THE STORY OF RADIO

BY

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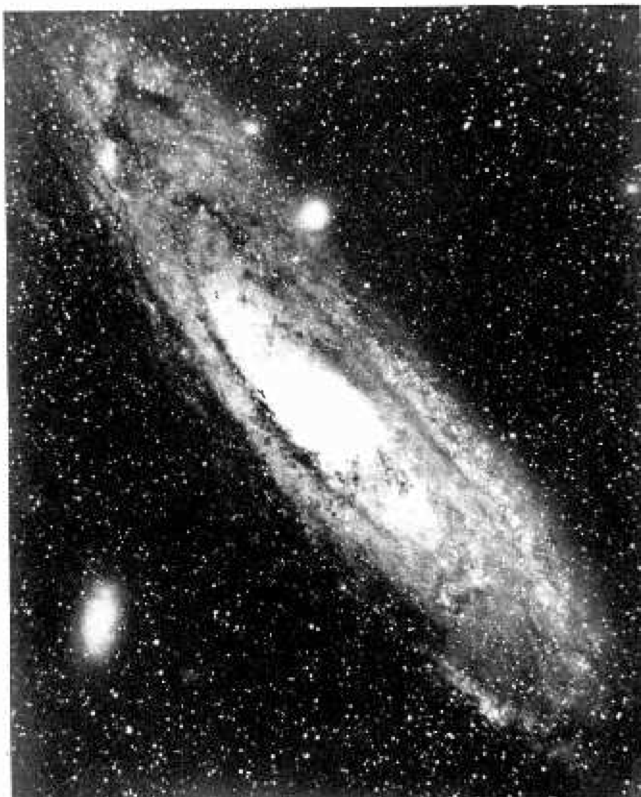
DUNLAP'S RADIO MANUAL

THE STORY OF RADIO

ADVERTISING BY RADIO

RADIO IN ADVERTISING

THE OUTLOOK FOR TELEVISION



Yerkes Observatory.

THE PLAYGROUND OF RADIO

Where do the radio waves come to an end, or do they go on into the infinite to register in other worlds? Despite the speed of the waves, 186,000 miles a second, it would take a program from the earth 1,000,000 years to reach this spiral nebula in Andromeda. There are from 200,000 to 700,000 of these island universes beyond the solar system, and some are 10,000,000 light years away.

TO

LOUISE LEGGETT DUNLAP

TO THE READER

One of the radio-photographs flashed on the screen by Dr. E. F. W. Alexanderson, early in 1927, during a demonstration of his television projector, was that of the electrical wizard Charles Proteus Steinmetz, who had passed on to the Great Beyond several years before.

What a miracle it would have been if Steinmetz, listening-in or looking-in, from his laboratory in another world much further advanced in radio than the earth, had picked up his own picture, wafted into space from WGY, near his familiar haunts in the Mohawk Valley!

But the picture might not have reached him that night. It may still be flying toward him, off through the great emptiness of space at the speed of sunlight, 186,000 miles a second. But that is slow compared to celestial movement in the mysterious sea of space that separates Mother Earth from the sun, moon, stars and other planets. In fact, if the noted Steinmetz were on the North Star he could not receive the picture for fifty years, yet the same photograph could travel around the tiny earthly sphere seven and one-half times in a second.

Do radio waves ever stop? Or do they go on and on into unfathomable distances shooting through other worlds, across the craters of the moon into whirling nebulæ, dashing along with meteors and through the tails of comets to Jupiter, Mars, Neptune and on into the Infinite?

Will the millions and billions of musical scores and countless numbers of spoken words ever return from the Infinite? Will the waves all roll back some day, all intermingled, the music of centuries, the works of all composers a hopeless jumble, a babel of voices, all so powerful electrically that the onslaught of invisible waves will burn up the ether and radio will be no more?

