 2, 1920, KDKA established a one-hour-a-day schedule from 8:30 to 9:30 in the evening.

For a while, the chief program item was phonograph music. Those first audiences weren't particular. Anything that came through the air was fine. But as spring, 1921, approached, KDKA decided to improve its programs by broadcasting the company band. Their first concerts were held in an auditorium, but fans complained that the reception wasn't good. There were echoes and reverberations. Since the weather was now becoming warm, the band was moved to a factory roof and the unpleasant noises disappeared.

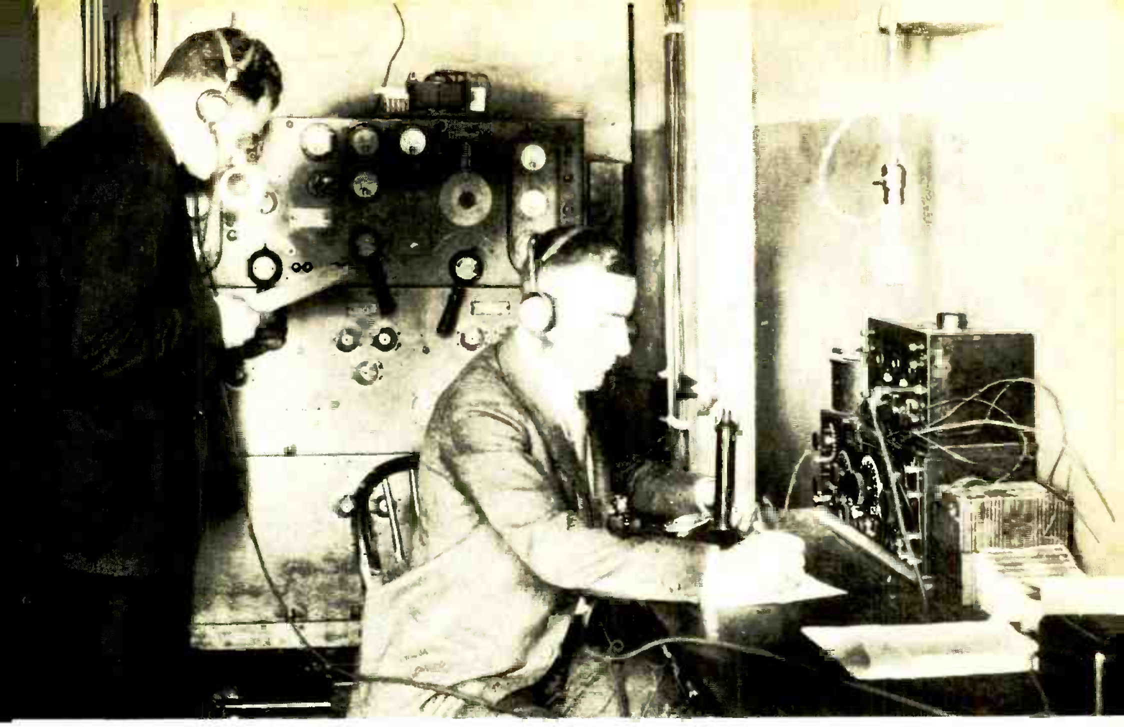
The rains came and the station pitched a tent, and the reception was even better. One day a storm blew the tent down, and the band was faced with the necessity of going back to a hall. But since a hall had already proved to be unsatisfactory, the resourceful managers pitched a tent inside one of the largest rooms available. The result was good.

Eventually, to duplicate the indoor tent, KDKA built a studio and lined it with burlap. Groping in the dark, the pioneers were arriving at the modern broadcasting studio with its walls specially designed to prevent echoes and give clear acoustics.

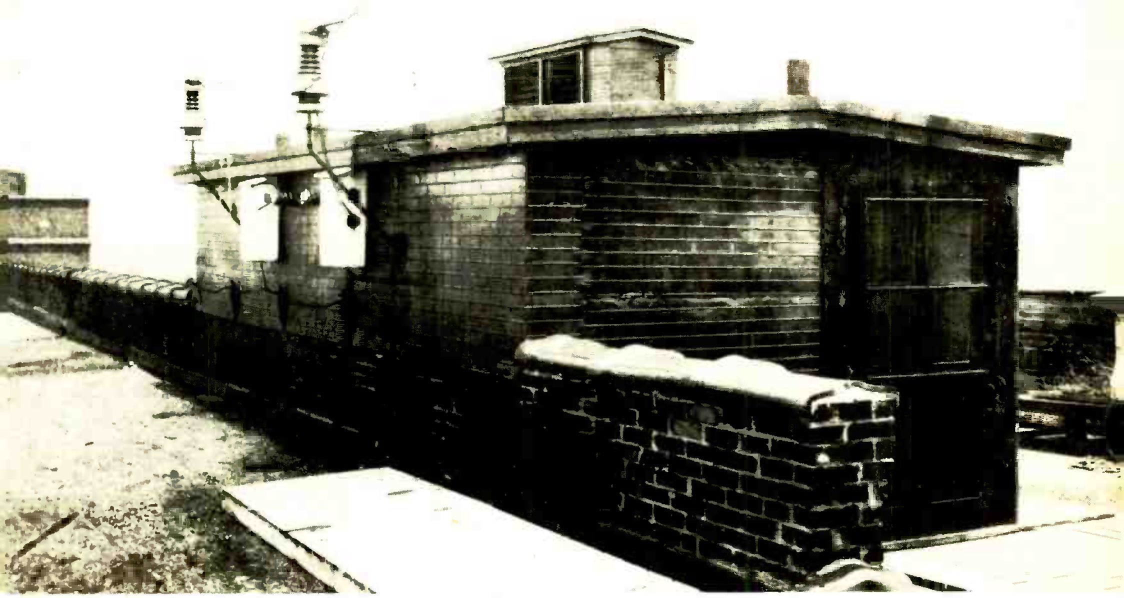
In its first few months of operation, KDKA pioneered another type of program. They staged broadcasts from the Calvary Episcopal Church of Pittsburgh. Three microphones were placed in the auditorium for preacher, choir, and organ, and the result was highly satisfactory. Thus the first broadcast originating outside a studio was held.

For many months, KDKA had the field to itself, but in the fall of 1921 other stations began to appear. WJZ, a Westinghouse station, went on the air from Newark, New Jersey, on October 1, 1921. Another Westinghouse station, WBZ, started up almost exactly the same time in Springfield, Massachusetts. In New York the Radio Corporation of America obtained a license for Station WDY, October 1, 1921, and began broadcasting the January following.

Before these full-fledged stations came into existence, however, RCA established a station for a single day, for the purpose of broadcasting the heavyweight boxing match between Jack Dempsey and Georges Carpentier on July 2, 1921. David Sarnoff, now general manager of the RCA, called on Major J. Andrew White, editor of *Wireless Age*, to conduct the broadcast.



RCA's first venture in broadcasting: station WJZ was established for a single day, July 2, 1921, in Hoboken, New Jersey. *Courtesy of Radio Corporation of America.*



WBZ in Springfield, Massachusetts, was another of the very early broadcasting stations. *Courtesy of Radio Corporation of America.*

Major White and his assistants worked fast. The fight was to be held in Jersey City, so they appropriated a nearby shack belonging to the Lackawanna Railroad for their transmitting station. They worked all night, until early dawn, to get their equipment ready.

Then Major White and one man proceeded to the outdoor arena, to set up their microphone. Their work done, they sat through the early hours of the morning in a drizzling rain, getting soaked to the skin. They had nothing to eat. They had given up their tickets at the gate and didn't want to take a chance on leaving the arena.

Finally, after endless hours, the fight started and Major White began his blow-by-blow description. Word came from the transmitting station that everything was all right. The broadcast was "coming through." It almost didn't. The tubes at the transmitting shack became overheated. One of them exploded and had to be replaced. But something like two hundred thousand people heard the broadcast. Radio's audience was growing.

The first broadcast of a World Series was given by WJZ in October, 1921. Out at the park, a sports writer watched the game and telephoned a play-by-play description to the studio. There an announcer received the account and relayed it over the microphone in his own words. To give the audience the impression that the broadcast was coming directly from the park, the announcer had placed a group of factory workers on the roof outside the studio window, to cheer every time the announcer signaled. To imitate the crack of bat meeting ball, the announcer broke a match stick close to the microphone. In this way, it seems, sound effects were born.

As might be expected, those first stations were small affairs. KDKA began its existence in a wood shack and a tent. The Newark station, WJZ, was installed in a part of the ladies' rest room at Westinghouse's eastern factory. It was just about the size of a small living room. Microphones and a switchboard were installed

A WORLD EVENT
—A CALL FOR YOU

Amateur Radio Will Earn a New Place in History on July 2nd.

YOU'LL BE NEEDED! YOU ARE WANTED!

The greatest international sporting event in the history of the world, the Dempsey-Carpentier boxing match on July 2nd, will be voice-broadcasted from the ringside by radiophone on the largest scale ever attempted.

The co-operation of amateur radio operators has been provided for and is required to make the unprecedented undertaking successful.

Through the courtesy of Tex Rickard, promoter of the big fight, voice-broadcasting of the event is to be the means of materially aiding the work of the American Committee for Devastated France and also the Navy Club of the United States. These organizations will share equally in the contributions secured by large gatherings in theatres, halls and other places. The amateur radio operators of the country are to be the connecting link between the voice in the air and these audiences. There are no restrictions. Any amateur who is skilled in reception is eligible, whether or not he is a member of any organization.

Will you help?

Tex Rickard believes you will, the American Committee for Devastated France believes you will, and the Navy Club believes you will.

Now—once again—will YOU help?

Nearly 200,000 people heard the broadcast of the Dempsey-Carpentier fight on July 2, 1921. *Courtesy of Radio Corporation of America.*

1922 saw the beginning of operatic broadcasting. *Courtesy of National Broadcasting Company.*

and the walls hung with red drapes.

In such settings as these, the operatic artists and Broadway stars of 1922 made their bows over the air. In most instances they performed free of charge, for the novelty of the experience and whatever publicity value there might be.

As programs developed, all the problems of a new industry cropped up. A Metropolitan soprano sang over WJZ and her voice was so loud that the tubes gave signs of blowing out. During her solo the engineer kept moving the microphone farther and farther from her, until she was at one end of the small room and the mike at the other, and still the tubes were in danger. Later, engineers would be able to reduce a singer's volume with the simple turning of a knob, but at that time no such control existed.

On another night, also at WJZ, a pair of cats set up terrific howling outside the studio window, and scores of letters poured

Miss Vaughn de Leath, "The Original Radio Girl." First at WJZ, Newark, New Jersey, 1921.
Courtesy of Radio Corporation of America.

in to the station asking what kind of "interference" noises had afflicted the program. It sounded, said the letters, like an army of cats. To which the station replied that it not only sounded like cats, it was cats.

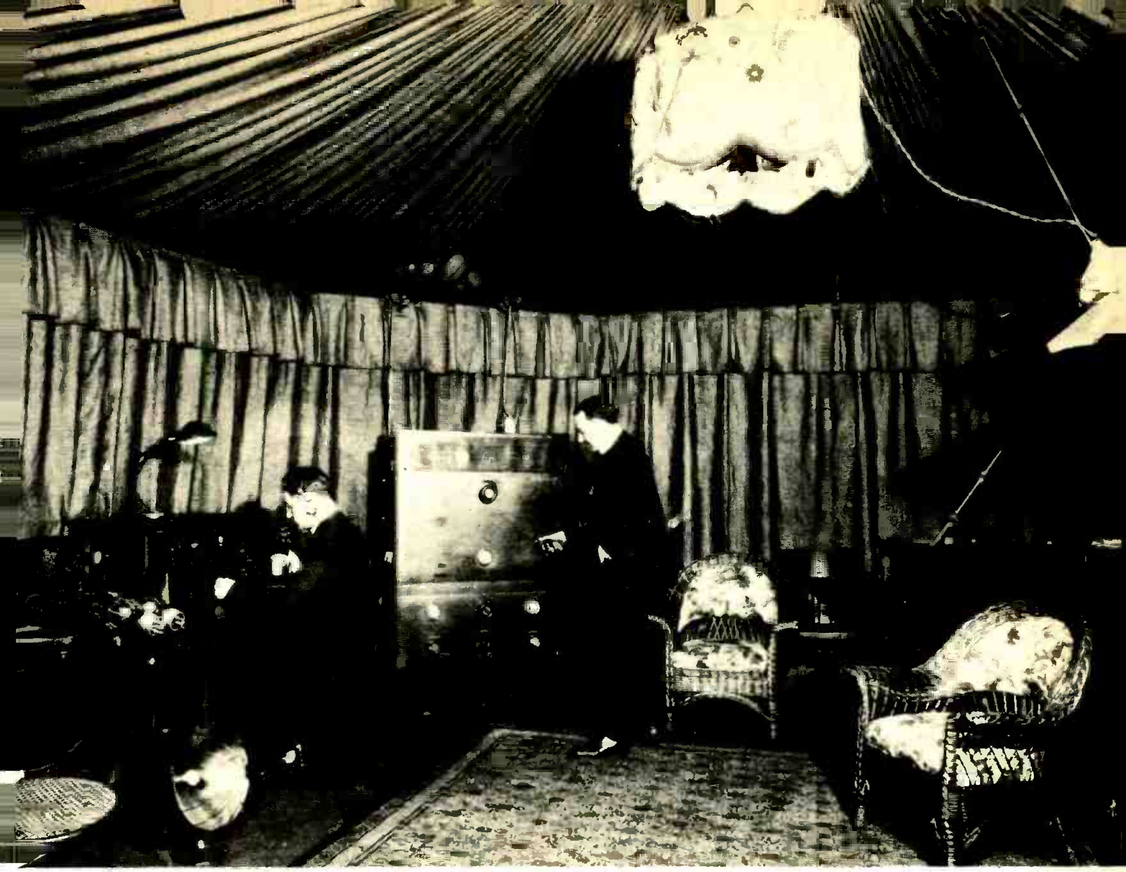
When RCA established station WDY late in 1921 the studio designers did a little better job of it. The studio was hexagonal in shape, finished in draperies of blue and gold, with Oriental rugs on the floor. Over this station, in 1922, the comedian Eddie Cantor made his radio bow, and like many entertainers who get inspiration from the response of a live audience, he was distressed at the silent impersonal nature of the microphone. He couldn't believe that anyone could actually hear him.

Toward the end of the program he asked his listeners to send in a dime for a certain charity. The shower of dimes that arrived in the mails convinced him that beyond the microphone there was, actually, an audience of listeners.

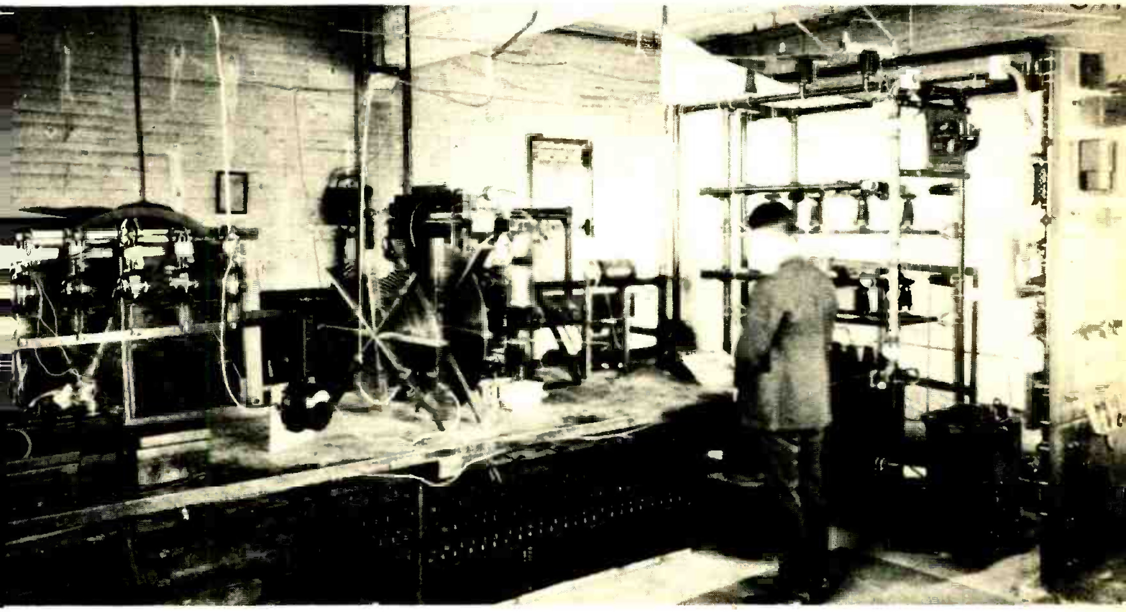
In February, 1922, Ed Wynn made his air appearance on WJZ, and the lack of an audience so bothered him that he turned to the announcer and said that he couldn't go on. So the announcer hastily rounded up everyone he could find from other parts of the building and crowded them into the studio. Very soon their chuckles and applause restored the comedian's confidence and he finished in triumph.

In February, 1922, KYW started up in Chicago with broadcasts of the Chicago Opera. In the same month, WGY was opened at Schenectady. The number of stations was increasing, the audience was becoming nation-wide, and troubles were arising.

One of the troubles was interference. At that time, most stations were broadcasting on the same wave length, which was around 360 to 400 meters. Wherever two stations close to each other went on the air at the same time, the listeners ran into the annoyance of hearing two programs coming from the loudspeaker in a confusing jumble. To avoid this difficulty stations broadcasting from the same area had to split up the time between them.



Station WDY, Roselle Park, New Jersey, 1921. *Courtesy of Radio Corporation of America.*



Station WGY, Schenectady, New York, 1922. *Courtesy of Radio Corporation of America.*

Later, as DeForest's miracle tube was improved, and government regulation stepped in, stations were to be assigned their own channels, well enough separated so that interference was reduced almost to the vanishing point. Eventually 110 radio channels were to be established.

Another trouble was cost. Stations were spending thousands of dollars a week and there was no return. The only ones making money were the manufacturers of sets and parts. England was to solve this trouble by establishing government-controlled radio and charging an annual fee to every set owner.

The same plan was discussed for the United States, but in the summer of 1922 came a promise of revenue from an entirely different source from that used by England.

Late in August, the American Telephone and Telegraph Company's New York station, WEAF, just opened, learned of a real estate development just getting under way. One of the station's managers suggested to the real estate promoters that a ten-minute radio program might help sell lots.

Five ten-minute programs went on the air, for which the real estate company paid approximately five hundred dollars. The next month several companies bought short programs. The sponsored program thus had its start, in the early days of broadcasting, and station managers began to see how they could pay the enormous costs of running a studio.

Late in 1922, radio took another long step forward. In those days, stations were not connected with each other by telephone lines. A program originated in a small studio and went out into space, to be picked up by anyone within range. Since the transmitting power wasn't great, the range was relatively small. So, if an important broadcast was staged in New York, there was no way for another city to enjoy it. Radio stations were separate little islands, entertaining their own inhabitants.

Then station WEAF in New York wanted to broadcast the Princeton-Chicago football game from Stagg Field, Chicago. The program was successfully carried from Chicago to New York by telephone wire and put on the air from WEAF's transmitter. The date of the historic event was October 28, 1922.