Scientists say that this is not likely to happen, at least not until the seas dry up and reveal their dead. Then the earthly show will be over. The Day of Judgment will be at hand. There will be no need for broadcasting and a mystic stratum of air far up in the clouds may lift as a vapor to let the combined radio power of centuries pour back upon the earth to destroy the ether as the world itself shrivels and with a little puff, vanishes off into the Infinite —where radio went long, long ago.

O. E. D., Jr.

New York, 1935.

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CHAPTER I

IT SPEAKS FOR ITSELF—

"Give ear, ye heavens, and I will speak;
And let the earth hear the words of my mouth."
Deuteronomy xxxii. 1

DID you ever stop to think as you look up into the blue sky or at the Milky Way, at the sun, the moon, at the zig-zag lightning flashes, or into the rolling clouds, that the vast emptiness of space is vibrant with human thoughts, emotions and music, criss-crossed through the air at the speed of light? This is true today but was not so when your forefathers glanced into the heavens, for in those days I was at peace—a calm, latent expanse of ether, dormant but potent, waiting for man to beckon me to serve him.

Today I am a visitor in millions of homes throughout the world; a companion for shut-ins; an entertainer for the lonely; a life-saver for sailors in distress; a medium of education; a carrier of religion; a contact with the land for ships and airplanes; a conveyor of pictures and a medium of television!

Since 1920 I have become so well-known that everybody calls me by my first name—Radio! My full name is Radio Ether. I also have several nicknames such as "Wireless," "Broadcasting" and "Radiocast," but best of all I like "Radio." It is a symbol of speed and world-wide activity!

The ether has been ever present around the earth since the creation of the planet, but in hiding, protected by the mysteries of science until man reached a stage where a rapid system of communication might be useful. I knew that necessity is the mother of invention, and when man was ready he would seek and find me.

SOME REFLECTIONS

Noah could have used me, but even if there had been an electric spark and the associated apparatus on board the Ark, a broadcast would have been of no avail because there would have been no one to pick up his messages. The raven and the dove were of a greater utility to that 600-year old sailor who saved the animals when the flood of waters was upon the earth.

The ether lurked in the air when Alexander the Great conquered the world; when Cæsar marched his legions into Gaul. It was present at the time Napoleon retreated from Moscow and when the Man of Destiny was defeated at the battle of Waterloo. In those days wireless would have been of little service to mankind, which was not yet prepared to receive it. The people of that age had no need for such speedy communication because the world was a much smaller place as far as man's activities were concerned than today. I have always felt that broadcasting might have brightened the sunset of Napoleon's life had it been in existence to carry music to him at St. Helena.

The ether spread over the Atlantic in a mystic state when Columbus and his three tiny sailing vessels set out toward American shores in 1492, and I wished that I might have the honor of keeping that brave, undaunted sailor in touch with his home shores, and later of bringing back to Spain the glad tidings that he had discovered a new continent.

The ether was present but in hiding, when the Pilgrims landed at Plymouth and when the *Mayflower* sailed away leaving that brave little band on the bleak New England coast. I wanted to entertain them; to carry messages of cheer from friends overseas. Radio might have warned them of Indian attacks, but it was yet undeveloped.

I have always had an inkling that radio could have been of great service to Washington and Lincoln, but man had not seen fit to unfetter the necessary electric sparks before these two men passed on to the undiscovered country, the only land from which man has never been able to receive or send a message. Any wave length could have saved Paul Revere that strenuous ride in April, 1775, if there had been a broadcasting station in Boston and receiving sets scattered throughout the commonwealth. But in spite of anxiety caused by the host of possibilities, I learned to be patient, observing that man's progress on this globe is sort of a process of evolution. There came a realization that I must await my turn and follow the ordinary slow course of events which would finally lead to the necessity for more rapid means of communication, evolving from the smoke signals of the Red Men to the runner, the stage coach mail carrier, the telegraph and the telephone.

IN ANY ENVIRONMENT

I say all this because I have been in hiding in the ether, which has enveloped the earth for centuries as an invisible, odorless, tasteless substance occupying all space. The ether is ever present in all homes, rich and poor alike. The waves pass through every human body carrying dots and dashes, news, time signals, weather reports, speeches, music and pictures, yet they do not disturb the human system in the least. They pulsate through mountains and can even hide in the vacuum of an incandescent lamp. As such I am known as "the ether," but when set in motion by electricity I am called "Radio."

A message can slip around the earth seven and one-half times in the twinkling of an eye, because the waves travel at the speed of sunlight. These invisible dispatches can reach the face of the sun, 93,000,000 miles away, in eight minutes, but they travel for fifty years before striking the Polar Star. Radio wings its way over water more easily than over land, because there are so many tall buildings, steel structures, trees, electric wires and dozens of other objects on land which impede the flight and absorb energy, while over the sea the waves can sweep unhampered except for peculiar layers of air which are difficult to penetrate. The rays of the sun also sap about seventy percent of radio's strength, and that is why the waves are more frisky at night and span greater distances under the cover of darkness.

Despite all this power, radio was in a help-

Thos. Coke Knight.

GUGLIELMO MARCONI

less state until man discovered that such a medium as the ether existed, and that the expanse could be set in motion by the action of an electric circuit. In 1867, it could be seen that several inhabitants of the earth were beginning to suspect that the ether might be utilized as a medium for signaling. In that year, James Clerk Maxwell, of the University of Edinburgh, outlined theoretically and predicted the action of ethereal waves. He really identified radio. However, nothing more was done and this method of communication remained in bondage until an electrical wizard caught a glimpse of a strange current which seemed to have possibilities for wafting messages through space.

INCOGNITO

On the evening of November 22, 1875, Thomas A. Edison, observed a peculiar scintillating spark in one of his experiments with an electro-magnet, and after study he proposed the name, "etheric force," for the phenomenon. I jumped with glee when he tested in various ways to discover that the new current refused to obey any of the established laws of electricity, except that of traversing metallic conductors. A lack of polarity was observed as one of its peculiarities. It was indifferent to the earth and consequently capable of being transmitted through uninsulated wires, and showed an independence of electric non-conductors.

I was happy to see Edison go deeper into the subject than previous experimenters, but if he had been more curious and had delved more thoroughly into the mystery, the ether might have begun to carry music much earlier than 1915. Edison apparently did not think much of "etheric force" because he did not apply for a patent on his discovery. I was disappointed. However, he was a very busy man and realizing how things happen on the earth I had hope, feeling that Destiny was saving wireless to be introduced by someone else.

One man, after reading of Edison's announcement of etheric force said, "I cannot but believe that somebody is somewhere mistaken. Mr. Edison is perhaps sincere in his belief that he has discovered a new and valuable force; but he will soon learn that the hopes are elusive and evanescent."

A WORD FROM THE WISE

However, I had one friend with foresight in the editor of the *Scientific American,* who in the January 1, 1876 issue of the magazine said, "It is a new and distinct phase of force, an unstudied phase of electricity, which will rank Mr. Edison the most fortunate and eminent of scientific discoverers."

The gods of science tried to attract Edison in a radio-way again in 1880 while he was experimenting with incandescent lamps. His curiosity was aroused by black deposits inside the glass bulbs and by a blue halo surrounding one of the legs of the carbon filament. He thought that the blackening of the glass might be caused by a molecular bombardment. He coated a lamp on the outside with tinfoil and found that when it was connected in series with a galvanometer and the positive terminal of the filament there was a current flowing across the gap between the filament and tinfoil plate. He then placed a platinum foil between the legs of the filament inside the bulb and the effect was greatly increased. Scientific men named this phenomenon the "Edison Effect."