Later that fall Station WNAC in Boston suggested to WEAF in New York that the latter send one of its programs by telephone wire to Boston, so that both stations could broadcast the program simultaneously. This important experiment occurred on January 4, 1923. On that evening WEAF put on the air five minutes of saxophone music. The music traveled to Boston over a telephone wire and took the air at WNAC.

The result of these early attempts was encouraging. Bell Telephone engineers learned that land wires would have to be improved if more linked programs of this kind were to be put on, and they got busy in their laboratories. Two years later, twenty stations were webbed together by telephone wires for a speech by Calvin Coolidge, and network broadcasting came very close to reality.

The early years of the 1920's were the years of a radio boom. In 1920 KDKA was alone in the field. By the end of 1922 there were some six hundred licensed stations. Beginning quietly enough with the election broadcast from East Pittsburgh in November, 1920, the radio age swept the nation like a forest fire.

7

Inside the Local Station

WHEN the cables of the telephone company began linking one station with another, network broadcasting was born. For a few years, these telephone hookups were made only for special occasions such as Presidential campaign speeches and intersectional football games.

Then the leaders of radio realized that network programs should be provided on a regular day-to-day basis. That way, well-known musical and dramatic talent, as well as important events, could be sent out to local stations in a continuous flow.

The first network was the National Broadcasting Company. Under the sponsorship of the Radio Corporation of America and the American Telephone and Telegraph Company, NBC was incorporated September 9, 1926. Two networks were planned: a Red network with WEAF as the parent station, and a Blue network with WJZ.

The inaugural program of NBC was held in the grand ballroom of the Waldorf-Astoria on November 15, 1926. Symphony orchestras, dance bands, and an imposing array of stars, among them Will Rogers, the comedian, and Mary Garden, the operatic singer, appeared on this first program.

Meanwhile, NBC prepared for a new home at 711 Fifth Avenue. Oscar B. Hanson, now vice-president of NBC, designed eight studios, each separated from the building itself by cushions of felt, so that sound vibrations would not carry from studio to the structure of the building. Double sound-proof doors, dead air space in the walls, and triple glass between the studio itself and the adjoining control room insured ideal conditions for broadcasting.

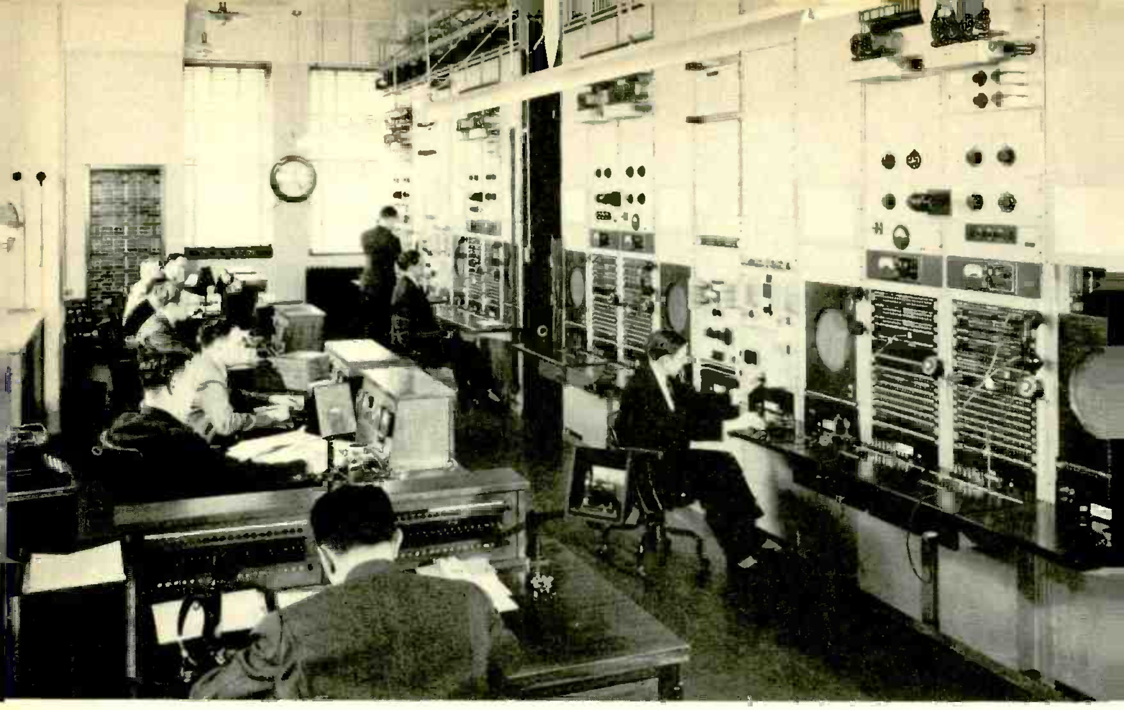
By the following summer there were twenty-three stations in the Red network, eighteen in the Blue, and seven on the Pacific Coast, all a part of NBC.

It was natural that a rival should spring up before long. In 1929 the Columbia Broadcasting System, under the aggressive leadership of William S. Paley, went into action. In 1934, the Mutual Network made its appearance.

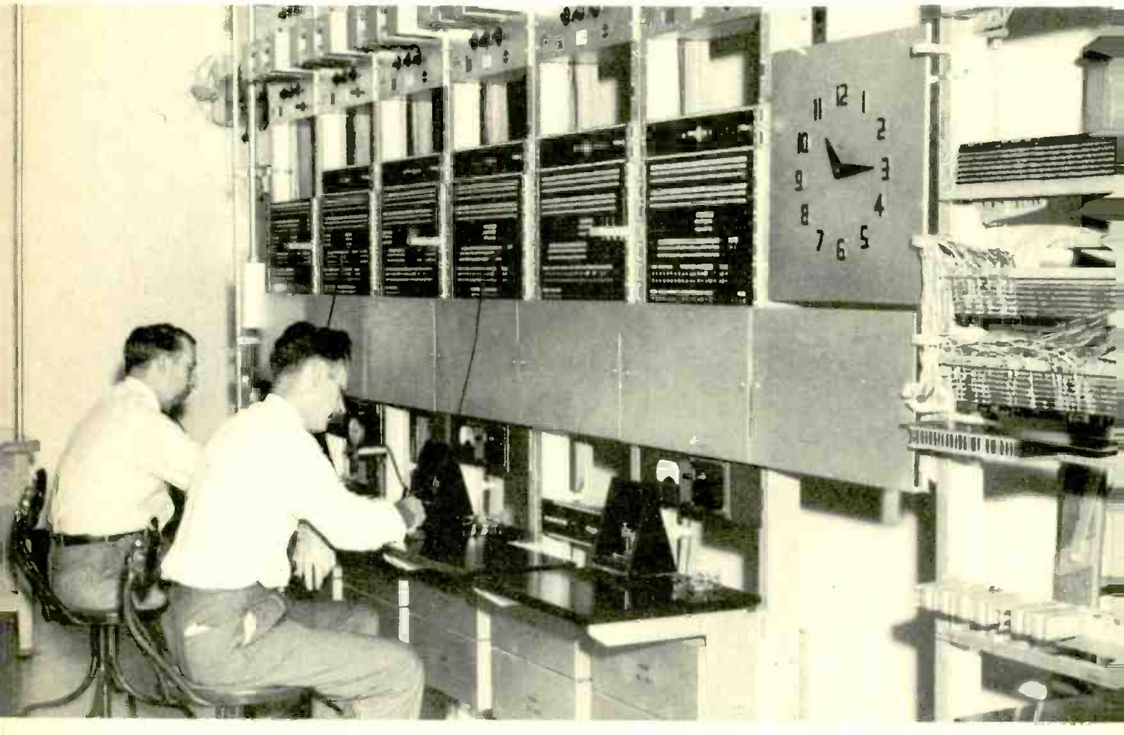
Today there are 900-plus radio stations in the country, and more than half of them belong to networks. In 1941, the Red and Blue networks of NBC were compelled to separate by law, and now the Red is known as NBC. So we have NBC with 137 stations, the Blue with 115, Columbia with 121, and Mutual with 201.

In addition to these four national hookups, there are many regional networks. Thus we have nationwide networks to give programs of national interest, regional networks to broadcast material of interest primarily to one region, and local stations to present programs that interest a town or a county. This is the setup that serves the owners of the thirty million-plus radio sets in the United States.

The building stone of this radio structure is the local station. At the local station the network program leaves the telephone wire and takes to the air. So let us go through a local station, inspecting the equipment and talking to directors, actors, announcers, engineers, and officers who supervise our radio fare. They can tell us how stations operate, how people get into radio, and something of the rewards, penalties and chances of advancement in a radio career.



All network programs starting in New York go to the telephone company's control room. Here they are routed over the country according to instructions from the network. *Courtesy of American Telephone & Telegraph Company.*



National programs travel by main lines to various switching points, from which they are routed to branch lines leading to individual stations. Here's the Dallas, Texas, switching point. *Photo by G. A. McAfee.*

We'll call our station, WWW.

Station WWW is one of the larger local stations, located in an important midwest city. It goes on the air at six in the morning and signs off at one A. M., although in times of national emergency it may operate twenty-four hours a day. Its programs are heard over a radius of forty to fifty miles during the daytime and twice that at night, though at times listeners a thousand miles away will report that WWW came in clearly.

WWW occupies two floors of a downtown office building. Here are the studios, offices, main control room, musical library, and auditorium. The transmitter, with its mastlike antennae, is six miles away, in the suburbs, isolated from the interference of office buildings and high-tension wires.

Beyond the reception room, down a long corridor, there's a frosted glass door marked "Program Director." You enter the office and meet Mal Black, who has charge of all programs going out from WWW.

When you hear that more than one hundred broadcasts a day are under his supervision, you realize that his job isn't an easy one.

Mr. Black tells you that WWW's programs come from two sources. The network, he says, provides those big variety shows you hear at night, the important sports events, and a long list of dramatic shows. About half of the station's time is devoted to network shows.

The other half is provided by the station itself. The station puts on its own newscasts, dramas, orchestras, singers, and forums. It broadcasts local sports events, political speeches, parades and celebrations.

Mal Black has the task of coordinating all this into a smoothly running show that lasts nineteen hours without any intermission whatever. Jobs like his in the larger local stations, you learn, pay anywhere from $75 to $150 a week. The announcers, actors, musicians and script writers are under his general supervision.

Mr. Black, you learn, grew up with radio. In his high school days he tinkered with a homemade radio set, and after graduation he played trumpet with a traveling orchestra.

After a year of orchestra work he joined a small-town station as script writer, announcer and general handy man. While working at the small station he watched for openings, and when he learned that WWW needed a script writer he applied and won the job. His work was so outstanding that when the program director left WWW for a network position, Mr. Black was promoted to the vacancy.

Mr. Black, in cooperation with the sales department, has to decide what kinds of show WWW should produce. Should the hot band known as the Aristo-cats be put on for a half hour in the morning, or at some other time? Should that dull half hour on Sunday be filled with a weekly dramatic show? Should an extra newscast be scheduled at nine in the morning? How does he decide?

"Horse sense," he replies. "A program director must keep track of what the public wants. He must create the kind of programs the sales department can sell to local advertisers. He must see that two or more programs of the same general type do not follow each other. There has to be variety.

"The program director works under a budget, and in his planning of local shows he must decide how much to spend on this one, and how much on that."

Now and then the program director must work fast. The station's owner may come to him and tell him to organize a two-hour Red Cross show for the day after tomorrow. This means a great roundup of talent—a hotel band, guest stars from visiting shows, the mayor, the Red Cross chairman, civic leaders. Mr. Black must meet with the script writer, the producer who will have personal charge of the show, and musical director of WWW and together they must plan just how much time to allot to each speaker, what musical numbers shall be played, what everyone is to say. Scripts must be written for the announcer and for some of the outside

Station WWW puts on a program of interest to housewives. The announcer, between the ladies, reads the opening and closing commercials. *Photo by Manning Bros., Inc.*

speakers. All must be put together in a smooth-running show.

Assembling such a show in a few days is a task calling for imagination and speed.

Now and then a scheduled show will fail to go on because of illness or a sudden cancellation. The program director must be ready to substitute another show in a hurry.

To help him in his complicated task, Mr. Black has an assistant director. This man prepares the daily schedule in advance, on mimeographed sheets. A glance at this sheet gives you a picture of the amazing variety provided by the station—get-up-in-the-morning programs, newscasts, music; midmorning and midafternoon dramas of the home; commentators and sports reviews in late afternoon; big network shows at night; late news and local dance bands until one A. M.

An announcer is assigned to each program. He may do no more than say: "This is WWW, the Midwest Station," but he must be on hand. Between programs he may announce a clothing sale, promote the buying of war bonds, or advise all citizens to go to the polls and vote. Or he may read the commercials at the beginning and end of a program.

Since the announcer is such an important part of the day's programs, let's go down the hall to Don Moore's desk.

Don Moore is one of eight full-time announcers employed by WWW. Announcers belong to an organization called the American Federation of Radio Artists, known among radio people as AFRA, and their pay is set by agreement between the federation and the stations. The basic pay varies from city to city according to the cost of living, and in this medium-large town the pay is $50 a week. In New York the pay is $60 a week.

Announcers, however, may earn more than the minimum. If a man has more than average ability his station will raise his salary.

In some stations, too, an announcer receives more when a show on which he is working is sold to a sponsor. Suppose, for instance, a department store buys a quiz program. The announcer receives not only his regular pay, but an added amount from the store. A highly rated local announcer who has created a demand for his services may receive as high as two hundred a week.

You meet Don Moore at his desk. He's tall, broad-shouldered, pleasant and soft-spoken in manner. He suggests that you and he go into a vacant studio where there'll be no interruptions, so you cross the hall into Studio C, a room perhaps fifteen feet square,

When you hear a transcribed program over your local station, here's where it originates. This is the transcription table of a local studio. Transcribed programs are always kept on hand for emergencies. *Photo by Herrmann, Detroit News.*

the walls covered with a gray, perforated composition material to absorb echoes. You sit down at a black chrome and plastic table over which a microphone hangs.

Don Moore, you learn, intended to be a teacher of English, specializing in speech. He did everything possible to fit himself for his chosen profession. He took extension courses provided by the state university, studied voice at a conservatory of music, and dramatics at a local school of expression.

A group called the Stratford Players was giving regular dramatic broadcasts over a local station, and for six months Don played small parts with the group, giving his services free for the privilege of learning radio acting. Meanwhile, to support himself, he was teaching English at a local high school.

He learned of an opening on the announcing staff of one of the smaller stations and took it, even though it meant a reduction in pay from his teaching salary. Don highly recommends working on a small station in order to get a rounded experience. In his first radio job he broadcast news, acted, announced, and even worked sound effects. He wouldn't give anything for his experience with this station.

"If a man wants a job in a large station," he says, "let him cut his teeth on a two hundred watter somewhere. There he'll get used to the mike. He'll do a bit of script writing, make spot announcements and even handle an athletic contest. In that way he'll have a chance to learn where his real talents lie. When he gets to a big station he'll tend to specialize, working only those types of shows for which he has shown special ability."

It's wise, too, Don says, to have a working knowledge of one or two foreign languages. Then, if you have to read copy containing foreign words or phrases, you'll know enough to decide on a pronunciation before going on the air. Don himself took Italian by mail from the Berlitz School of Languages.

From the thoroughness with which he prepared himself you can understand why Don Moore was called to WWW when an opening occurred. He is now close to the top of his profession.

You ask him to describe a typical day's work and he obligingly tells you what he does on Monday. According to federation rules he works eight hours a day. He arrives at the studio at 9:45, drops into the script writer's office and picks up the copy he is to read ten minutes later.

It's a somewhat routine job, this first one, a five-minute drama pointing out the value of a newspaper want ad. Don reads the preliminary and ending copy, or in the words of the studio "puts on" and "takes off" the show. Nevertheless he studies the copy carefully in advance. If he finds unfamiliar words he looks them up for meaning and pronunciation. He discusses with the producer of the show the question of what points to emphasize in the copy.

After this bit is over, Don has a chance to study the day's mimeographed schedule. A few lines down the page he finds himself listed to read a "station break and announcement" at 10:45. This merely means that during the twenty seconds between programs he will go into a studio and read: "This is Station WWW, Midtown. It's time, now, to think about servicing your car for winter. Drop over to your Super Six dealer today and have him give your car a thorough going over." And so on. This announcement was written by a national advertising agency and mailed to the station.

At 11:45 he has another station break and announcement, and a half hour later he appears at Studio C for a fifteen-minute rehearsal of the program, News on Wings, a newscast sponsored by the local poultry dealers' association. Denman Smith is the newscaster. Don's job is to read the opening and closing commercials. The show has a producer who is responsible for the smoothness of the performance, and with the producer Don checks such points as emphasis, pronunciation, and the general manner of delivery.

He has another program to announce before lunch, entitled Men in Uniform, in which Cy Bryson reads excerpts from soldiers' letters.

From one to two he goes out to lunch. At two he returns to the station, and though he has nothing scheduled for an hour he must be on hand to fill in if another announcer becomes ill, or for special bulletins.

So the afternoon goes, ending with a sports review at six-forty. Adding it all up, we find that he has made nine appearances at the microphone, several of them requiring rehearsals, all of them requiring advance study and thought.

Whenever or not he is actually at the mike, he must be in the lounge or the announcer's booth listening to whatever is being broadcast. Then, if a program breaks down for any reason, the announcer goes to the mike with an apology, after which a substitute show is put on. Frequently the substitute show is recorded music, which is always kept at hand for emergencies.

Now and then, Don is asked to handle a "remote control" broadcast. A typical one would be the inaugural speech of the governor at the state capital, sixty miles away. He welcomes assignments of this kind because he can rely very little on copy prepared in advance. He must use his wits, describe what he sees, and be ready for such emergencies as the late arrival of the governor at the microphone.

When Don arrives at the state capitol he finds that a WWW engineer has already set up a microphone on the speaker's platform in the house chamber. The program will go by special wire to Midtown where it will be relayed out to WWW's antennae. Don's job at the capitol is to describe the setting, the filling up of the hall, and the arrival of the governor. This is called "color." After the governor has finished his address Don gives five minutes more of "color" and signs off.

The primary requirement of an announcer is voice. Your voice must be clear and have character, and it must sound well, after going through a microphone and emerging in the listeners' living room. Some people simply do not have good radio voices, and these people should never attempt to become announcers.

In addition to voice, the announcer should have enough educational background to enable him to understand the meaning of what he is reading, the ability to enunciate, and the curiosity to look for errors in copy. Given this foundation, his own energy and persistence will govern how high he builds his career.

What Don Moore does in a day is similar to what the seven other salaried announcers on WWW's staff are doing, and between them they divide up the nineteen hours the station is on the air, with at least three on duty at the same time.

We've spent considerable time with Moore because his work gives us a good picture of a station's daily program. But there are other important departments. Let's go down to the news room.

What announcers like best is to be assigned jobs outside the studio. Interviewing a pursuit pilot about to make an altitude flight, for instance.

A radio station's news room is like the city room of a newspaper. Those two cabinets in the corner are teletypes bringing news bulletins from the press service. *Photo by Manning Bros., Inc.*

8 · News, Music, Engineering and Sales

WWW's newsroom is like the city room of a newspaper. There's a desk for George Cousins, the news editor, and other desks for the six newscasters employed by the station. Along one wall of the room is the black enamel box known as the teletype from which a wide ribbon of paper is constantly unreeling.