BORDERING ON DISCOVERY

Thus it was Edison who first discovered that a glowing filament in a partial vacuum within a glass bulb not only shed light, but also a shower of electrons, tiny specks of negative electricity, so small that the most powerful microscope cannot detect them. These little particles of electricity have been described by one scientist, who estimates that if a drop of water, which includes a great number of electrons, because of the hydrogen and oxygen within it, were magnified to the size of the earth each electron magnified in proportion would be about as large as a grain of sand. Nevertheless, these tiny electrons are to my electric system of communication as blood is to the human body.

Edison continued his experiments and invented the electric light but did not perfect the vacuum tube detector and amplifier, despite the fact that he had uncovered the basic principle. Again he left me so that someone else might gain fame by solving the mystery that surrounded the ether as a medium of communication.

Nothing more of consequence was done along this line until 1886, when Heinrich Hertz, a physicist of Karlsruhe, Germany, confirmed Maxwell's theory. Hertz was a student of higher mathematics and a profound experimenter in electrical phenomena, and his efforts to prove or disprove Clerk Maxwell's theories carried the work on farther than had Maxwell himself. He succeeded in showing by means of exact experiments that the ether would transmit the so-called "electro-magnetic waves." Hertz in his research found that when an electric spark leaped across the space between the terminals of a proper spark gap, electrical oscillations took place in the terminals and created waves of an electro-magnetic character in the surrounding ether and these vibrations would in turn affect any adjacent conductor in the field. If that conductor were formed in such a shape as that of a circle of wire in which a small opening had been left, a tiny stream of sparks would jump this second gap while the induction coil, or transmitter, was in operation. In the case of the Hertz experiments the wire ring, or resonator, served as the "detector." His next step was the discovery that the waves had the power of traveling for quite a distance even though objects, such as partitions, were placed between the source of transmission and the resonator coil, or detector. These experiments by Hertz were made the basis of a series of most profound mathematical essays and conclusions, most of which were presented before the Berlin Academy of Science in 1887 and 1888. And that is the reason why radio impulses are sometimes called "Hertzian waves."

The next important step was in 1890, when Professor Edouard Branly of Paris discovered that a short glass tube loosely filled with fine metal filings and normally a poor conductor of electricity, because of the high resistance, could be made a good conductor under the stress of Hertzian waves. Branly called his device a coherer, because the feeble impulses at the receiving station caused the filings to cling together and form a cohesive conductor, or a good path for an electrical current. The Branly method was a more certain and more sensitive way of detecting the signals than was the simple coil used by Hertz.

HAPPY HOURS UNFOLD

A year later several other men including Sir William Preece, Sir Oliver Lodge and Professor Augusto Righi of Italy, and Professor Branly proposed to employ the ether as an invisible method of signaling. Professor Righi tried to utilize the unseen force at Bologna, Italy, and Sir William Preece did likewise in his laboratory in England. But radio remained elusive. However, it was more apparent that some one was soon going to learn the ether's secrets and harness space to serve mankind. Professor Righi had a young student working with him. He was practical, energetic, and persistent. He was radio's champion! He made a set of instruments in 1894 and I could see that he was on the right track. I was happy. Ere long this youth would set the ether free, unfetter radio and let the waves flash through space, carrying messages, music and pictures to all corners of the earth.

My young friend's name was Guglielmo Marconi. He was twenty years old. Day after day he worked with his apparatus and aerials in the fields of his father's estate at Bologna trying to learn more about wireless. He built one device which would set the ether in motion in the form of dots and dashes, and another instrument to decipher the waves by converting them into sound several hundred feet away. As he pressed the key I could feel life being instilled into my ethereal system, but I was very weak. I wanted to be more powerful, to leap around the earth and sail off into the infinite.

THE CHILD OF CENTURIES

Marconi took his apparatus to England in 1896 to demonstrate what could be done with wireless. At Salisbury Plain a message was sent and received across a span of two miles. By the end of 1897 he flashed waves from land to a ship ten miles out at sea and then between two shore stations, Salisbury and Bath, twenty-four miles apart. I was like a baby learning to walk. Marconi was like a father to me. He coaxed the waves from aerial wire to aerial wire, gradually lengthening the distance between the sending and receiving points just as a proud father entices the baby to walk, and then moves the chair further and further away as the tot struggles to reach it.