This little box is an automatic printer operated electrically from the headquarters of a national news service. As you watch the unreeling paper, typewriter keys are printing news bulletins on it. Thus WWW is constantly receiving up-to-the-minute news from all capitals of the world and all parts of this country.

Newscasters, like announcers, are paid according to the scale set by the American Federation of Radio Artists. Their minimum pay is $50 in Midtown and $60 in New York. At WWW their pay averages $75 a week. They work five days a week, eight hours a day. Now and then a newscaster may be in such demand from sponsors that he may receive as high as $150 a week.

Where announcers are selected primarily for voice, newscasters are picked for their ability to analyze and report news. That is why you may hear voices on newscasts that are not so pleasing. Having a good voice is just as important to a newscaster as it is to an announcer, but it isn't the *primary* consideration.

The standards of newscasting, Mr. Cousins tells you, are those of a newspaper. The newscaster strives for accuracy. He selects items according to their importance or their human interest. He avoids rumors, especially in war time, because there is something about an excited voice, coming through a loud speaker, that tends to make things seem more important than they really are. The human voice can convey panic more quickly than print. It is doubtful if fake news stories of an invasion from Mars, however realistically printed in the papers, would have sent thousands of people out of doors to gaze skyward for the invader. But Orson Welles once staged a broadcast that did this very thing.

A newscaster must do more than rip off the latest bulletins from the teletype and read them. He must condense long stories, combine and clarify conflicting news reports, and reduce the day's grist to an interesting, intelligible story. So he usually comes to the microphone from the ranks of the newspaper reporting staff. A background of journalism, the ability to write simply and clearly, and a good voice are the chief requirements of the newscaster.

Down the hall from the newsroom is WWW's staff writer. The station employs only one, though some stations use two, or even more. WWW's writer must be able to create good dramatic and humorous dialogue. He writes a half hour Sunday show called

The WWW Playhouse; he composes short spot announcements; he prepares continuity for WWW's sustaining shows. (A sustaining show is one that isn't sponsored, and therefore represents an expense, not a source of revenue, to the station.) For these varied writing assignments, WWW's writer receives a salary of $75 a week.

Some writers receive much more. At another Midtown station, a Sunday night mystery show has become so popular that it is distributed to a regional network and sponsored by a coal company. The two authors of this show receive $200 a week for that single half hour show.

Another Midtown station originates a western drama, Lone Cowboy, that is nationally sponsored. The writer of it receives ten thousand dollars a year and has assistant writers to help him.

Generally, though, local station writers are men of moderate salary. Most of the big-money writing for radio is done by men and women employed in advertising agencies, or by free-lance writers who work up a show and sell it to a national advertiser. The chosen few who succeed in creating nationally popular shows may receive fifty thousand or a hundred thousand dollars a year for their work. Writing scripts for a local station is one avenue of approach to this dizzy and thinly populated mountaintop.

Let's pay a quick visit to the musical director and the music librarian. Paul Vance and one assistant musical director, both accomplished musicians, share the work of getting up music for WWW.

Paul's musical education is typical of many capable directors. He took violin lessons at a local studio, played in the high school orchestra, played violin in a three-piece movie orchestra, and finally became a member of a small traveling band. On one of his engagements in Midtown he tried out for a position with a nationally famous dance band and won it. Now and then he made radio appearances, and when an opening came at WWW he was selected for the post of musical director.

With a worry bird hovering over the typewriter, WWW's writer works on a dramatic script. *Photo by Herrmann, Detroit News.*

Local stations put on many musical programs ranging from full bands to string ensembles and rhythm groups. The two musical directors share in the production of these shows. They must select the music, rehearse the orchestras, and conduct the programs.

Some of the musicians under Vance may be full-time staff members. Most of them, however, are town musicians who are under contract to WWW for certain programs. According to union scales, these musicians receive nine dollars for a fifteen minute show preceded by forty-five minutes of rehearsal, and twelve dollars for a half hour show plus an hour and one-half of rehearsal.

Mr. Vance relies heavily on the musical library for his selections, so let's take a look at it. It's a large room, the walls entirely lined with shelves on which are ranged pieces of sheet music in manila folders. The floor space of the room is occupied with cabinets containing more music.

The librarian, Henry Hoffman, tells you that the library has 150,000 pieces of music all indexed and catalogued. In one section of the room are all the volumes of collected songs that have ever been published, including Cowboy Songs, Negro Spirituals, Stephen Foster collections, and so on. In another section are the complete scores of nearly every musical comedy produced in the United States in the last fifty years.

Mr. Hoffman shows you a book containing a record of the most popular songs of the year, for every year back to 1874. So, if you wanted to play a hit song of World War Number One, the book would tell you to take your choice between, "There are Smiles," "A Pretty Girl is Like a Melody," and "Oh, How I Hate to Get up in the Morning."

The musical library is an important part of every local station.

"But," warns Mr. Hoffman, "you can't just extract a sheet of music from these shelves and play it on a program. Much of the music in this library is 'owned' by one of three organizations. These are the American Society of Authors and Composers, called ASCAP; the Society of European Stage Authors and Composers, known as SESAC; and Broadcast Music, Incorporated. For every playing you must pay a fee to one of these organizations, and the organization in turn pays part of the fee to the composer."

Soon, now, we want to watch the production of WWW's Sunday dramatic show, from the birth of the idea to the actual performance. First, though, let's complete our tour of the station by visiting the engineering department and the sales force.

Already, as we have walked through the halls, we have glimpsed a room containing a large switchboard, a wizard's array of wires, plugs, and lights. Let's stop and talk to Andrew Rose, chief engineer of Station WWW.

The radio station couldn't get along without its musical library. This one has 150,000 pieces of music, all catalogued. *Photo by Herrmann, Detroit News.*

Like most of radio's station engineers, Rose was once a "sparks" aboard a ship. As a youngster he had rigged up batteries and wires to light lights and ring door bells, and when the wireless age arrived he built his own receiving set. During World War One he served in the Navy as a wireless operator, and helped organize radio schools in San Diego; Bremerton, Washington; and the Brooklyn Navy Yard. When the war was over and broadcasting began, he became one of the engineers of WWW.

Engineers are a clannish group who live in a world of volts, watts, frequencies and decibels. According to Rose, most of them live and breathe their craft twenty-four hours a day. They're hobbyists, getting paid for the one thing they love to do above all else. Their pay runs from $45 to $60 a week, though a chief engineer may be paid a hundred a week or more.

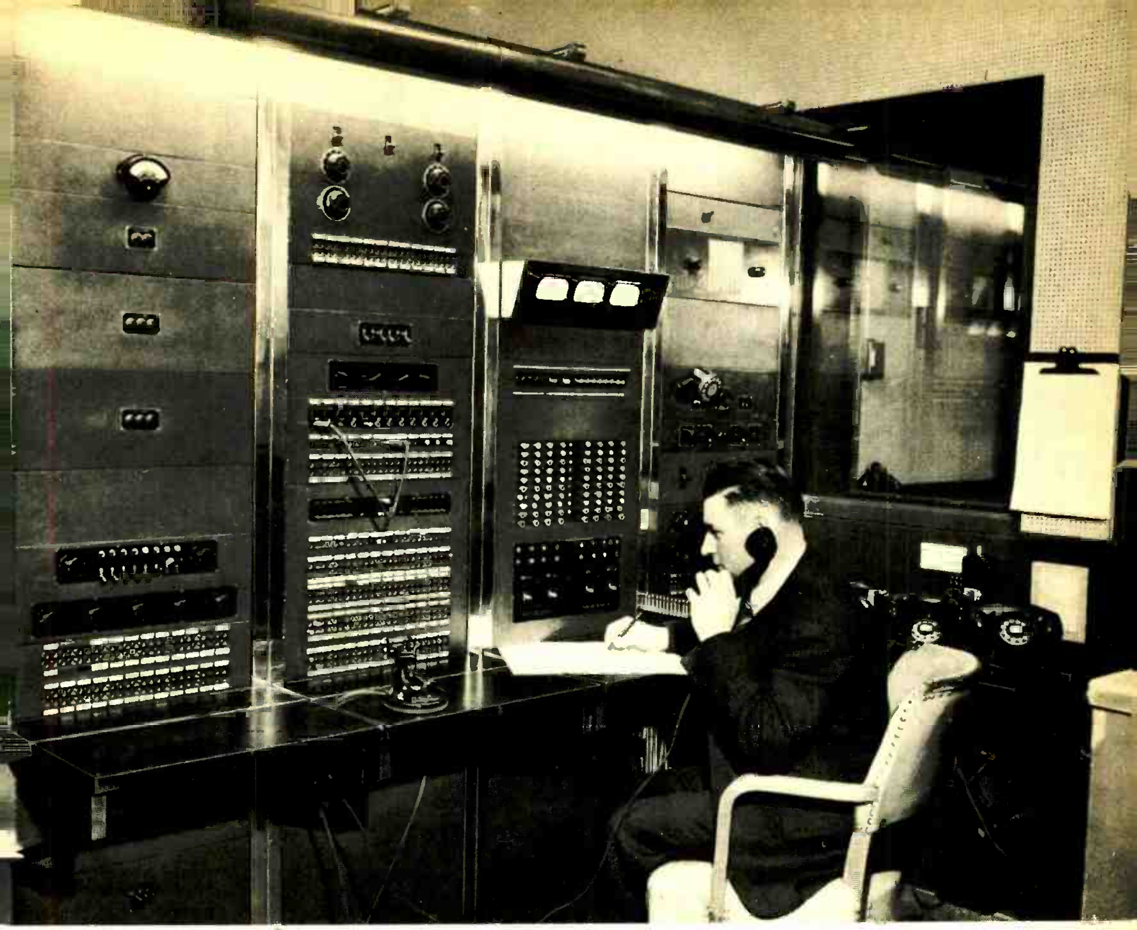
The large switchboard in this room, sometimes called the master control board, is the receiving and distributing point of all programs. If a program originates in Studio A, it comes to this board and is relayed out to the transmitter six miles outside of town. If a program originates in New York, Chicago, or Hollywood, it arrives at this board and goes out to the transmitter. But WWW also has private wires to the city hall, the state capital, night clubs and churches and hotels. A program may originate at any of these outside points, but it must go through the switchboard.

The engineer at the switchboard is the man who routes the program from studio to transmitter, from the network line to the transmitter, or to any office in the building in case an official wants to hear what is on the air at the moment.

"We have twelve engineers on the staff," Rose tells you. "They take turns in the studios and at the master control board."

Rose takes you to the control room of a studio where a newscast is in progress. You look through the glass of the control room into the studio proper, where the newscaster and announcer are sitting at a table with the microphone between them. Through a loud speaker on the wall of the control room you can hear what the newscaster is saying. At the control board sits an engineer, his fingers resting lightly on a knob. With this knob he can control the volume of sound going through the mike. If the newscaster speaks too loudly, the engineer turns the knob slightly and the voice comes down. Or if the voice is too faint, a turn of the knob will bring it up. When an orchestra is playing, the engineer can literally mix the sounds and bring the parts of the orchestra into balance. Every studio show has an engineer assigned to it.

Also in the control room is a cabinet along the wall called an amplifier. Here the tiny voice currents from the microphone are



All programs go through the master control board. It's a sort of Grand Central Station for radio waves. They come in on one track and go out on another. *Photo by Herrmann, Detroit News.*

increased in power and sent along to that room you just left. There, another amplifier further increased the power of the voice currents for the trip to the transmitter.

The engineer has a highly technical job. In one piece of equipment alone are thousands of wires and connections. He must know their location by heart, so that he can instantly make any repair necessary. The engineer nurses the show from studio to transmitter, carefully tending it so that it comes to you in good order.

A station must make money in order to stay in existence and pay the salaries of writers, announcers, musicians and engineers.

That takes us to the man in the next office, Hal Priest. Priest is sales manager of WWW, with a staff of three men under him.

As has already been explained, part of the station's revenue comes from the network. Those big variety shows—the one featuring your favorite comedian, for instance—pay WWW for the use of the station. On the other hand, the network also delivers lots of non-revenue shows to WWW—sustaining shows. WWW needs these to fill out its day and must pay the network for the privilege of using them. So WWW not only receives money from the network, but pays to the network as well. The station could hardly stay in business if it depended on network revenue entirely.

Local revenue makes the station profitable, and the main item of local revenue is the spot announcement. This is the short, fifty- or sixty-word announcement calling your attention to a grocery sale, auto club membership, or the advantage of ordering your coal early. For such an announcement the station may receive from ten to sixty dollars depending on the time of the day at which it is delivered. The evening is the most valuable time because more people are listening to their radios then. So Hal Priest and his staff spend much of his time calling on merchants and selling spot announcements.

But the sales force also sells complete shows, such as a mystery drama, fifteen minutes of orchestra music, or a ten-minute newscast. So the sales force must cooperate with the program department in working up shows that have strong public interest and will appeal to advertisers.

Mr. Priest believes that a young man wanting to sell radio advertising should have some experience on the program side of the local station. The more he knows about programs the better he can serve clients by recommending only shows that will be worthwhile and popular.

So far, in Chapters Seven and Eight, we have told you of the type of experience and training needed for various jobs in a local station. Perhaps you're wondering how much of this training can be received in college. Are there radio courses in college?

The answer is yes. Nearly every college, today, has one or more radio courses. The least you will find is a one-hour course in which the student gets a little practice preparing copy for the microphone and talking into it. The most you will find is a complete set of courses including writing for radio, newscasting, producing, acting, and selling. In between there are all degrees of coverage.

Radio is still new enough so that education for radio isn't standardized. In selecting a college with radio in mind, look in the catalogue for the number of courses given, and find out how large is the enrollment of these courses. If the courses seem complete and the enrollment large, the chances are that the instruction will be thorough.

The best college is the one that cooperates closely with a large local station, keeps in touch with actual practices in the field, and incorporates these practices in its courses.

Radio education will improve as time goes on. You should, if you are careful, be able to select a school that will give you a good grounding for a radio career.

9

Producing a Radio Drama

NOW let's watch the production of a dramatic show from rough draft to final presentation. Drop in at the office of Dave Pinelli, producer of the half-hour Sunday drama called the WWW Playhouse.

Pinelli has a background of high school dramatics and a college education with the emphasis on speech. He joined WWW as sound effects man and later was promoted to the production of shows. He's one of WWW's two staff producers and earns $75 a week.

You ask Dave about next Sunday's show and he points to a script on his desk entitled "Soldier's Return." It was written by Jack Sanders, WWW's staff writer, after a conference with Dave and Mal Black, the program director.

After reading over the script, Dave goes into a huddle with Sanders and Musical Director Paul Vance to decide on a "frame" for the show. The "frame" is nothing more nor less than a combination of sound effects and music to set the mood for the play. On a certain network show, for instance, you hear the sound of a train coming into a station followed by a voice saying: "Grand Central Station!" This is part of the "frame" of that show.

For theme music to open the show, Vance suggests "When Johnny Comes Marching Home," the drums coming up strong in the middle of the tune, then both drums and music fading to bring in the announcer, Don Moore, with the words: "The WWW Playhouse presents the original radio drama, 'Soldier's Return'!" This is to be the "frame" of the show.

Station WWW is lucky, in planning its shows, to have a musical director who is a skillful composer. During "Soldier's Return," there will be eight or ten shifts of scene to be covered by fragments of music, and for these moments the musical director will compose original bits of music in keeping with the mood of the play.

While the musical director is planning the music, Dave casts the show, sets a rehearsal time, and notifies the cast.

In casting shows, Dave selects his actors from a large group of local radio performers. He knows the ones who are gifted at character parts, who can play "tough," who can talk in dialect, and who can play juvenile or paternal roles, and in selecting his actors he tries to fit the man to the part.

This done, he meets the sound effects man and discusses how sound shall be handled. On page three, for instance, the script calls for the closing of a door. Dave tells the sound effects man just how hard to slam it.

Now, after minor editing, the script is mimeographed, double-spaced, with wide margins. All sound instructions are indented so the sound man can locate them instantly. Musical cues are underlined. Character names are at the left, in capital letters. Every line is numbered, so that Dave, when he is instructing an actor on how to deliver a line, can quickly identify the speech by page and number.

The actors don't see their scripts until Sunday, the day of the show. The show is to take the air at 4:00 and the cast reports at the studio at 11:15. At that time the director hands out the scripts and for the next few minutes the actors are busy underlining their own speeches in pencil.

Then the director gives the cast brief, general instructions,

Rehearsal gets under way with the actors underlining their own speeches in pencil. Director seated on the low platform. Sound men behind him. Note the cups and dishes. Somewhere in the play a meal will be served. *Photo by McGraw, Detroit News.*

telling them what mood he is trying to achieve and where the "punch" of the show lies. He doesn't try to be too specific in telling them how to play their parts. After all, they're professionals. He'd rather let them go ahead, and see how they want to do it.

The engineer in the control booth and the sound man at his "truck" are both present.

A word about the sound man. Station WWW has 350 recordings on which there are 3,500 sound effects. If a show calls for the sound of an airplane motor or the noise of a crowd on a circus midway, there's a record for it. So the sound man's chief job during a show is to lower needles on whirling records at exactly the right moment. His truck is an enlarged phonograph with three or four turntables.

But he also has what are called manual effects, the chief of these being door frames. These are exactly what the words say, wood frames with doors mounted in them. Studio door frames are numerous. There are large ones and small ones, heavily and lightly built ones, so that anything from the sound of a screen door to that of a heavy oak door can be reproduced.

When Pinelli has finished his preliminary talk, the first rehearsal begins. He lets the cast go on through to the finish, without interruption, meanwhile making notes of the lines that are weakly read and the scenes that need improvement. As the play progresses he marks the passing of minutes in the left hand margin.

Perhaps the first reading will show that a short scene is needed. The writer, who is present, immediately gets busy with pencil and paper and writes it.

Sound effects man with his truck, a door frame, and a gong. *Photo by Herrmann, Detroit News.*

If you're surprised that parts of the play are written during a rehearsal, with only a few hours remaining until the performance, be warned that radio demands fast work. One producer, discussing this point, said: "There's very little *manana* in this business." Which means tomorrow!

He meant that you can't put off things in radio because you may not be feeling well. You have to work swiftly and skillfully under the drive of a relentless clock.

Before the second rehearsal the director gives the actors detailed instruction. He tells them to play this scene stronger, to adopt a more sentimental mood on another scene, and so on.

The second time through, the director stops the actors wherever necessary, to correct them. By the time this rehearsal is over, an hour and one-half has gone by and the cast, according to the rules, is entitled to fifteen minutes' rest.

After the short breather, they go back to work again, and at two-thirty, they adjourn for a half hour lunch period. While they are out of the studio the musicians arrive to rehearse the nine or ten musical cues of the show—those bits of music that carry the drama from one scene to another.

At three the actors are back for dress rehearsal. This time Dave doesn't stop them. He treats the dress rehearsal exactly like the final production. It must start and end on the second. The dress rehearsal takes a half hour, which leaves Dave just twenty-five minutes for final bits of polishing. Then the cast takes a brief rest.

Two minutes before the show is due to take the air, everyone is back in the studio. The announcer is at the mike, ready to introduce the show with a suitable announcement. The orchestra is seated at one end of the studio, the director with his baton raised.

The producer, Dave Pinelli, is in the control room with the engineer. All eyes are on the clock. When the second hand reaches the top of the dial, the words "On the Air" appear in a lighted glass panel alongside the control room window. Dave points a finger at Paul Vance and the orchestra strikes up "When Johnny Comes Marching Home." As drums and music fade, Dave's hand

The WWW Playhouse is on the air! Principal actors in front. Angry crowd in the background. Sound man ready to open a door, lower right, with a mike to pick up the sound. *Photo by McGraw, Detroit News.*

swings to Don Moore, and Don begins reading his introduction: "The WWW Playhouse presents—!" For better or for worse, the show is on.

Elsewhere in this chapter are illustrations showing the hand signals by which the director controls the show while it is in progress. He can speed the show up or slow it down, move actors closer to the mike or farther away, lift tempo or increase crowd babble, all with hand signals.

So you see that the producer of a radio show is like the director of any play. He is responsible for its total effect. Taking the elements of writing, music, actors, and the announcer, he must see that a good show results.

Here are the signals by which a producer controls a radio drama that is actually on the air. The actors, musicians, and announcer all watch him. Here he's swinging an index finger at one of the performers. It means: "Begin to talk."

Fingers waving toward lips. This means: "Come closer to the mike. You're too far away."

Fingers of both hands stretching apart. It means: "Stretch it out a little. You're going too fast."

Index finger describing a circle, watch in other hand. This means: "You're falling behind. Speed it up."

Finger on nose, watch in other hand. This means: "On the nose." Or, "You're exactly on time."

Fingers pointed upward, wiggling. The producer is asking the cast to show more life, more spirit. It's probably a crowd scene.

This is the coveted signal. The producer is saying: "You're going swell. Keep it up."

This signal is for the orchestra or the organist. The fingers form the letter T. It means: "Begin theme music." *Photos on these two pages by Detroit News Staff Photographers.*

A word about actors. In towns smaller than Midtown, the actors for radio shows are drawn chiefly from high school or amateur groups. These people work for little or nothing. Their only hope for reward is that a local merchant will buy the show, in which case some small pay will be theirs.

In Midtown the situation is better. Here there are four radio stations that are members of networks, and several small independent stations. To serve the needs of these stations a large group of professionally trained actors has gravitated to the city. Some of them make their entire living off radio. Others depend chiefly on regular jobs, and take radio assignments as a sideline.

For a local half-hour sustaining show, actors receive $8.40, which includes four hours of rehearsal time. This is the minimum pay. A star actor may receive more.

For a sponsored half hour show the rate is $14, which includes two hours of rehearsal time.

In Midtown, actors who work full time at radio average perhaps $40 to $50 a week. But the best of them may make $100 a week. One of these, Chick Wallace, who has acted in professional stock companies, traveled with a carnival as a barker, and is adept at both "tough" and "comedy" parts, makes considerably more than $100 a week.

Station WWW will audition newcomers. If you apply for an acting job, and your record looks promising, you will be put in a studio and allowed to read parts of your own selection. If you pass the first test, you will be called back to sit in on the rehearsal of a regular show. Some time during the rehearsal the director will hand you a script and say: "Read the part of Spike French." Then is the time for you to forget all self-consciousness, live the part, and give a whole-hearted reading of the lines.

The director looks for naturalness, ease in delivering lines, sincerity, and the ability to forget yourself in the scene you are playing.

If you show these qualities, a career as a radio actor may open up for you.

10

Inside the Network

OUR trip through WWW has shown us how far the local station has progressed since the pioneer days of KDKA. It has become a highly organized business. There are trained specialists to handle dramatics, music, news, show production and announcing. There are well developed engineering and sales departments. The local station has a large and loyal audience that depends on it for spot news, comment, and entertainment. It has a long list of clients who use it as an advertising medium. The local station has learned how to support itself and how to appeal to its audience. It has passed the pioneer period and become a part of our national life.

To complete our story of broadcasting, we must pack our suitcases and visit network headquarters. Our understanding of the local station will help us here. The network, we'll find, is really nothing more than a local station operated on a national scale.

The network has its sales department, just as the local station has, except that the network is trying to sell a program over a hundred stations, instead of just one.

The network has its engineering staff to handle individual shows and keep equipment in repair. The chief difference is that the network engineers are also working on the frontiers of science, developing such new arts as television, facsimile, and frequency modulation. A little later we'll learn more about these trail blazing activities.

The network has its program division with writers, producers, and announcers working on shows, except that these shows do not take the air over a single station, but travel over the country by telephone wire to many stations.

Because the network serves a hundred-plus stations instead of one, it can afford to carry an expensive program such as a famous symphony orchestra, the Metropolitan opera, a variety show of high-priced Hollywood talent, a national political convention, or a world round-up of news from the capitals of the globe. The local station can't afford to broadcast a political convention. But it can share the cost with a hundred other stations. Because of the network, your station and mine are able to offer programs of national interest.

So, with a high sense of adventure, you arrive at New York network headquarters, for a behind-the-scenes tour of the studios. After certain necessary preliminaries you find yourself sitting in the office of the man who is to steer you through the maze.

This man is one of the higher-ups in the program department, so you begin by talking about programs.

Network shows, you learn, originate not only in New York, but in Hollywood and Chicago as well. These are the three chief network cities and most of our shows come from them, although other cities do produce shows that go on the network.

Here in New York, the work of producers, announcers, sound men, and actors is much like that of WWW.

Producers in New York are paid more. If they happen to be in charge of a popular sponsored show they earn $200 or more a week.

Announcers receive a staff pay of $285 a month, but here, again, there's the chance to strike it rich. If an announcer happens to have a special quality of voice and personality, and if the sponsors of expensive shows begin bidding against each other for his

This is what the public doesn't see. The NBC Symphony, in shirt sleeves, rehearses under the skillful drive of Bruno Walter, famous conductor.

services, then he may receive as much as $50,000 a year. But this is only for the lucky few. Highly paid announcers are as unexplainable as movie stars and foremost stage performers. They have that special "something" that people want and sponsors will pay for.

There are more available radio actors in New York. Where Midtown had a group of sixty or seventy trained actors, New York can draw on a list of several thousand. Their minimum pay is $19 for a fifteen-minute show and rehearsal, up to $27.50 for a one-hour show and rehearsal. Chicago and Hollywood pay somewhat less. The actors who are most in demand receive much more than the minimum.

Many of the network's best shows, you learn, are not produced by the network at all, but by advertising agencies. These agencies have for their clients the makers of breakfast foods, soft drinks, cosmetics, automobiles, paints, and the like. In the interests of these clients, the radio departments of the agencies work up shows and present them to the network. The network, in such cases, merely provides time on the air over as many stations as the agency wants.

Three-fourths of the network's sponsored shows, you learn, are created by agencies. One-fourth originate in the program department of the network. So it is apparent that the young, ambitious radio dramatist or producer might well seek a job in the radio department of an advertising agency.

With these few general facts tucked away in your mind, you begin your tour by dropping in at the network's newsroom. Here it's called the News and Special Events Department, and its field of operation covers the entire world. Staff members are in Australia, Russia, England, North Africa, and South America. Like the foreign correspondents of newspapers, radio reporters roam the far corners of the globe.

You sense an air of tension in this small room, filled with desks, clacking typewriters, teletypes, and batteries of telephones. This is the department that brings you world news while it's hot. This is headquarters for rapid-fire sports announcers and world-famous commentators.

On one wall you see a series of clocks all set at different times. These clocks tell you at a glance that when it is five o'clock in New York it is eleven o'clock in London, Paris, Berlin, and Rome; one A. M. in Moscow; and seven o'clock in Tokio, one day later. If nothing else gave you the impression of a department whose long electrical feelers reached all parts of the globe, those clocks would.

In normal times, this department goes afield to report all types of special events. A championship boxing contest. A log-rolling

War news goes out from the news room of the network. Notice the clocks above the studio window telling the time all over the world. *Courtesy of National Broadcasting Company.*

contest in Northern Michigan. A national political convention. A total eclipse of the sun in a lonely Pacific island. The death of a Pope in Rome. The burning of a liner at its New York dock.

For these field reports, the special events news reporter employs a pack transmitter. This is a complete broadcasting unit that the reporter straps on his back. With it, he can walk through the tumult of a convention hall, or along a shore overlooking a shipwreck, describing what he sees into a microphone that he holds in his hand. No wires connect him with any nearby station. His words travel a mile or two, by ether, to a truck called a "mobile unit." This truck rebroadcasts the words to the nearest radio station from where it is put on the network. These field programs are arranged from this room, in which you are now standing.

You stand at the entrance to the Special Events room, absorbing the atmosphere of a department that keeps pace with a swiftly moving world. At one desk sits a commentator whose name is a household word. His hands are busy at a typewriter, preparing his next broadcast. Alongside the machine are scribbled notes and bulletins ripped off the teletype.

Your eyes swing to the teletypes. Instead of the single teletype of WWW, here is an entire row of them, one for every news service of the country. Other teletypes are connected directly with special events stations in other parts of the nation.

One of the teletypes is a very special one. It connects with a listening post on Long Island, where experts in a dozen foreign languages sit in a circular room with earphones clamped to their heads, listening to broadcasts from Germany, Italy, Belgium, France, and Norway. Their object is chiefly to learn, in war time, what the enemy is saying about us.

They listen to all the propaganda broadcasts aimed at us by short-wave. They intercept Berlin and Rome newscasts designed for German and Italian consumption. Every word that comes through is permanently inscribed on records. In addition, the listeners select the important bits and relay them to this room via teletype, for use by the network's newscasters.

The *Normandie* burns, and the network announcer, with a pack transmitter, is on hand to tell the story. That small pack is a complete broadcasting studio. *Courtesy of National Broadcasting Company.*

While you stand there, the special events director, Frank Smith, throws a switch and begins to punch the keyboard of the teletype, writing the following words: "Anything from Tokio?"

To which the listening post replies: "Nothing now. It is too early in the day. Were you expecting something special?"

You read the words as they appear, then Mr. Smith replies: "No, thanks. Will contact you later."

This is how the newsroom keeps in touch with the listening post thirty miles away. It contacts San Francisco and Los Angeles just as easily and quickly.

All this time you have noticed a small broadcasting studio through a glass pane at the left of the room. There's activity in that studio now. A commentator and an announcer go in, bearing their scripts. In the control room, next to the studio, an engineer and a producer are sitting. Frank Smith tells you that in fifteen minutes these men will stage a world round-up of news in which there will be direct reports from Melbourne, London, Moscow, and Washington. He asks you if you would like to sit in on it, and you eagerly accept.

As you go into the control room, Smith tells you what has already been done to prepare for this broadcast. Wires have been sent to all the foreign points telling the men there just how long they are to talk. Melbourne is to talk two minutes, Moscow three, London two, and Washington two. But there's always the chance that one of the foreign capitals won't be heard, possibly because of bad radio conditions. So, in the ten minutes preceding the broadcast, the show's producer, Arthur Field, must check all foreign points.

He sits in the control room at a desk for all the world like a school desk except for the microphone hanging above it. You sit along the wall nearby and watch him get in touch with the foreign capitals.

He talks into the mike: "Bill, you may have to go on for three minutes tonight instead of two. We may not be able to get Melbourne."

This is a listening post, where experts on many languages listen to the broadcasts of other nations.

From a loudspeaker on the wall a voice replies: "All right. You let me know."

There's nothing unusual about this little conversation until you realize with a shock that "Bill" is in London, three thousand miles away. At the beginning of wireless the world thought it a miracle that Marconi should pick up three faint clicks across seventeen hundred miles of ocean. Today two men talk to each other over three thousand miles of ether as if they were in the same room.

Arthur Field then turns to a teletype at his elbow and types out a message that is repeated in the network's headquarters in San Francisco. He asks for more specific information about Melbourne.

San Francisco replies: "Landlines from Melbourne to Sydney are down."

You interpret this to mean that there's no way for a voice originating in Melbourne to travel to the short wave transmitter at Sydney. Melbourne itself does not have a short wave transmitter. It had counted on sending the voice by wire to Sydney, but something has happened to the wire. A storm has probably blown it down.

Melbourne is definitely out, so Field talks to London once again, telling Bill he'll have to take three minutes instead of two.

After this, Field again teletypes to San Francisco to check on Moscow. San Francisco replies that it is listening to a broadcast from Moscow at the moment—a symphony program. It's coming through clearly, San Francisco says. There should be no trouble getting Moscow. The only hitch is that Moscow clocks are twenty seconds slow. San Francisco knows this because it checked the exact moment the symphony program started.

Field conveys this information to John Cook in the adjoining studio, the broadcaster who gives the news at the New York end. Thus Cook can fill in the twenty seconds himself before saying: "Come in, Moscow."

A little thing to fuss over, you think. Then you remember that a twenty-second period of silence on the radio seems like an age to a listener.

For a nerve-wracking ten minutes, Field talks to London and the Pacific Coast until he has checked the program as far as is humanly possible. Then the clock reaches 7:15, a staff announcer in the adjoining studio starts to talk, and the world round-up of news is on the air.

There is a one-minute commercial of the drug manufacturer who sponsors the broadcast, after which John Cook begins to give a fast, crisp résumé of world news. After two minutes of this, he says: "Come in, Moscow."

There is a tense wait while you count up to five, after which a

A young Britisher in the United States talks to his parents in England. *Courtesy of National Broadcasting Company.*

voice, somewhat distorted, yet clear enough to be understood, begins to speak, giving news of the Russian Army.

The thought awes you a bit. You realize that this voice is traveling more than halfway around the world to reach this studio. Sometimes the Moscow broadcast comes via London, but when the peculiar conditions that govern radio reception dictate, the broadcast must come the long way over Asia and the Pacific Ocean.

The short wave that carries it is an interesting wave. The ordinary medium-length wave of regular radio broadcasts tends to follow the curve of the earth. The short wave tends to go in a straight line. It shoots off from the Moscow transmitter toward the upper spaces above the earth.

Up there, it encounters an ionized stratum called the Heaviside layer, a sort of wavy electrical blanket rippling high above the earth.

Off this layer the short wave rebounds toward earth, and so it goes, zigzagging its way over continents and oceans. On the California coast it is picked up by short wave receivers, strengthened and refreshed by vacuum tubes, and sent on its way over network wires to the hundred or more stations carrying the broadcast. One of these wires takes it to this studio where you sit, listening.

Moscow signs off, after which John Cook takes the air, saying, "Come in, London."

London talks for three minutes, and then Cook shifts the program to Washington for news of our capital. Then back to John Cook for a final résumé, after which the announcer gives a one-minute commercial and the program is finished.

More than anything else, this program makes you realize how far radio has traveled since its recent pioneer days. By ether wave and telephone cable, the homes of a hundred thirty million Americans are in split-second contact with the action centers of the world.

11

Network Activities

CHAPTER TEN mentioned the network's listening post on Long Island. Both the National Broadcasting Company and the Columbia Broadcasting System maintain listening posts to keep in touch with what the rest of the world is saying.

The government, too, has similar stations located on the Atlantic and Pacific Coasts, in Texas, and on some of our island possessions. This work, in war time, is extremely important because the Axis powers are directing a constant stream of propaganda not only at the United States but South America, China, Australia, and England. South America is told that the United States is selfish and ambitious, and that neither Japan nor Germany has designs on South America. England is told that the United States wants her Empire, and we are told that England wants us to save her Empire for her. It is important for us to intercept this stream of words, analyze it, and reply to it. Our object is to build up confidence, strength, and a united spirit among the United Nations.

In addition to listening posts, the networks and the government have created special broadcasting services to other continents. These services are specially designed to reach the peoples of Germany, Italy, and all occupied countries.

Here, at the network we are now visiting, this service comes under the head of the International Division. This division has a staff of eighty men and women of whom about twenty are actual broadcasters.

You stop at a desk to speak to the editor of the International Division.

"We are on the air seventeen hours a day," he tells you, "sending out news in French, German, Italian, Spanish, Portuguese, Swedish, Danish, Greek, Turkish, and English. From our West Coast station we broadcast in Japanese, Chinese, and the dialect of Tagalog, a language you've probably never heard of."

He shows you a daily schedule, and you notice that the day's programs start entertainingly enough with music. There follows, during the rest of the day up to late afternoon, news in English, Swedish, French, Danish, Italian, German, and Turkish, these news programs interspersed with music.

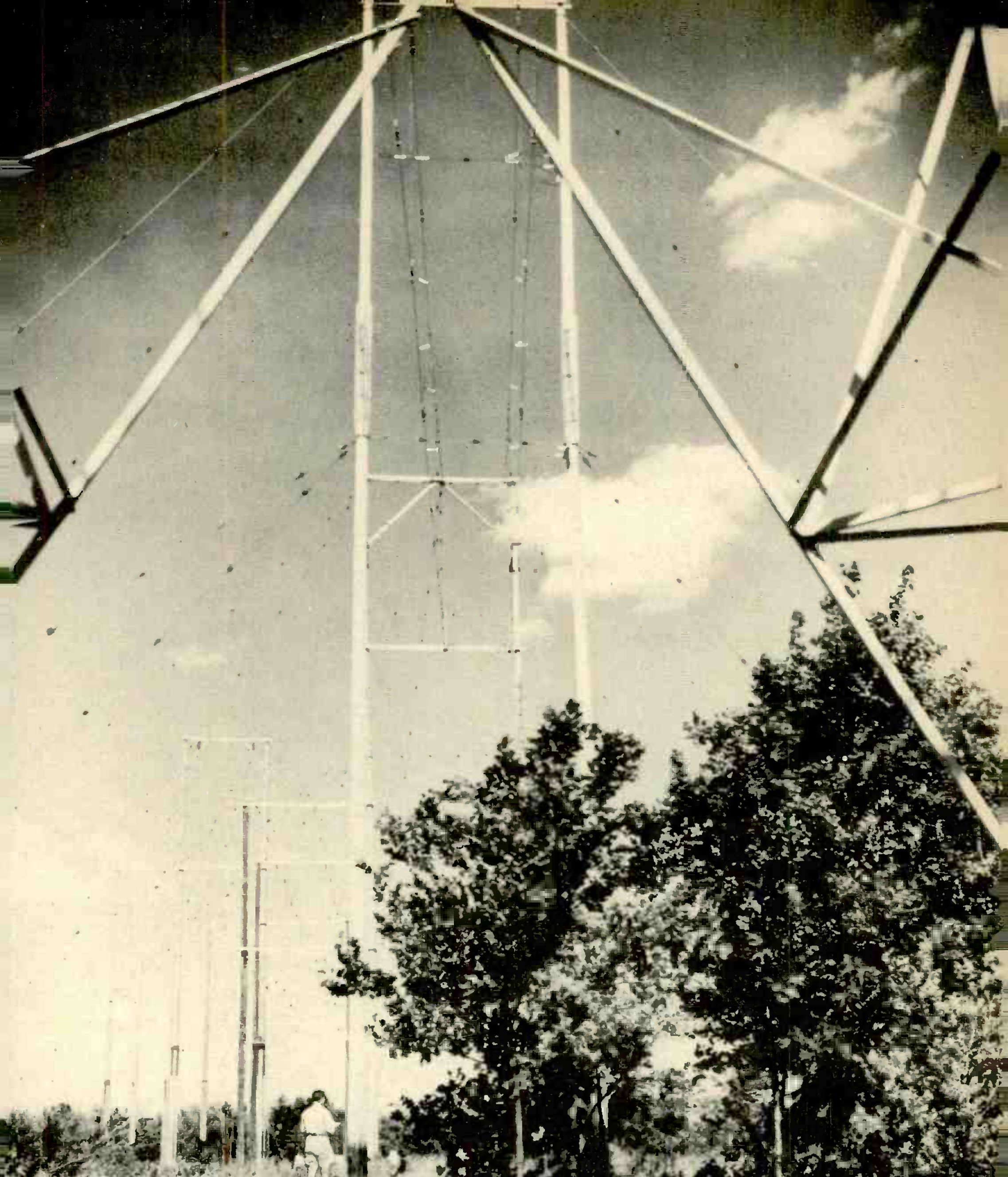
Up to this point the programs are beamed at Europe by means of directional antennae that enable the broadcaster to focus his program at a certain area, much as you would aim a searchlight. At five o'clock the beams are aimed at South America, carrying programs in Spanish and Portuguese.