NO SMALL SIGNIFICANCE

Marconi's experiments in 1896 and 1897 encouraged the installation of wireless equipment on board ships. On April 28, 1899, the steamer *R. F. Mathews* collided with the *East Goodwin Sands Lightship*. This gave wireless an opportunity to carry a call for assistance, and help came from shore, twelve miles away before the ship went down. This proved the value of Marconi's invention as a means of reporting marine accidents. It led to the birth of the S O S. I knew that this performance would please my good friend Marconi when he heard about it. Others would have more faith in his work.

A REPORTER AT LARGE

Wireless carried messages between British Naval vessels more than eighty-five miles apart and reported the international yacht races between the *Shamrock* and the *Columbia* to the press that year. Marconi, in November, 1897, rigged up a transmitting station and a mast 120 feet high at Needles on the Isle of Wight. He put out to sea in a tug boat, taking along a receiving set connected to an antenna hung from a sixty-foot mast. The object was to determine how far the Needles' spark would send a message. Tests continued for several months, and finally, messages leaped across to the mainland. A permanent station was erected at Bournemouth, fourteen miles from Needles, but was later removed to Poole, eighteen miles away. It was another case of the father pushing the chair back a trifle to make the baby toddle a little further.

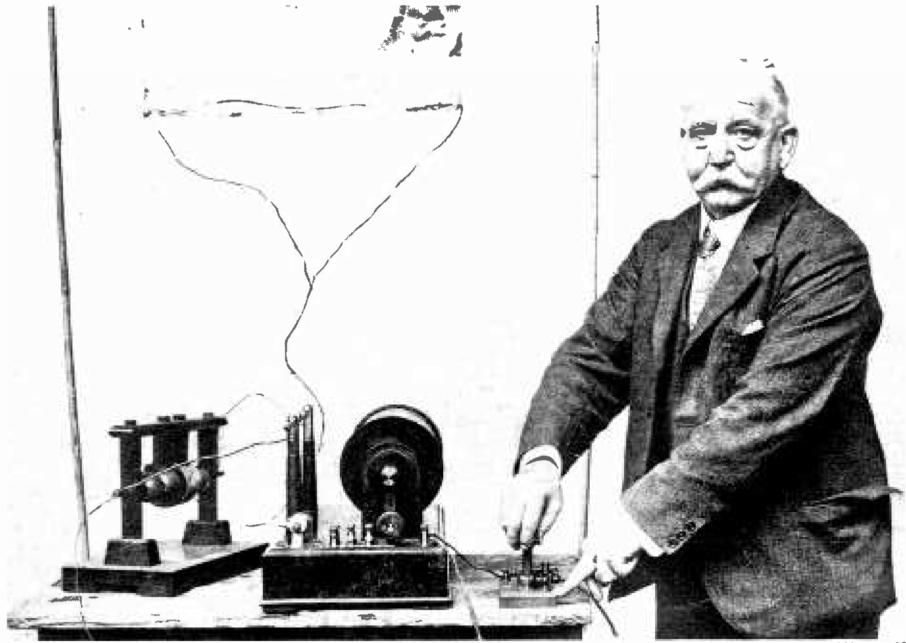
Then came the Kingston regatta in July, 1898. The *Express* of Dublin arranged to have the races observed from the deck of the steamer, *Flying Huntress,* and wireless was to carry the reports to shore. A receiving station was installed at Kingston and dispatches copied there were telephoned to Dublin, enabling the paper to print full accounts about the yachts almost before the races were finished, and while the craft were still out of range of telescopes on the shore. More than seven hundred of these bulletins were handled during the regatta.

IN VICTORIA'S REIGN

A few days later, Marconi was called upon to establish communication between Osborne House, on the Isle of Wight, and the royal yacht anchored off Cowes Bay, with the Prince of Wales on board. During sixteen days, one hundred and fifty private messages were delivered to the Queen, furnishing her with frequent bulletins regarding the Prince's injured knee.