Thus our large networks and our government broadcasters are aiming streams of words to all the nations of Europe, Asia and South America.

America's object, in this war of the air, is to force the truth past the barriers of censorship and silence, into the camp of the enemy; to keep alive the hope of freedom in the occupied countries; and to combat and answer Axis propaganda in South America.

As you learn these things, your eye swings around the busy room. At the third desk along the wall sits an Italian, the son of a former official in the Italian government. He is typing his next broadcast, a news summary to the people of Italy.

At another desk sits a Swiss Journalist who for years represented French newspapers in this country. Now he delivers broadcasts in perfect French to listeners in that nation.



These are the short-wave directional antennae by which American broadcasts travel to other continents. Radio waves from these antennae can be focused like a searchlight on a certain area.

In another part of the room sits a refugee German who delivers news and discussion to secret listeners in the country of the enemy. The penalty in Germany for listening to an American station is a long term in prison, and death if the listener repeats anything he hears. Yet smuggled letters come out of Germany—and all the other occupied countries—proving that a vast audience in darkened rooms and cellars turn on their short-wave sets to hear news from the outside world.

The last two chapters have mentioned frequently the obliging short wave by which programs are carried across oceans to other continents. There's an interesting story of the way in which the unsuspected abilities of short wave were discovered. It begins in the early days of broadcasting.

Back in 1922, when the first pioneer stations were beginning their operations in makeshift studios, most broadcasting was done on one wave length, 360 meters. C. W. Horn, who worked for Dr. Frank Conrad of the Westinghouse Company, went to Washington to try to get another channel of 400 meters.

He succeeded in his mission, but while in Washington he heard that amateurs were dissatisfied with a ruling which compelled them to use wave lengths below 200 meters. On his return to East Pittsburgh, Horn reported this dissatisfaction to Conrad.

"Amateurs don't like to be limited to those lower bands," he said.

"Why not?" Conrad asked.

"Because they can't get enough power in those bands." In those days, with spark transmitters, the shorter the wave length the weaker the power, because of natural limitations of the circuits.

"But with tubes," Conrad replied, "you don't have that trouble."

Horn suddenly realized that this was true. The DeForest tube would obligingly generate waves of any length, and there was no limit to the amount of power that could be applied to them.

So the two went eagerly to work experimenting with short wave transmission. They reduced the wave length to 100 meters, to 50, and even below, and discovered that waves of this length transported programs over longer distances with less power than the standard lengths then used.

Two years later there was an international radio conference in London. Dr. Conrad was present. At this conference the officials decided that extremely long waves would be necessary for all transatlantic wireless—waves of 10,000 to 20,000 meters. Long waves and tremendous power—this was the formula for international wireless.

At this point Dr. Conrad brought out a short-wave receiver the size of a candy box. In the presence of the international engineers, Dr. Conrad turned on his receiver, and the clear, faint voice of his associate was heard, coming all the way from Pittsburgh. It was coming by short wave, with only a fraction of the power needed for the ultra-long waves then being used.

This spectacular demonstration showed the value of short wave broadcasting for distance and today our international divisions use these wave lengths developed by Dr. Conrad and C. W. Horn in 1922.

So far we have seen how the network produces programs for a national audience, how it provides world news and special events, and how it tells America's story to the rest of the world in war time.

There are other fascinating departments to cover, and one of them is the Radio Recording Division. This division is almost a complete broadcasting company in itself, except that instead of putting "live" talent on the air it cuts its programs on records and mails out the records.

The records you buy for your phonograph are usually twelve inches in diameter and run at a speed of seventy-eight revolutions per minute. The records made for radio use are sixteen inches in diameter and run at a speed of thirty-three and one-third revolutions per minute, so that one record lasts just fifteen minutes.

These records fill a great variety of needs. Hundreds of stations throughout the country belong to no network at all. They would like to have, say, a fifteen-minute sports review, a Hollywood news reporter, or a discussion of fashions. They can buy such programs from the radio Recording Division. The record is shipped to them and they play it in a studio, and the small station's audience gets a big-time show at low cost.

There are advertisers, too, who don't want to buy the services of a network. Instead they would like to sell their wares in perhaps ten widely scattered towns. So the Recording Division makes ten copies of the program and mails the records to the ten towns with full instructions for broadcasting.

Smaller stations, too, can buy a regular monthly service from the division. In this service the local station receives a whole library of recorded programs. Twice a month it receives new records. It can play any of these records whenever it needs them in its program lineup. Thus the smaller station, by means of transcription, can offer its audience well-known singers and bands without paying network fees.

There are in the country a dozen transcription companies, some belonging to the networks and some independent, all providing recorded programs for the stations that require them.

This is what the television screen in the standard set looks like. *Courtesy of National Broadcasting Company.*

12 · Television Today

HERE at network headquarters, in the engineering research department, men are working on new uses for radio waves. Among these new uses are television, frequency modulation, and facsimile printing.

Television today is an accomplished fact. Studios, mainly in New York, are broadcasting on a regular weekly schedule. There are about six thousand television sets in the living rooms of owners, throughout the country. World War Two brought a temporary halt to the development of television. Before the start of the war, studios in Chicago and on the West Coast were operating on regular schedules. There seemed to be no reason why the number of stations and set owners shouldn't increase month by month, until television became a part of our lives. When men and materials can be spared once more for peace-time arts television will enter its era of expansion.

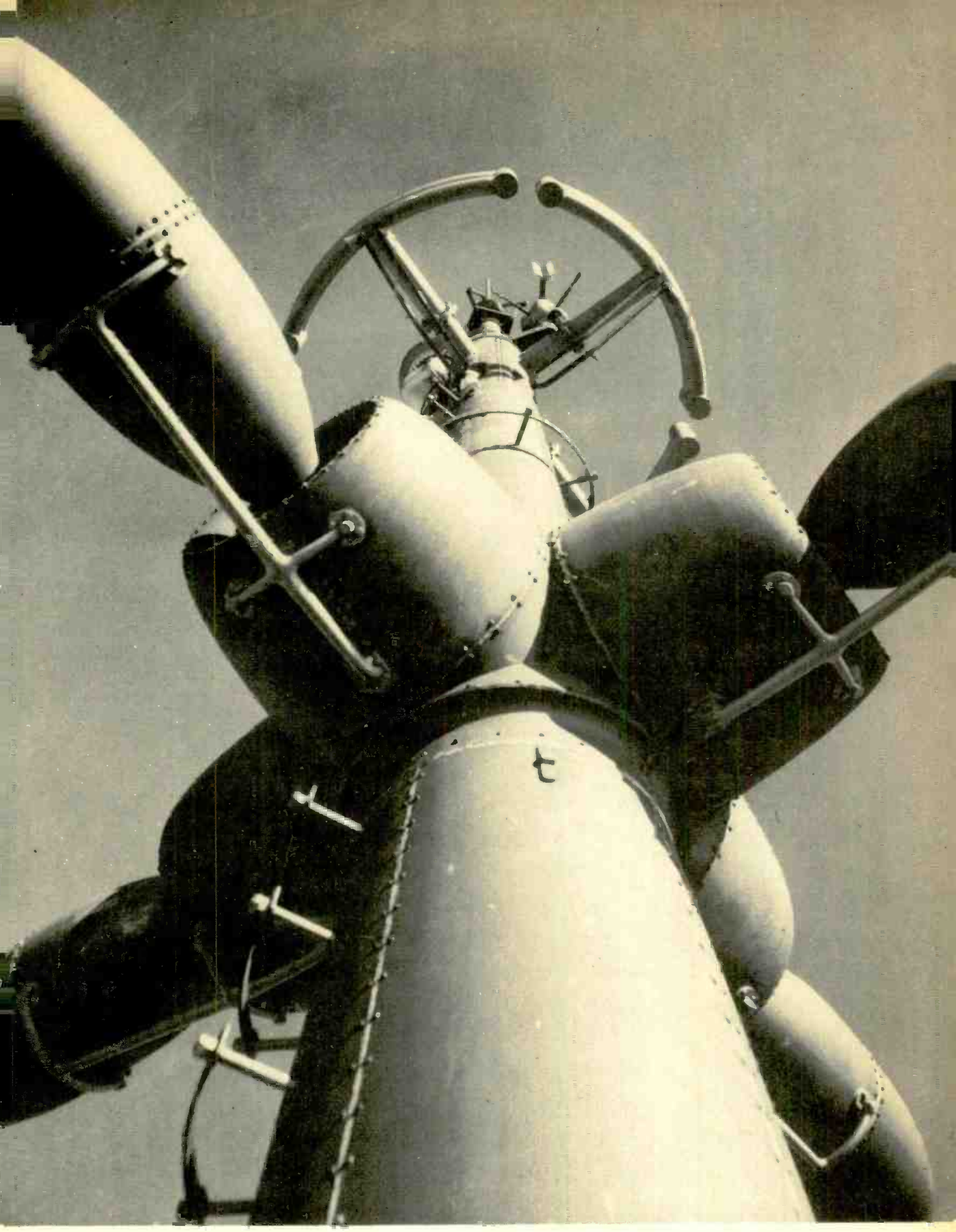
This being so, let's visit a New York television station and find out how this new form of art operates. There are two studios in New York, WNBT of the National Broadcasting Company, and WCBW of the Columbia Broadcasting system. They operate on a schedule of fifteen hours a week for the benefit of some five thousand set owners in and around New York.

The first thing you notice about the television studio is that it is equipped with floodlights and spotlights, so that the actors can be properly lighted. There's a microphone on a long boom that can be swung back and forth to follow the actors as they move about. And there's a cameraman standing behind a huge television camera, to photograph the action of the scene, and broadcast the action along with the sound.

At one end of the studio a scene has been set to represent the interior of a New Hampshire inn. A man and woman wearing outdoor clothes are putting long wooden skis on their shoulders, ready to go out. You're about to see a one-act play with a skiing background.

The thought comes to you that not only what these actors say, but what they do, will be broadcast. Words and sounds will leave the studio by the familiar microphone. Their actions will go out by way of the miraculous television camera.

Your imagination ranges wide. In the future you'll be able to see that big intersectional football game from your living room-chair. Sitting at home, you'll see the winning hit of the final World Series game. When the President speaks to Congress you'll not only hear his voice but see the rostrum, the attendants, and the crowded House of Representatives.



Television signals leap into space from torpedo-like aerials. *Courtesy of National Broadcasting Company.*

How does it work? you wonder. How can moving action be broadcast? Let's briefly follow a bit of action from studio to receiving set, exploring the mystery of the television camera and the receiver as we go.

The task of the television camera is to receive the picture of the man and woman in ski clothes, convert the picture into electricity, and send it on its way. While this is being done, a microphone must pick up their voices, the tramp of feet and the opening of a door, and send the sound on its way in perfect time with the action. We're familiar with the broadcasting of sound, so we'll concentrate on the picture.

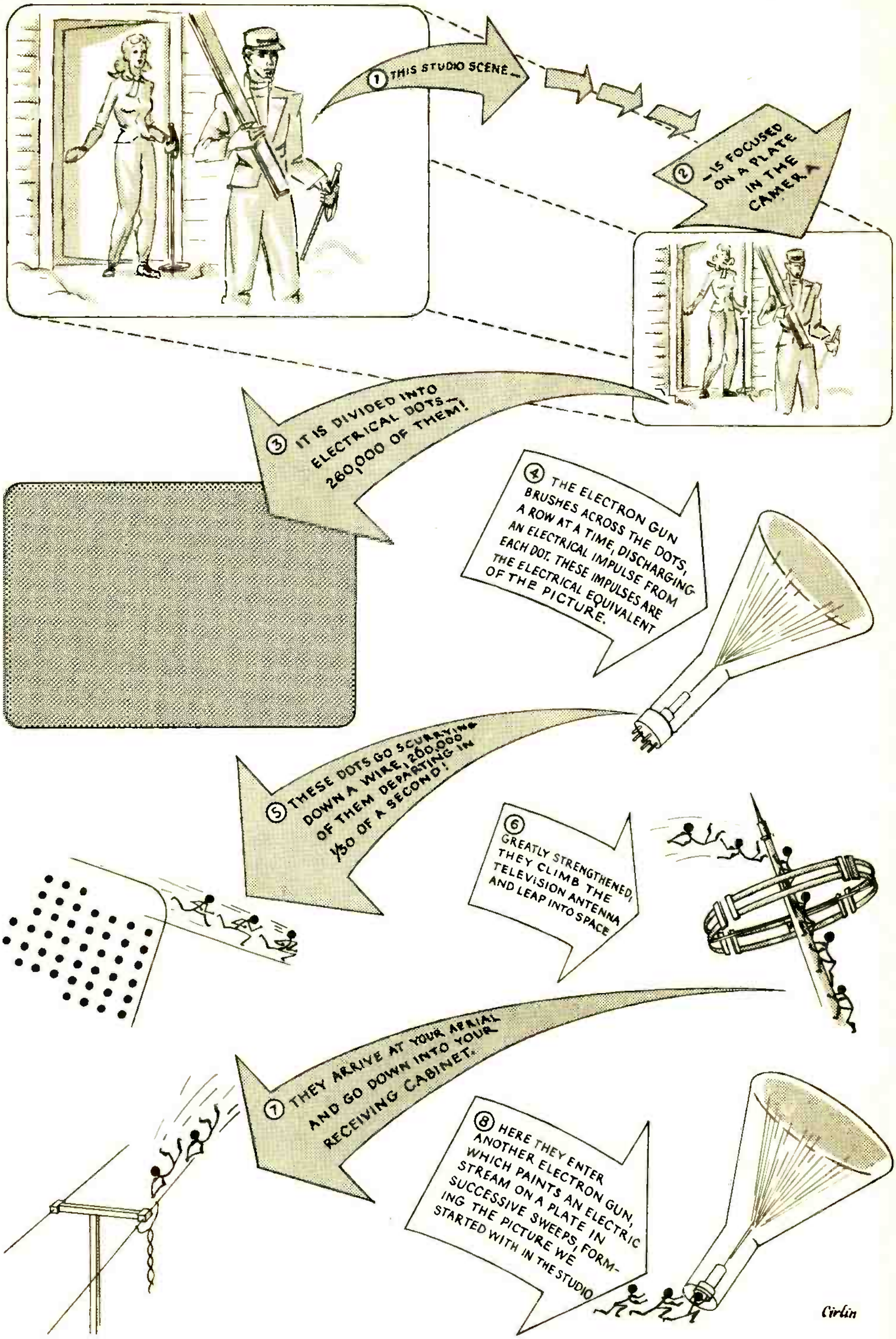
Those two people in the studio are a pattern of lights and shadows. The faces reflect lots of light, the hair less, the bridge of the nose more light, the shadow alongside the nose less. If you could divide the entire scene up into tiny squares, the squares would reflect varying amounts of light. When you understand this much you are on the threshold of understanding how television performs.

The engineers have a good way of putting it. They say that television divides up a picture into thousands of dots and sends it out a dot at a time. This is, literally, what television does.

The fast-acting device that performs this task is a vacuum tube shaped something like a large dipper, called the iconoscope. The iconoscope is divided into two parts—a "mosaic" mounted in the cup of the dipper, and an electron gun located in the handle.

At the moment the two skiers are standing up, looking toward the camera. The lens of the camera focuses this picture upon the rectangular mosaic, and the mosaic in turn does what seems to be an impossible job. It divides the picture up into a quarter million dots, each dot an electrical charge that is the equivalent of the light on that tiny part of the picture. How?

When you look at the plate called the mosaic there seems to be nothing remarkable about it. A smooth, metallic surface, nothing more. Yet, in reality, this smooth surface consists of a quarter mil-



How television works.

lion little silver and caesium cells, and these tiny cells are the key to television. How these cells can be mounted on a plate in such numbers, each cell with its own wiring, is a manufacturing miracle that would need an entire book fully to explain.

Caesium is a strange metal (some dictionaries spell it cesium). It is sensitive to light. Throw a light on it and it stores a charge of electricity. The more light, the heavier the charge. The less light, the smaller the charge. The discovery of this property of caesium goes all the way back to 1873, so that the beginning of television may be said to date from then.

Thus, at any instant, the two actors are represented on the mosaic by a pattern of electrical charges in those tiny cells. Heavy charges for glistening skin; smaller charges for dark hair. Charges of all degrees, all over the plate.

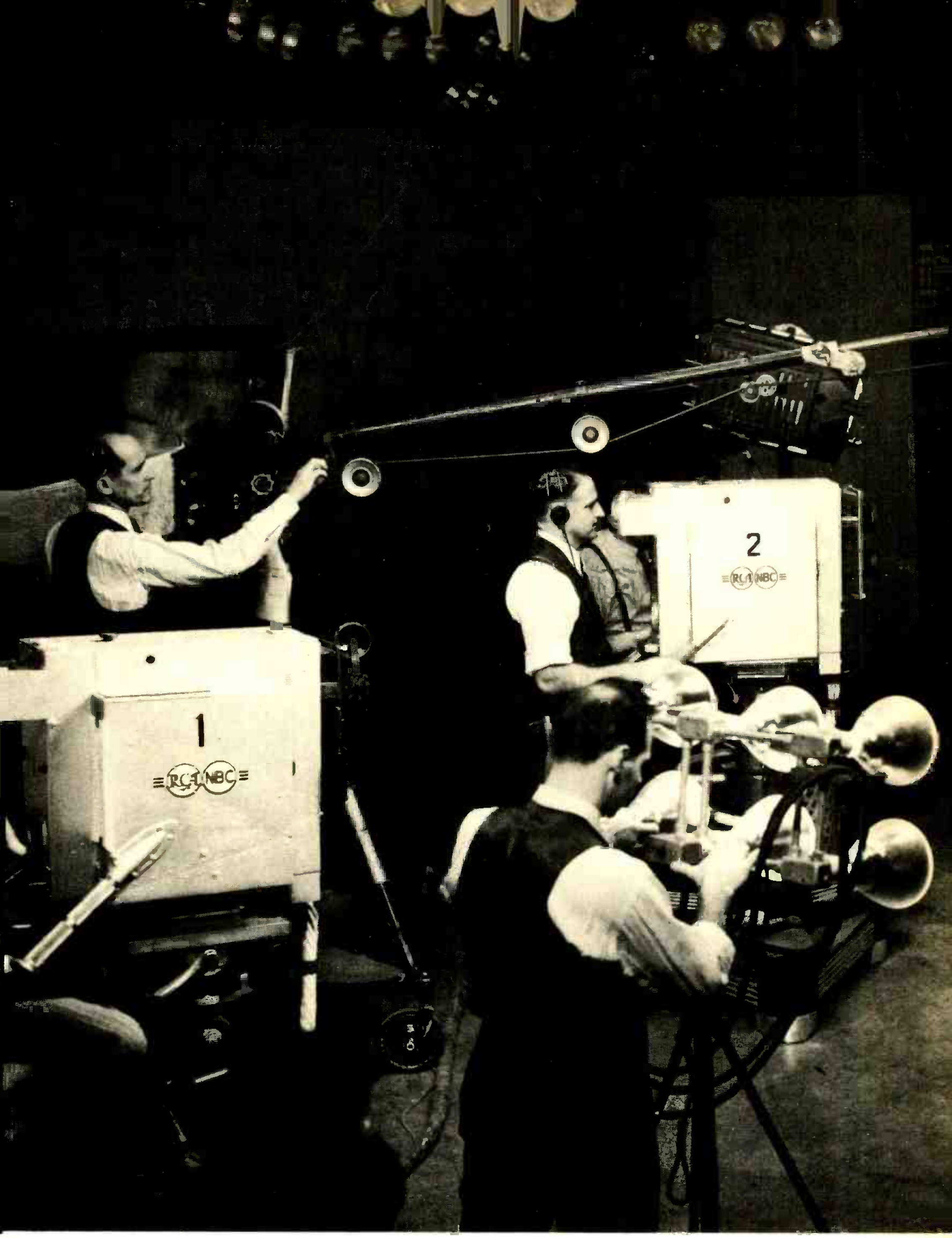
So far so good. The actors have been converted into electricity and stored on the mosaic. Thanks to the properties of caesium they have been divided into 260,000 dots, each dot a charge of electricity.

Now the job is to send these charges on their way. The neat device that does this is the tubular affair in the handle of the dipper called the electron gun.

The electron gun shoots a thin stream of electrons at the mosaic. Starting at the upper left-hand corner, it sweeps across the mosaic from left to right, discharging those tiny cells as it goes. Then it drops a notch and sweeps another row of cells. It describes no less than 525 lines across the mosaic and does the entire job in less than one-thirtieth of a second!

As each cell is discharged, an electrical impulse leaves the plate and hurries down the wire on its trip to the television transmitter. One after the other, 260,000 impulses, each representing a part of the picture, start on their way.

Thus, in one thirtieth of a second, a single complete image is dispatched from the studio. But the iconoscope doesn't stop working. It sends another image and another. It sends thirty per



A television studio is full of equipment. Here you see two television cameras, a long boom carrying a microphone, and a battery of lights. *Courtesy of National Broadcasting Company.*

second. Thus, what you see in your receiver are thirty still pictures each second. But each picture represents the actors in a slightly different pose, and therefore your eye seems to see continuous motion. The movies you see each week are also a succession of still pictures, except that there are fewer images per second.

The iconoscope that scans the picture and sends it on its way in electrical form was developed by Vladimir Zworykin of the research laboratories of RCA Manufacturing Company. Zworykin was formerly a radio expert of the Signal Corps in the Russian army. Before he developed the iconoscope, men had tried mechanical, rotating devices to "scan" a television picture. None of them was fast enough to create good images. It was the perfection of the iconoscope, with its stream of electrons—known as the cathode ray—that made television a reality.

Thanks to the iconoscope we now have a constant stream of electrical signals leaving the studio and traveling to the transmitter where they are amplified and broadcast just like sound radio. But where sound radio travels through the ether on waves several hundred meters from crest to crest; where the short wave broadcast that comes to you from Europe travels on wave lengths of fourteen to fifty meters; television travels on waves from seven meters down to a fraction of one meter.

Television uses ultra-short waves, and these waves tend to travel in a straight line. Therefore the distance at which you can receive a television broadcast is limited by the horizon. That is the reason NBC's television transmitter is located atop the Empire State Building in New York. From that eminence, the television radius is about fifty miles.

When the electrical signals go down your aerial into your television set they arrive at what is known as the kinescope. This is the device that receives the electrical signals and converts them back into a motion picture of two actors with skis. Just as your radio loud speaker converts electricity into sound, so the kinescope converts electricity into light.

The kinescope is shaped like an overlarge funnel, and in the shaft of the funnel there's an electron gun that produces a sharp beam of electrons. This gun is a counterpart of the gun in the iconoscope. Guided by magnetic yokes, it moves back and forth in exact duplication of the iconoscope gun. It draws 525 pencil lines of electrons back and forth and repeats the operation thirty times per second. But where the iconoscope gun wipes the picture off the mosaic, the kinescope gun paints the picture on the screen of your receiver.

This screen looks like a plate of frosted glass. On a standard set it is eighteen inches wide by thirteen and one-half inches in depth, or large enough for the pictures on it to be enjoyed by a large roomful of people. This screen is in reality the wide end of the funnel-shaped kinescope and though it looks like frosted glass it isn't glass at all, but a fluorescent material. Material, in other words, that glows when struck by a beam of electrons. Thus the screen, influenced by the electron gun, converts those thousands of tiny signals of varying strength into succeeding patterns of light and dark. In other words, to the moving picture of the two skiers in the New Hampshire inn.

Meanwhile, the voices of the actors and such other sounds as are picked up by the microphone are broadcast separately and reproduced in your loud speaker in exact time with the action on the screen. And you sit comfortably in a chair, enjoying a talking picture in your own home.

Television has grown out of its experimental stage. The pictures are now clear and the action smooth and continuous. The extremely short wave employed is free from static, so that there'll be little distortion of the image from electrical conditions. The entertainment, in other words, is now fairly satisfactory and reliable.

Nor is the size of the screen limited. In May, 1941, RCA brought its television cameras and microphones to the ringside of Madison Square Garden to telecast a championship boxing match. The telecast traveled by telephone wire several blocks away to the New Yorker theatre. There the kinescope projected the picture on a fifteen by twenty-foot movie screen. The picture was as clear and detailed as a motion picture.

This creates startling new fields for television. Perhaps in the future events of national importance will be broadcast to entire theatres full of people. You may, for instance, pay a small fee at your local theatre and actually watch a World Series baseball game while it is in progress.

This, however, brings up the question of how television can be distributed on a network to the entire country. Our sound broadcasts are distributed by special telephone wire to local stations. But, though television can be carried by telephone wire for a short distance, the short waves required by television lose power when sent longer distances by wire. A mile is about the limit for transportation by ordinary wire.

To send television longer distances requires special cable called a coaxial cable. This is a hollow tube with a wire inside. It is entirely capable of handling the tiny, rapid signals of television, but it costs around five thousand dollars per mile. The expense is so great that there's little chance now of linking city to city with coaxical cable.

There's another way, however, of creating a network. Experimental work is being carried on at Long Island on transmitting telecasts through the air. Waves under a meter long are beamed from directional towers. Like the short waves for international broadcasts they are focused and aimed at other towns. A Philadelphia station, for instance, now receives television broadcasts from NBC in New York, by air, and rebroadcasts them to a local audience. Schenectady, New York, also receives New York telecasts by beam.

So here, already, is a three-city television network joined by beam transmitter, without wires at all! There seems no good reason why, in the future, relay stations can't be established over the

The television camera goes to the racetrack. Several thousand people saw this race in their living rooms.

country, so that ether-borne telecasts can be distributed to the entire nation.

Today, the few privileged owners of television receiving sets can enjoy the telecasts of a handful of stations. They are enjoying prize fights, races, football and baseball games, and studio shows on a schedule of fifteen hours a week, or a little more.

There the matter will probably rest until the demands of such emergencies as war are met. Television is a fully developed art waiting for peace.

13

Radio Free of Static

THE newest and brightest development to occur on the radio frontier is the type of broadcasting called frequency modulation. Like television, the spade work has been completed and the technical problems overcome, but unlike television, frequency modulation has already spread widely throughout the country.

Frequency modulation, or FM as it is generally called, is the type of radio that brings the listener programs free of static and interference, with a purity and accuracy of sound unknown to the conventional kind of broadcasting. Although the first experimental station went into regular operation as recently as 1938, there were, in January, 1942, twenty-nine FM stations broadcasting on daily schedules, and thirty-four other stations in process of construction.

The fall of 1941 and early winter of 1942 saw a full-fledged FM boom, with a score of manufacturers making FM sets and selling them as fast as they could make them, and new stations springing up overnight. Only the rationing of war was able to slow up the tidal wave.

The story of frequency modulation is the story of Edwin Howard Armstrong, a man whose working life coincides exactly with the radio age and whose name has already appeared in this story of radio.

Armstrong was born in New York City December 18, 1890, just a few years before Marconi's first wireless experiments. As a youngster, he tinkered with home-made wireless sets. His father, the American head of the Oxford University Press of England, encouraged him in his hobby.

At Columbia University, Armstrong studied under the famous electrical inventor, Michael Pupin. In 1910, when he was a sophomore, he began working with DeForest's three-electrode audion. Although he found it a more sensitive detector of radio waves than any he had previously used, he wasn't satisfied with its performance nor the current explanations of how it functioned.

Out of his experiments with audions and hookups, he developed new circuits that made the audion an astonishingly good detector. With his circuits he was able to pick up signals from San Francisco and Honolulu with small aerials. This was something very much like a miracle for those days.

He called his hookup the "regenerative feedback circuit" and after graduation had it patented.

During the war he served as an officer in the Signal Corps, and in his effort to pick up weak German short-wave signals he developed what is known as the superheterodyne circuit, the basis of the present-day radio receivers in our homes. Thus it becomes apparent that E. H. Armstrong, born at the beginning of the radio age, was one of those keen-minded men who take the basic inventions of a new art, solve their mysteries, and bring them to a state of perfection where the whole public may enjoy them.

But all this time, Armstrong was interested in the problem of static, and out of this interest frequency modulation was to grow. As early as 1915, experiments convinced him that static and radio waves were practically the same thing. Experiments by other research workers reached the same conclusion.

The radio waves that brought words and music to receivers, and disturbances caused by electrical storms, automobile ignition, and high tension wires, were the same kind of vibrations in

Edwin Howard Armstrong, who developed frequency-modulation broadcasting. FM provides static-free reception. *Photo by Brown Brothers.*

ether. Therefore, if radio waves could enter a receiving set, so could static.

Engineers, in the 1920's, concluded that static would always be with us. They did much to soften its effects. By adding power to radio broadcasts they were able, to some extent, to overwhelm static. But the buzzings and cracklings were still there, as they are today in conventional broadcasting.

Armstrong decided to get away from static by working on new lines. First of all, he decided to use an extremely short wave. Instead of a wave length of several hundred meters, he went down into the range of one to seven meters. Short waves, he knew, are less bothered by static.

But in addition to using short waves, he decided to use an entirely different principle of broadcasting, and this calls for a brief explanation.

Conventional broadcasting operates in this way:

The voice and music signals go from the studio to the transmitter where they are "impressed" on a carrier wave. The wave length (or frequency) of the carrier wave remains constant. If the wave length is 400 meters, it remains 400 meters. The voice and music signals are impressed on it by varying its *strength,* or *voltage.*

Engineers say that the "amplitude" of the carrier wave is varied. So our powerful carrier wave, its amplitude or voltage subtly varying, goes flying through space at the speed of light, bringing us our radio program.

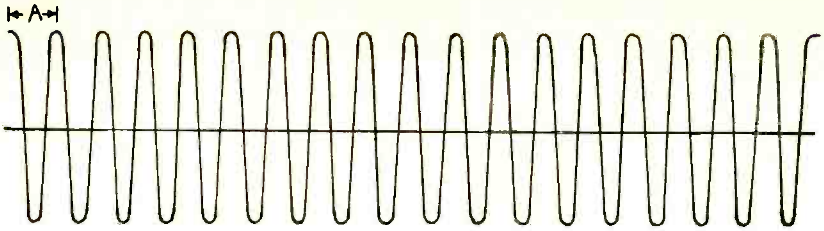
Because the amplitude varies, conventional broadcasting is called "amplitude modulation," or AM. But static is also an amplitude-modulated ether wave. Its voltage varies too. So the only way AM broadcasting can overcome static is by overpowering it, and this doesn't always work.

Armstrong decided to modulate his carrier wave in another way. He decided to give it the characteristics of sound by varying its frequency or wave length, within wide limits. The voltage, or amplitude, would remain constant. This would remove his type of broadcasting entirely from the field of static.

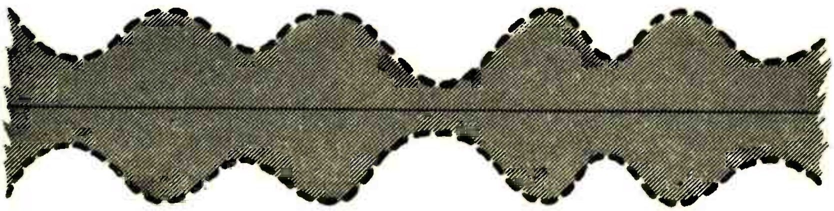
So he called his kind, frequency modulation, or FM. What he had done, in short, was to provide a new kind of winged steed to carry our programs through space. This new steed was a sort of one-man horse. It would accept only studio sound—music, speech, sound effects. It refused to permit static to hike a ride.

He built experimental receivers, and since these receivers were constructed only to receive FM, AM static couldn't enter.

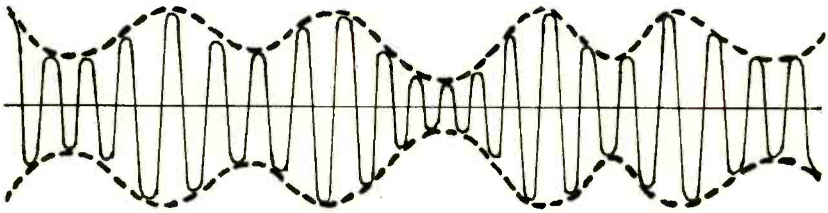
Like most men with a radically new principle, Armstrong had difficulty gaining acceptance for his invention. He applied for his FM patents in 1932 and received them in 1933. In December,



This is a carrier wave before speech is impressed on it. The distance from crest to crest "A" is the wave length. The height of the wave indicates its voltage or amplitude. Before speech is impressed on the wave, this height remains the same.

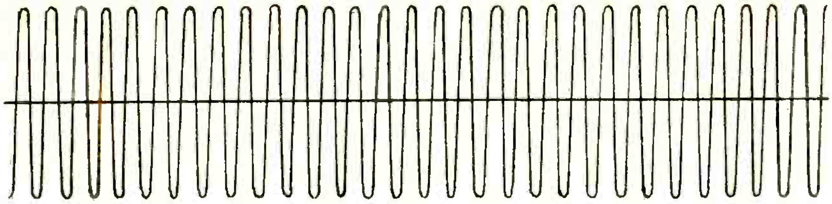


But when a man talks into a mike, his voice currents affect the amplitude. The height of the wave varies. Here is the carrier wave, its amplitude modulated by the voice. This is how the broadcast goes through the ether.

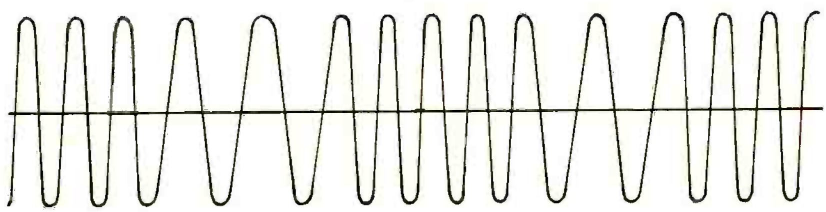


At your receiver the carrier wave is wiped out entirely, leaving only the speech signal, indicated by the lines above.

CONVENTIONAL RADIO, OR AMPLITUDE MODULATION (AM).



FM has a carrier wave, too. It is a much shorter wave than our regular AM waves: under seven meters long, instead of 200 to 600. In FM the amplitude, or height of the wave, remains constant.



Speech is impressed on the FM wave by varying the wave length, or frequency, as indicated above by the wider, then closer, spacing of the waves. Hence the name FM, or frequency modulation.

THE NEW STATIC-FREE RADIO, OR FREQUENCY MODULATION (FM).

1933, he invited the Radio Corporation of America out to Columbia University to watch a demonstration, and the officials were so impressed that they invited him to conduct his experiments under RCA auspices in the Empire State building.

But RCA was at the time more interested in television, and after a year withdrew its support from the FM project.

Left to himself, Armstrong went to his friend Carman Runyan, a coal company executive by day and a radio experimenter by night. Runyan had a licensed amateur station operating on short wave, Station W2AG in Yonkers. Armstrong built an FM transmitter and installed it at W2AG.

In November, 1935, Armstrong brought a receiver to a meeting of the Institute of Radio Engineers in New York City. The meeting heard the words: "This is amateur station W2AG at Yonkers, operating on FM at two and one-half meters." The voice was clear. There was no buzzing or other radio noise. Armstrong told his audience that the words were coming from Yonkers, fifteen miles away, on a power output that would hardly have carried an AM signal across the street.

Two years later, spending his own money, Armstrong built experimental station W2XMN at Alpine, New Jersey, operating on a wave length of seven meters. He began broadcasting in 1938, and the results were so astonishing that opposition began to crumble.

Meanwhile the Yankee Network, a group of four New England stations and eighteen affiliates, became interested in FM. Paul DeMars, technical adviser to the network, induced John Shepard, owner of the network, to invest $200,000, and an experimental station went up on Mount Asnebumskit, Massachusetts, forty-three miles from Boston. Armstrong developed a beam transmitter—much like the short-wave beam transmitter used to send NBC television broadcasts from New York to Philadelphia—that would send FM programs from Boston to the station at Mt. Asnebumskit, there to be relayed to other members of the Yankee network.

Now manufacturers began to offer FM sets. FM listeners in the East grew enthusiastic. This type of reception, they said, was far superior to AM. If the reader is privileged to listen to one of the several hundred thousand FM receivers in the nation today, here's what he'll find:

There'll be, first, a complete absence from static. Even during a thunderstorm there'll be no crackling or buzzing in the loudspeaker.

Between words, or bars of music, the loudspeaker will be silent.

Sounds will be more realistic. If the announcer whispers, the whisper will sound like that of a person in the same room. If a bell is rung, even the overtones will be heard. Such sounds as the tinkling of silver, the pouring of water, or the crackling of paper, difficult for conventional broadcasting, will be as real as life in FM.

These qualities were not to be denied, and FM began to spread. General Electric built two experimental stations near Schenectady, fifteen miles apart.

GE's experimenters discovered something else. In riding from one transmitter to the other, with their receiver turned on, they found that there was a borderline at which one station faded out and the other came in. There was no time at which both stations came into the receiver at the same time. In other words, there was no interference.

We know, today, how interference mars our enjoyment of radio programs. Now and then, especially at night, two or more stations will come in on the same wave length and it will be impossible to tune out one or the other. This can't happen in FM.

Still another advantage of FM, men found, was that it opened up a wide new range of frequencies. The area of short waves in which it operates is like an immense new continent. It contains many channels. It is possible, experts say, to have as many as fifty stations operating from one city.

In this chapter we have been using two terms—frequency and wave length. We have used the terms "short wave" and "high frequency" as synonyms. Perhaps we'd better pause to explain the relationship.

As you have learned, ether waves travel at the speed of light, or 186,000 miles per second. If you could imagine an ether wave 186,000 miles long, such a wave would take one second to pass a given point. It would have a frequency of ONE.