At that time a newspaper man asked Marconi if he thought it would be possible some day for wireless to jump from Paris to New York, and he answered, "I see no reason to doubt it. What are a few thousand miles to this wonderful ether which brings us light every day across millions of miles?"

The ether's short distance performances were giving Marconi more confidence in his discovery and in his ability. The eyes of others were beginning to open to the possibilities.



Wide World.

MARCONI'S FIRST TRANSMITTER

It was with this induction coil and spark gap that the inventor conducted tests at Bologna in 1895. The copper plate at the top was used as the aerial.

THE TURNING POINT

Wireless was subjected to the most severe test up to that time, at the end of March, 1899, when the French Government asked Marconi to attempt sending messages across the English Channel between Dover and Boulogne. At five o'clock on the afternoon of March 27th, Marconi pressed the key which released the first electric sparks that set the ether in vibration across the Channel. Thirty-two miles seemed a long way. Marconi stopped sending and tuned the receiver, hoping to hear the impulses bring back the news that the waves had reached England and that others had returned to France carrying the first dispatch from the British Isles to the Continent. I seemed to have much reserve strength on this day. Perhaps it was because of the fresh Spring air; anyhow, the waves had no difficulty in reaching Dover and British signals darted back with the good news to Marconi. Wireless had crossed and recrossed the English Channel!

Radio beat its own record for distance early in 1901 by carrying a message from an aerial on the Isle of Wight to the *S. S. Lizard,* about 200 miles over the horizon. I was beginning to get my stride! After this triumph the next step was obvious. Marconi said that he was absolutely convinced that transatlantic wireless telegraphy, not merely as an experiment, but as a sound commercial proposition was possible.

CHAPTER II

TRANSATLANTIC TRIUMPHS

"Remember the days of old,
Consider the years of many generations."
Deuteronomy xxxii. 7

A WIRELESS station was built at Poldhu, in Cornwall, on the southwest tip of England, from which I could hop off for an attempt to leap across the Atlantic! An aerial system was erected and supported by a ring of twenty masts, each about 200 feet high, arranged in a circle 200 feet in diameter and covering an area of about one acre.

THE BLUES—!

By the end of August, 1901, the masts were nearly completed. And then, unfortunately, a terrific gale swept the Channel and the English coast, with the result that the entire construction was wrecked.

Naturally, everyone was extremely disappointed, because owing to the nature of the coast at that site and the special character of the work some time must elapse before the damage could be repaired. For several days there were visions of the experiment having to be postponed for three months or longer.

Then Marconi decided that it might be possible to make a preliminary trial with a simpler aerial. Thereupon, ten masts, each 170 feet high, were reerected. A triangle stay was stretched between the two end masts, and from it were suspended sixty almost vertical bare copper wires, the distance between each being about a yard at the top. These wires converged at the bottom, making an aerial in the shape of a fan.

DAYS OF REAL SPORT

In the middle of November I was able with this temporary aerial to develop great strength, in fact the broadcasts had no difficulty in reaching a receiving station at Crookhaven, Ireland and it seemed certain that the waves would be detectable at ten times that distance—across the Atlantic.

On the 26th of November, Marconi sailed from Liverpool on the Allan liner, *Sardinian,* accompanied by two assistants, G. S. Kemp and P. W. Paget. As it was clearly impossible at that season of the year owing to inclement weather and especially in view of the shortness of the time at their disposal, to erect high masts to support an aerial, they had arranged to have the necessary antenna held aloft by a small captive balloon. Part of their equipment was two balloons and six kites of bamboo and silk.

The trio of pioneers landed at St. John's on Friday, December 6, 1901, and the following day before beginning operations they visited the Governor, Sir Cavendish Boyle; the Premier, Sir Robert Bond and other members of the Canadian Ministry, who pledged their heartiest cooperation and placed the resources of every department of the Government at their disposal in order to facilitate the work.