However, the longest ether wave dealt with in this story is the twenty-mile-long wave formerly used in transoceanic wireless telegraphy. Quite a few of these twenty-mile waves could pass a given point a second. Divide 186,000 by twenty and you have a result of 9,300. That many twenty-mile waves could pass our theoretical point per second. The frequency of this wave length would be 9,300, or, expressed in thousands, 9.3 kilocycles.

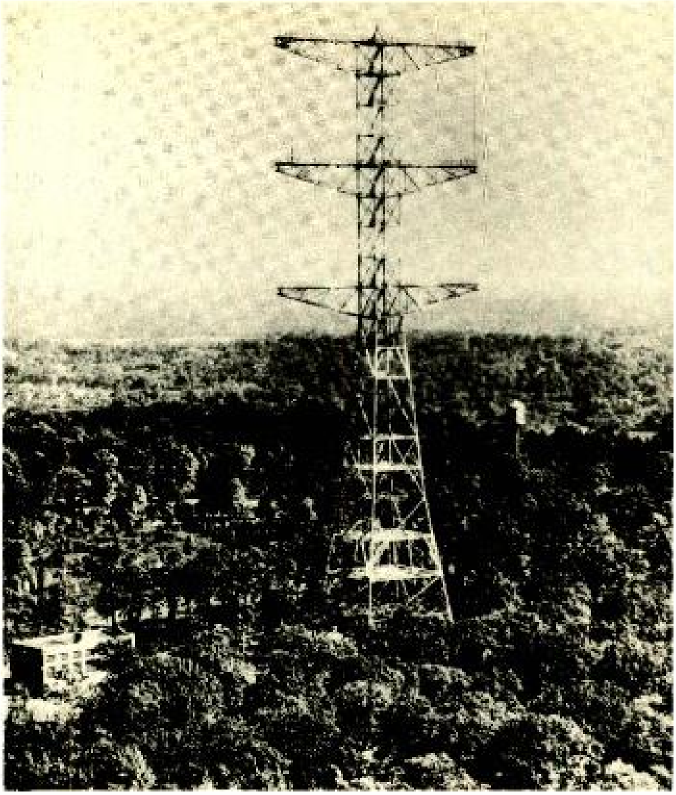
Let's get down to the wave lengths used in conventional broadcasting, for example 360 meters. Three hundred sixty meters is about a quarter of a mile. In round numbers, 750,000 of these waves would pass by in a second, therefore the frequency would be 750 kilocycles.

Thus the relationship between frequency and wave length is simple and arithmetical. The higher the frequency the shorter the wave.

If you want to change wave length in meters to frequency, or the other way round, there is a simple formula for doing it. If you know the frequency and wish to find the wave length, use this formula:

$$\text{wave length} = \frac{300{,}000 \text{ (speed of light in kilometers per second)}}{\text{kilocycles}}$$

Let us say your local station operates on a frequency of 1,000 kilocycles. Divided 300,000 by 1,000 and the result is 300. This is the wave length in meters. If you know the wave length and wish to find the frequency, use this formula: $KC = \frac{300{,}000}{\text{wave length in meters}}$. Suppose an international news roundup is broadcast on a wave length of 30 meters. Divide 300,000 by 30. The result is 10,000. Thus the station oper-



The 400-foot FM tower (with turnstile antenna at upper right) and transmitter building of station W2XMN, Alpine, New Jersey. *Photo by Brown Brothers.*

ates on a frequency of 10,000 kilocycles. Now, back to FM.

Where conventional broadcasting is measured in hundreds of thousands of cycles, FM is measured in millions of cycles, or megacycles. Most FM broadcasting is carried on waves of forty to fifty megacycles, or around six and seven meters. This is the new continent explored by FM, a wide continent with lots of room for newcomers. Back to our story:

When all the advantages of this new kind of broadcasting had seeped into the consciousness of people, FM took hold with a rush. A station was established in Chicago in the fall of 1941, and in a few short months the number of FM receiving sets in the Chicago area leaped from a few hundred to 25,000.

At this point we may ask what are the chances of FM programs being established on a network basis. Like television, FM uses those short waves that travel in a relatively straight line and are limited by the horizon. As in television, the answer will probably be relay stations between which the programs can be beamed by directional transmitters. In fact, the same relay stations could be used both by television and FM.

Meanwhile, any FM broadcasting station today can receive any network show distributed by telephone wire and broadcast it from its FM transmitter. Such a program will be static-free. It won't have the purity and range of sound of the FM broadcast, because telephone wires cannot carry the wide range of sound possible in FM. By the time a telephone-carried broadcast reaches an FM transmitter, it is minus many of the high and low sounds found in music and speech. Yet this program is as good as we are now receiving in AM broadcasts, and even a little better because there is no static.

If you were to visit an FM station you would find it no different from any broadcasting station. It would have its studios, announcers, engineers and sales department. The difference lies in what happens when the studio sounds take the air.

There in space, free of static, carrying the full ranges of sounds created in the studio, rides the new kind of winged horse, the FM Pegasus created by Edwin H. Armstrong, bringing you the best programs you have yet heard.

The long aerial marks the tank of a platoon leader, from which radio orders are transmitted to the other tanks of the platoon. *Photo by Ewing Galloway.*

14

Radio in War and Aviation

SINCE the beginning of history, our generals have been seeking ways of sending signals between combat units in war time.

In past wars, messages were sent mainly by scouts and runners, afoot and on horseback. The Indians, in their tribal wars, sometimes signaled each other with a column of smoke and a blanket.

Just before the War Between the States, Major Albert Myer worked out a system of wigwagging with a flag mounted on a long staff. Other systems used by the Army and Navy to send messages were the heliograph, in which the rays of the sun are reflected from a mirror, and the semaphore system, in which two flags are manipulated by the operator.

During World War I, the most common system of communication was the field telephone. Long wires had to be laid over shell-plowed fields from headquarters to front line regiments. To some extent radio was also used for field communications, but the art wasn't well enough advanced in 1918 to be in general use.

In World War II, however, radio has come into its own. The modern war requires close cooperation between foot soldiers, tank units, and aviation. Seldom can one branch of the service win a battle without the help of the other. Without radio, this close cooperation would be hardly possible.

Picture a tank company going forward to the assault. In the company are three platoons of four tanks each. If you'll look at the four tanks of the first platoon, rumbling abreast over the field, crushing bushes and small trees under their treads, you'll notice that one of the tanks has a long pole aerial slanting from its steel top.

This is the tank of the platoon leader. The pole carries his transmitting antenna. Of all four tanks, the leader's tank alone has a transmitter. The other tanks have receivers only. They can hear the orders given them. They cannot reply. Their receivers are constantly tuned to the company's wave length so there need be no fussing with knobs.

The platoon leader's receiver is also tuned to the company's wave length so that he can instantly receive messages from the company commander. Thus the company is a small network. In fact it is called the "company command net."

The company commander has two receivers. One is tuned to his company's wave length so that he can hear from his platoon leaders. The other is tuned to the wave length of the next higher command, which may be battalion or regimental headquarters. If he had only one receiver he might miss a message while tuning from his company wave length to that of the higher command.

Tank regimental headquarters, in turn, is in radio connection with other branches of the service such as the infantry and air

A portable field transmitter in operation. *OEM Photo from Ewing Galloway.*

corps, so that over the radio network, all combat units can work together. If an advance tank unit, encountering stiff opposition, needs dive bombers, the platoon leader can send his request to his company commander who will relay it to headquarters, and shortly the planes will be on the way.

It was by this instant radio contact that Germany sealed the fate of France in the spring of 1940. Abandoning code or any attempt at concealment, the Germans barked their orders into the ether, sending panzer units and Stukas to the places where they would do the most good. The British and French heard these orders but things were happening so fast that their knowledge did them no good.

The infantry is just as well equipped with radio as the tank corps. There is communication from headquarters, right down to the platoon in the field.

The infantry platoon's radio is a small one. It is a compact set known as the Galvin radio, weighing just five pounds. Its range is only two or three miles horizontally, and possibly five or six miles upward, for communication with airplanes.

Armies in the field are equipped with many kinds of radio outfits. There are the walkie-talkies, weighing about twenty-eight pounds, handled by two men. There are radio-equipped scout cars. There are heavier stations, equipped with hand-driven generators, for field headquarters. There are radios designed to be mounted on a horse. Most of these kinds of outfits are illustrated in this chapter.

So far we have spoken of armies in the field. In this country, the Army has a nationwide network of approximately 150 stations. Operating on its own wavebands, this network provides instant communication from headquarters to corps areas and on to individual posts and camps. A general can transmit orders to the entire army in a few seconds merely by speaking into a microphone.

In the Navy, communication between units of the Fleet is by

These Navy pilots are on the alert for radioed instructions. *Official U.S. Navy Photograph.*

The Army's "jeeps," too, are provided with radio equipment. *Photo from Ewing Galloway.*

"Bridge" of modern airliner. Here's the aerial equivalent of a sea-going captain's bridge—the pilots' compartment of a United Air Lines Mainliner. Note the earphones through which the pilots hear signals of the directional radio beam, late weather reports, and company messages; also, the microphone in hand of the first officer (left) by means of which he talks to ground stations. *Courtesy of United Air Lines.*

radio, though under certain conditions the radio must be used with caution or not at all. For the enemy, by intercepting radio signals, can determine the location of the sending ship. For this reason, ships frequently must maintain "radio silence." But when the battle starts, the ether signals start, too, for then the important thing is to transmit orders.

The Army Air Force uses radio much in the same way that commercial aviation uses it. If you were to visit a large airport, you would find behind one of the forbidden doors the dispatcher's room. The dispatcher is in two-way communication with planes in the air. Pilots, at regular intervals, report their position to him, and tell him what the weather conditions are at that point along the route.

But to visualize just how important radio is in aviation, take an imaginary ride from, say, Detroit to Washington. You sit in the copilot's seat, with earphones over your head. The plane's receiver is tuned to the wave length of the airport on which your ship is resting.

The pilot has filed his flight plan with the Airways Traffic Control. He plans to follow the radio beams to Washington, flying at 9,000 feet because there's a thirty-mile tail wind at that altitude.

When the pilot is ready to start, he picks up the microphone and talks to the airport's control tower.

"NC 2139," he says, "from Detroit to Washington via airways. I want to taxi out."

Into your duplicate earphones comes the reply. "Surface wind so-and-so. Okay. Go ahead."

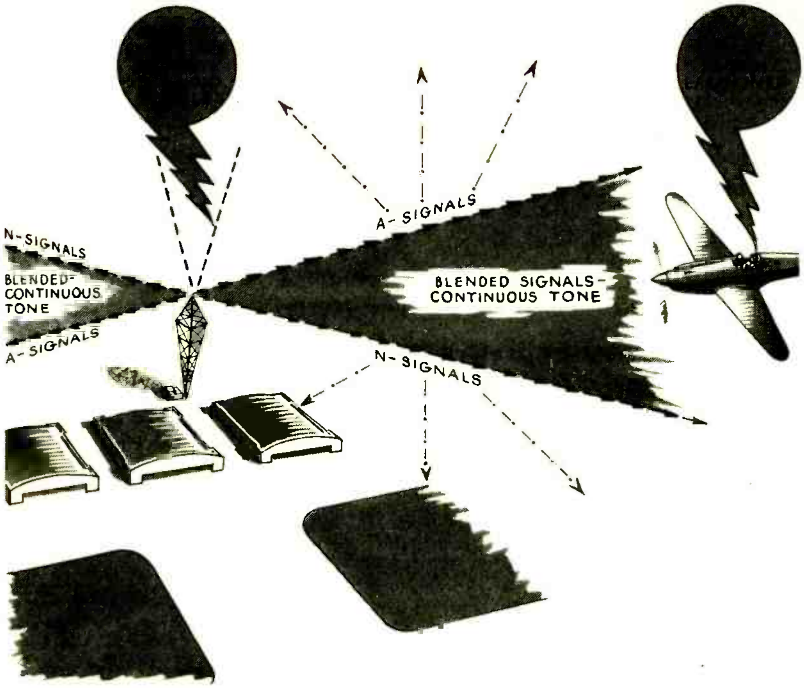
The pilot takes off and starts a gradual uphill climb for the 9,000 foot level. As he does this, he's riding a "beam." The beam is a stream of radio signals being broadcast from the airport he has just left. It widens out, cone-shaped, in a southeasterly direction. If the pilot gets off course to the right, a "dot-dash" will sound in the earphones. "Dot-dash" is the code for the letter A.

If a pilot gets off course to the left, a "dash-dot" will sound in the earphones. This is code for the letter N. If the pilot stays on course, the two signals blend into a relatively continuous sound.

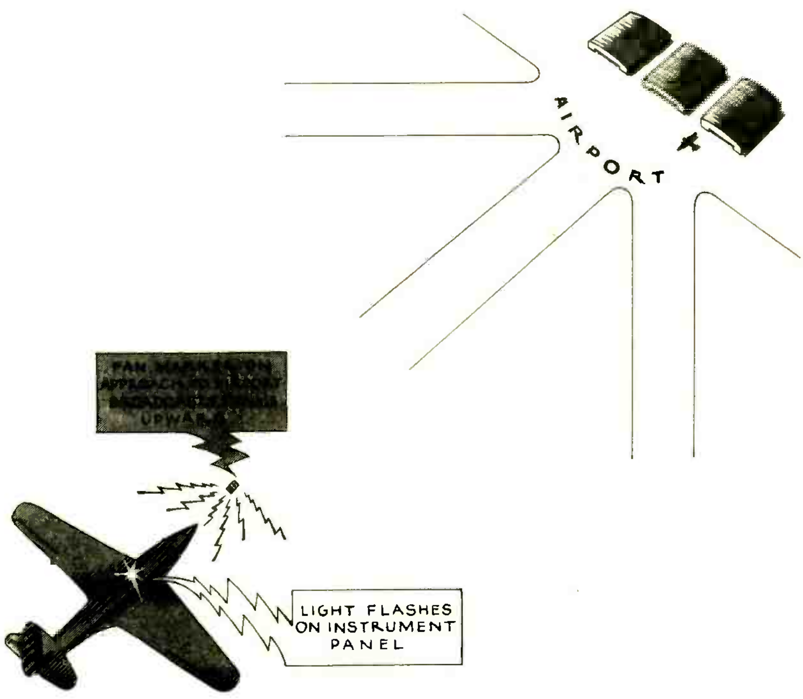
So, guided by tiny buzzes in the earphones, you ride the beam across the corner of Lake Erie. As you reach a point over the shore, the pilot picks up the mike again and calls the Cleveland airport, reporting his location and asking clearance to Pittsburgh. Cleveland says okay, and presently you're swinging eastward over the great dirigible hangar at Akron.

Now there's a new sound in the earphones, a definite "dot-dash" or A signal.

"We're in the A sector of the Pittsburgh beam now," the pilot tells you. "Listen."



Pilots fly radio highways.



Fan marker.

"There's a cone of silence over the airport," the pilot tells you.

This is another phenomenon of aviation radio. Directly over the station sending out the beam—called the radio range station—no signals can be heard. That way, a pilot riding above low-hanging clouds that conceal the ground, can tell when he's over his destination.

You take the southeast leg of the Pittsburgh range (or beam) toward Washington. Talking to Pittsburgh, the pilot learns that he must stay at 9,000 feet until he arrives at a fan marker thirty miles northwest of Washington. There he's to contact the Washington Airport for clearance into the port.

The pilot says, "Okay, thanks," and you soar on, over the Alleghenies.

When you reach the location point known as the "fan marker" the pilot calls Washington and receives permission to come in and land. Five miles away, he says: "Five miles northwest, at two thousand feet."

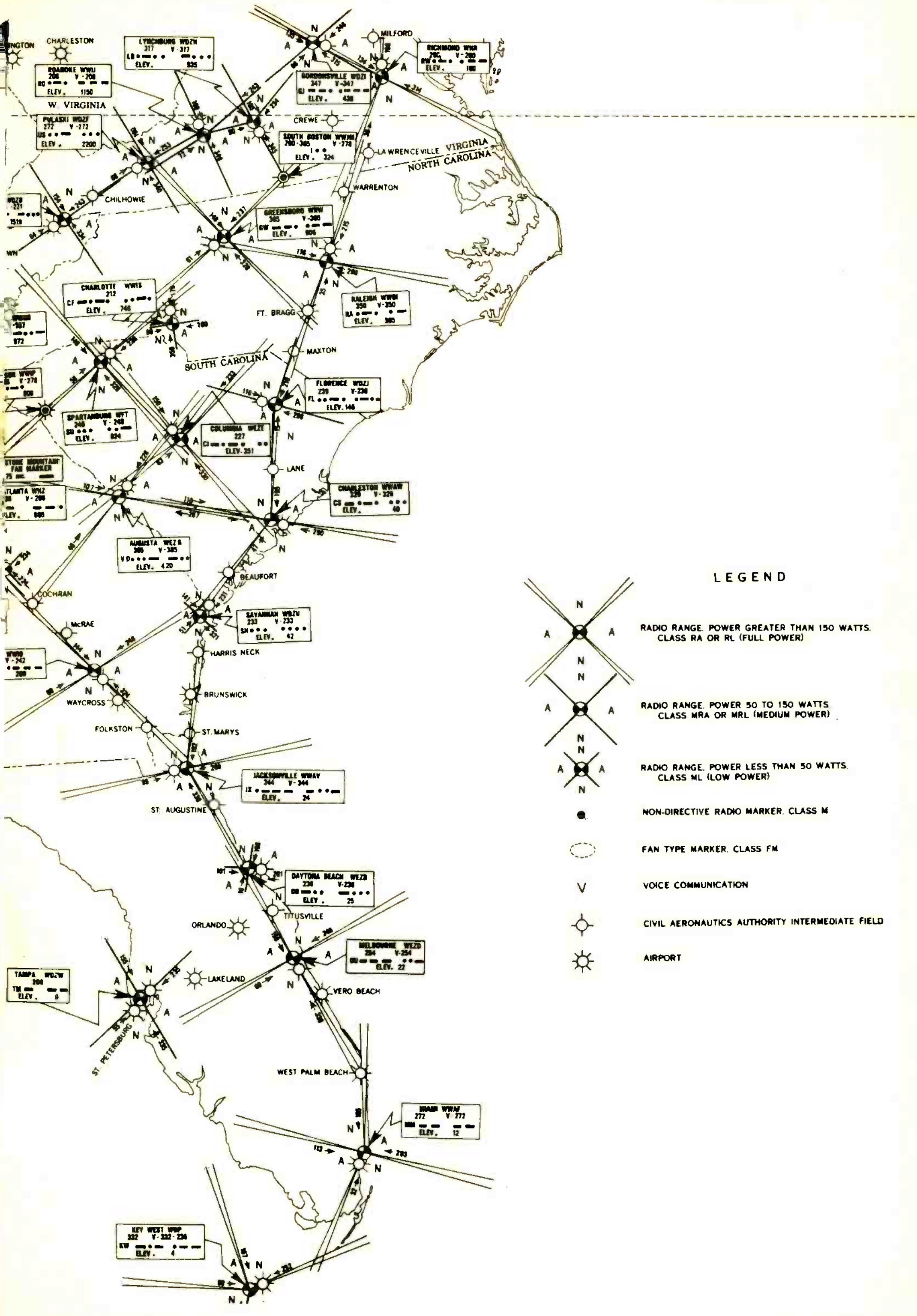
Washington replies: "You're cleared to the field. Wind is north northwest, eighteen, with fresh gusts up to twenty-five miles per hour."

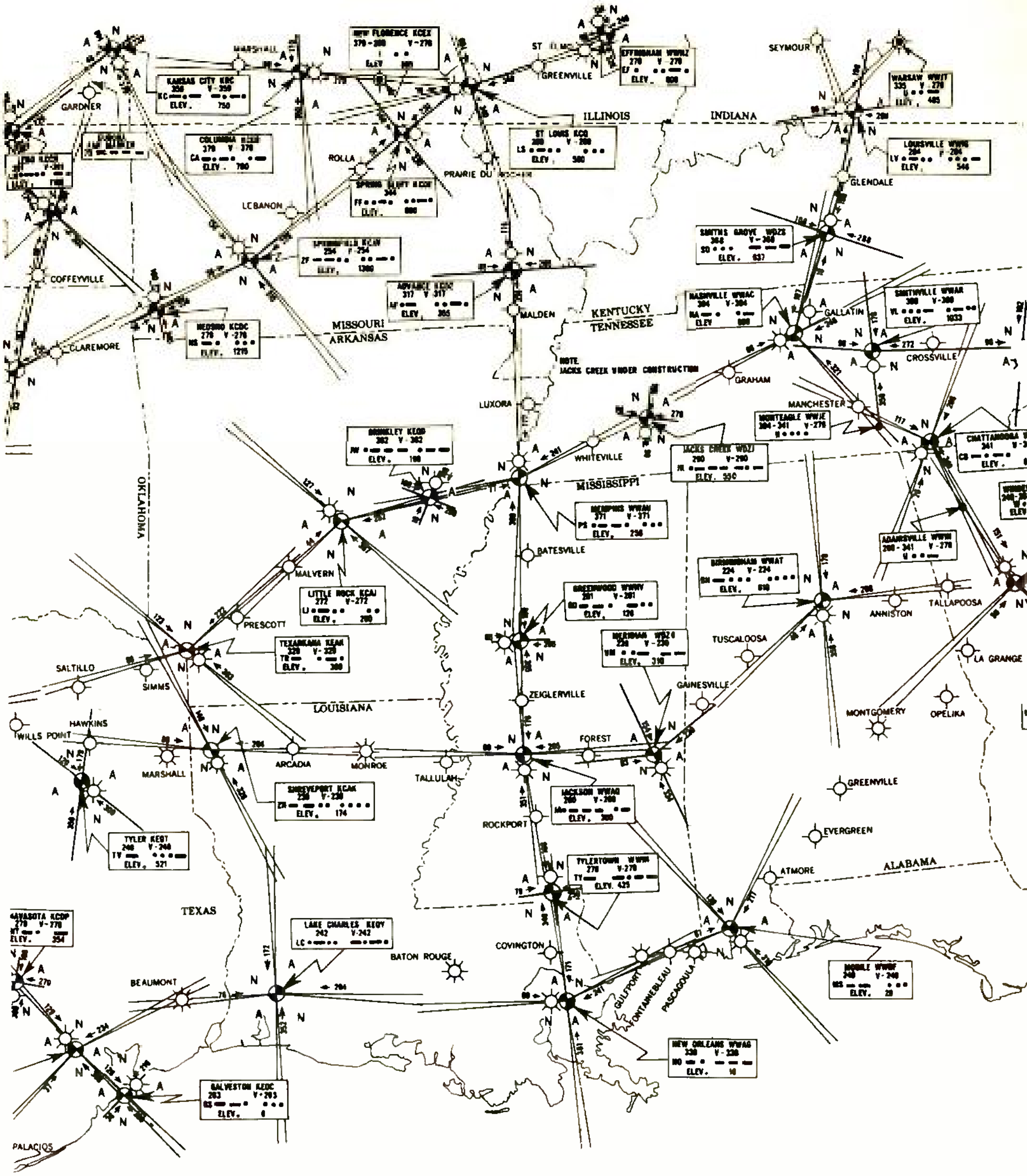
The white buildings of the nation's capital show up beneath the wing, and very soon you're banking steeply, in preparation for the long glide to the airport.

As the big tires scud over the turf, you realize how perfectly radio has guided you and kept you informed, during your five-hundred-mile trip.

The weatherman at our airports makes an interesting use of radio. Every so often, he sends a small broadcasting outfit into the upper air by means of a balloon. The little transmitter weighs just a pound and one-half. The balloon that carries it has a diameter of nine feet.

As the balloon shoots upward, such information as changing air pressure, moisture content, and temperature are recorded on delicate instruments. The transmitter, ingeniously connected to


LEGEND
RADIO RANGE. POWER GREATER THAN 150 WATTS. CLASS RA OR RL (FULL POWER)
RADIO RANGE. POWER 50 TO 150 WATTS CLASS MRA OR MRL (MEDIUM POWER)
RADIO RANGE. POWER LESS THAN 50 WATTS. CLASS ML (LOW POWER)
NON-DIRECTIVE RADIO MARKER. CLASS M
FAN TYPE MARKER. CLASS FM
VOICE COMMUNICATION
CIVIL AERONAUTICS AUTHORITY INTERMEDIATE FIELD
AIRPORT
CHARLESTON
MILFORD
W. VIRGINIA
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
CREWE
LAWRENCEVILLE
WARRENTON
CHILHOWIE
FT. BRAGG
MAXTON
LANE
BEAUFORT
COCHRAN
McRAE
HARRIS NECK
BRUNSWICK
WAYCROSS
FOLKSTON
ST. MARYS
ST. AUGUSTINE
TITUSVILLE
ORLANDO
LAKELAND
VERO BEACH
ST. PETERSBURG
WEST PALM BEACH



CIVIL AERONAUTICS AUTHORITY

RADIO FACILITY MAP – SOUTH EAST QUADRANT

ALL AZIMUTHS MAGNETIC – COMPUTED AT STATION

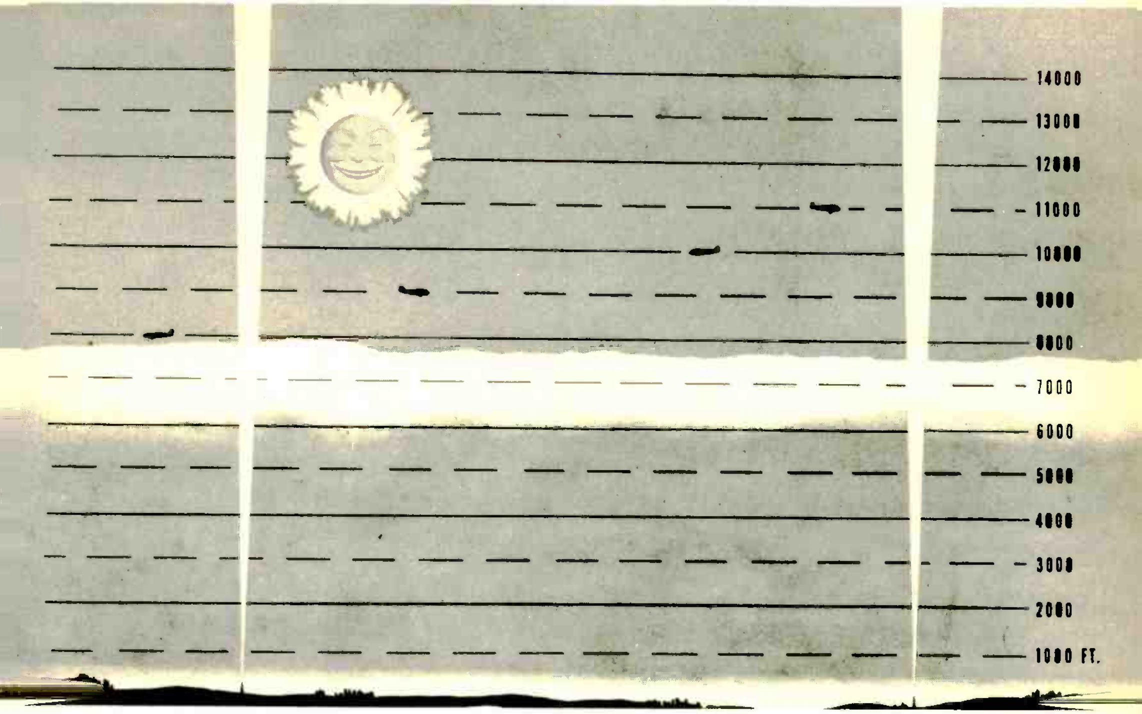
(ELEVATION APPLIES TO ADJACENT AIRPORT OR FIELD)

SCALE

25 0 25 50 75 100 MILES

JULY 1, 1939

Radio Facility Map, Northeast Quadrant. *Civil Aeronautics Administration.*



How modern airliners operate along radio paths of the airways. The drawing shows how planes are separated vertically by at least 1,000 feet as they fly at even altitudes westbound and at odd altitudes eastbound, in all cases using the directional radio beam as a guide to their course. The vertical beams in the sketch illustrate "cones of silence" directly over the radio range stations. *Courtesy of United Air Lines.*

You listen, and the dot-dash is interrupted by the letters P-T in Morse code. These letters stand for Pittsburgh.

You marvel. The air above the United States, you realize, is criss-crossed with invisible electrical paths, traveling cone-shaped from many airports. The trained pilot rides one of these electrical paths and at the proper time switches to another. The signals tell him whether he's on the right side, the left, or in the center of the skyway; and an identifying signal tells him which skyway he's on, just as a road sign identifies a highway for the automobilist.

As you pass over Pittsburgh, the radio signals temporarily cease.

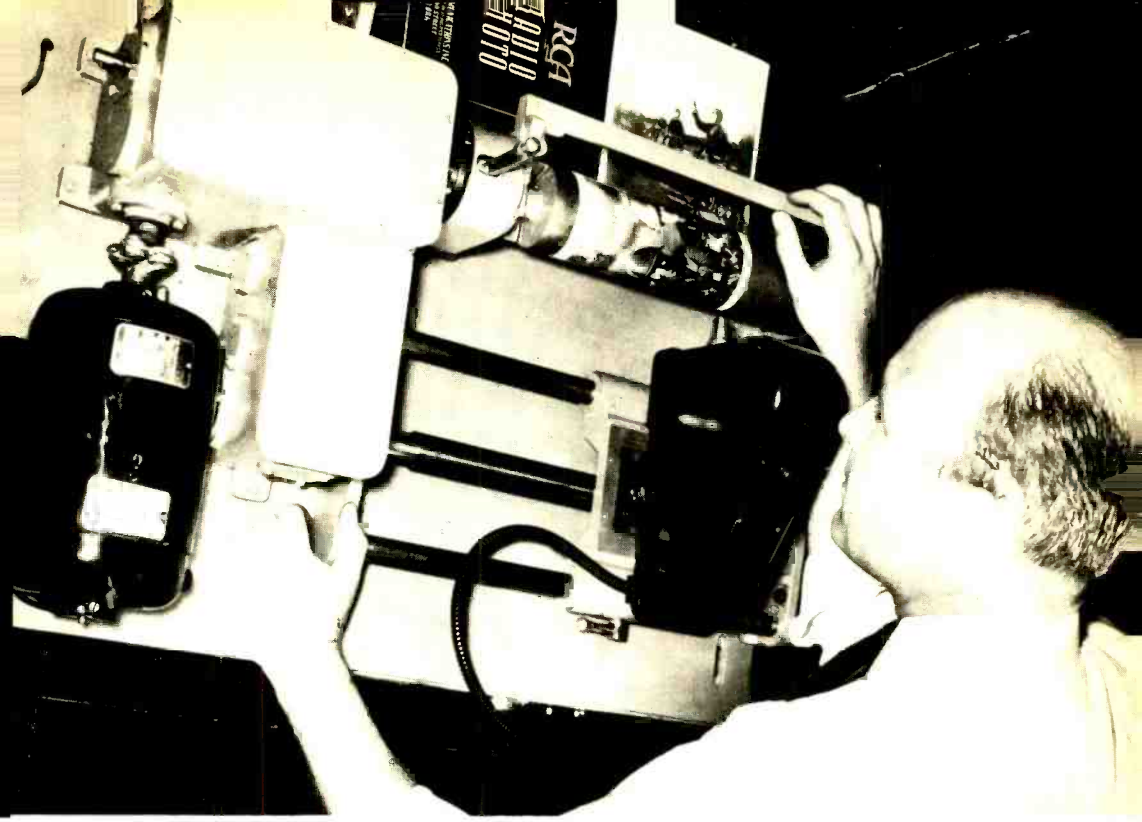
Radio operator aboard Navy Bomber. *Official U.S. Navy Photograph.*

these instruments, automatically broadcasts the information to the weatherman below.

The balloon rises to an altitude of 70,000 feet. By that time its diameter is twenty-five feet. With the pressure reduced the balloon bursts, a parachute opens, and the transmitter floats to earth.

The chances are it will land many miles from the point of launching. But a tag on it tells the finder that if he will mail the transmitter to the address attached he will receive five dollars from Uncle Sam. Perhaps some day *you* will find one of these tiny transmitters in your back yard.

Mike technique, necessary to radio, is taught Flying Cadets at Randolph Field, Texas. Ground-school instructor, third from left, explains intricacies of a "mocked up" communications set to a group of student flyers. *Photo from Ewing Galloway.*



Photos from the Russian front travel 4,615 miles in twenty minutes. In Moscow the picture is wrapped on a cylinder. As the cylinder revolves, a tiny needle or pin point of light causes the radio transmitter to send corresponding impulses. Simultaneously, at the receiving station, another cylinder is revolving at the same speed, and on it is wrapped a "negative." As this cylinder turns, a pin point of light reconstructs the picture line by line exactly as it is transmitted. When the pen has run the length of the cylinder, the picture is complete. *Courtesy of Radio Corporation of America.*

NOBODY quite knows what uses mankind will find for the ether waves propounded by Maxwell and demonstrated by Hertz. The vibrations of this immense ocean that fills all the space between the stars are only partly utilized. As we explore the ocean further, we'll uncover new treasures in the depths.

Let's take a swift cruise through the ether to discover what we already know. Check the following paragraphs with the chart of the ether ocean in the front of the book.

First there are the long waves, fifteen to twenty miles from crest to crest. These immense swells are the waves that were used for early wireless telegraphy across the oceans.

Next below the long waves are the medium-length waves measuring from 200 to 600 meters in length. These are the waves used by your local radio stations.

Farther down the scale are the short waves of fourteen to fifty meters used for present-day short wave broadcasts. The British Prime Minister's voice is carried to this country by waves within this range.

Next we come to the tiny waves ranging from seven meters down to a fraction of a meter. These waves are the carriers for television and frequency modulation. The armed services make considerable use of waves in this area.

Get down to waves measuring one five-thousandth of a meter and you have heat. That feeling of warmth coming from the radiator in your room, is a succession of tiny waves of ether.

Go below the heat waves to vibrations measuring just above $^{32}/_{1,000,000}$ of an inch and you have infra-red rays used in black photography. Just below that the waves become visible. You can see them as red. Then, as the waves grow shorter (or the frequency faster) they change to orange, yellow, green, blue, indigo, and violet. The colors of the spectrum are waves in ether. You'll remember that Maxwell said, in the beginning, that there was a relationship between light and electricity. Both are ether waves, the difference being one of length.

Just below $^{8}/_{1,000,000}$ of an inch you can no longer see the waves. The first invisible waves are ultra-violet, the ray that cures babies of rickets.

Below ultra-violet comes the X-ray, which has the ability to penetrate your tooth and take a picture of that ulcer. Below that comes the Gamma ray, emitted by radium, used by doctors in checking cancer. And finally there's the cosmic ray, tiniest of all known waves.

All of these are waves, or vibrations, in ether. Radio waves, heat waves, color waves, waves that heal bodies, all are phenomena of one vast permeating substance. This is what scientists have learned in the years since Maxwell published his treatise on magnetism and light in 1873.

There are bright new possibilities in the radio ocean, some of them partly realized, some of them still only in the realm of imagination.

There is already in existence a vacuum tube that will produce a fever in the human body. It's called a "radiotherm" and is nothing more nor less than a miniature broadcasting station sending out short waves, two to three meters long. Place a patient between the plates of the radiotherm and turn knobs and his body temperature can be raised to any desired degree. Doctors have discovered that by raising your temperature artificially in this fashion, certain disease bacteria can be killed, and the patient completely cured. Thus short-wave broadcasting, conducted inside a hospital room, is healing the sick. Radio waves are used, also, to preserve foods by destroying harmful bacteria. Subject a shelf of food to a radio broadcast and save it from spoiling! Turn a short wave of two to three meters' length on a granary of wheat and kill the weevils!

There's a big field to be explored in the transmission of power by radio. Imagine yourself in the research laboratory of an electrical company. In the room is a large tube used for the generation of short waves. The laboratory worker hands you an electric light bulb to which two dangling wires are attached and asks you to grasp the two wires.

You do so, wondering what is to happen. He turns on the tube and presently the bulb between your hands lights up, even though it is connected to nothing in the room. The current that is traveling through the filament of the bulb is coming through space from the tube.

This is power, transmitted through space. Similar power is already used to control model airplanes in flight and to maneuver boats without a crew. Power transmitted from an airport could take charge of an airplane and bring it in to a landing. Nobody knows just what practical uses will be made of radio-transmitted power, but the field is waiting, ready to be worked.

In the future it is possible that newspapers will be broadcast to a receiver in your home. A little cabinet, working away quietly while you're sleeping, will be turning out printed pages eight and one-half inches wide by twelve inches deep. When you wake up in the morning, a twelve-page newspaper, complete with illustrations, will be waiting for you.

The printing in this cabinet will be done by a kind of printer bar, operating with varying pressures on a roll of white paper and a roll of carbon paper. The bar, in turn, will be actuated by radio impulses coming down the aerial into the receiver.

The sender of this paper will be your local broadcasting station, not a newsboy. This art of sending a newspaper through the ether to your home is called "facsimile printing." Sending and receiving devices for facsimile printing have already been perfected.

By using the television principle of rapidly scanning a scene or a picture and sending it to a receiving station, the service of telegraphy may be vastly improved. Radio scientists look forward to the day when a man can hand a long typed letter to a telegraph station and this letter will be put in a frame where an electronic beam will scan it. In a fraction of a second, electrical signals representing the entire page will be on their way. They will arrive at their destination two thousand miles away almost instantaneously and there, on some form of sensitized sheet, your letter will instantly appear. Pictures are sent by radio today. Weather maps are broadcast to ships. Why not your letters and mine? One day, when enough sending and receiving equipment has been established, we can whisk letters to each other in a fraction of a second. We'll have something faster than air mail. We'll have ether mail.

Radio is a fascinating subject because it has done so much in such a short time.

In 1895 Marconi sent wireless code a distance of one mile on an Italian estate. In 1901 a faint signal crossed the Atlantic. In 1906 Fessenden delivered the first crude broadcast, and a year later DeForest brought out his magic three-element tube. In 1920 the licensed broadcasting studio went into action and six years later the first network was formed. Since then, short wave, television, and FM have become realities in quick succession.

Radio is fascinating, too, because so much of the ether ocean remains to be explored. The use of these mysterious vibrations in health, in industry, and in the improvement of communication has hardly been touched.

Radio is a fertile field for the readers of this book, the electrical explorers of tomorrow.

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