After inspecting various sites which might prove suitable, Marconi considered Signal Hill to be the best. This was a lofty eminence overlooking the harbor and forming a natural bulwark which protects the port from the fury of the Atlantic gales. On top of this hill there is a small plateau, about two acres in area, which Marconi deemed to be suitable for manipulation of either the balloons or the kites. On a crag on this plateau stood the new Cabot Memorial Tower, designed as a signal station, and close to it there was the old military barracks, then used as a hospital. It was in the forum of this building that the receiving apparatus was installed and preparations were made for the great experiment—the test of my life!

A FLEETING NEED

On Monday, December 9th, Marconi began work on Signal Hill. On Tuesday he flew a kite with 600 feet of aerial wire as a preliminary test, and on Wednesday he inflated one of the balloons, which made the first ascent during the morning. Its diameter was about fourteen feet, and it contained some 1,000 cubic feet of hydrogen gas, quite sufficient to hold up the antenna, consisting of wire weighing about ten pounds. A heavy wind toyed with the balloon and finally ripped it loose from the wire, which dropped to the ground as the balloon drifted out over the haze that overspread the Grand Banks. Marconi then came to the conclusion that perhaps the kites would answer better, and on Thursday morning, in spite of a heavy gale, he managed to fly a kite to a height of about 400 feet.

The critical moment had come, for which the way had been prepared by six years of hard and unremitting work, despite the usual criticisms directed at anything new. In view of the importance of all that was at stake, and fortunately for me, Marconi decided not to trust entirely to the usual arrangement of having coherer signals recorded automatically through a relay and Morse instrument on a paper tape, but to employ instead a telephone connected to what was called a "self-restoring coherer." This device was the detector of those days and it depended to a greater extent upon the human ear, which is far more sensitive than the automatic recorder.

Before leaving the British Isles, Marconi had given instructions to the operators at Poldhu to send the letter "S" at a fixed time each day, beginning as soon as word was received that St. John's was ready to listen. Everyone at the transmitter was jubilant when a cablegram arrived asking for the tests to begin at 11:30 A. M., and to continue until 2:30 P. M., St. John's time, on December 12, 1901.

NO HALFWAY STOP!

Immediately the huge induction coils at Poldhu were put into action producing current sufficient to light three hundred incandescent lamps and at the same time delivering the necessary power to create an invisible wave motion across a distance of 3,000 miles. An operator pressed the sending key controlled by a lever of wood three feet long, because it was dangerous for a man to get too

Herbert Photos.

ON A COLD RAW WINTER DAY

Marconi (at extreme left) and his assistants preparing to sail the kite that held up the antenna wire which acted as a slender target for the reception of the first transatlantic signal on December 12, 1901.

close to the high voltage apparatus. Sparks leaped from the knobs of the big Leyden jars, illuminating the room like lightning flashes and creating a deafening sound like the rat-a-tat-tat of a machine gun. The heavy currents surged into the aerial and I leaped into space! I knew that it would be a big task to travel across the Atlantic without getting lost in space. It made me more nervous when I thought of the slender target I must strike over in Newfoundland, beyond the curvature of the earth, where an uncertain, dangling wire suspended from a kite was riding in the Canadian air on this cold, raw day. I visualized Marconi wearing the headphones, sitting in a tomb-like silence carefully adjusting the tuning coils to the wave length on which the "S" was traveling through the ether.

IN THE TWINKLING OF AN EYE

I was in Canada within a fraction of a second, but had lost much of my power in the flight. The daylight reduced my strength and

I began to wonder why Marconi did not wait until darkness fell before sending me out from Poldhu. I had no difficulty in finding the wire hanging from the kite, because my wave fronts became broader with the distance as they traveled, much like the waves created when a stone is cast into a pond of water. The feeble impulses ran down the wire to the instruments but they were too feeble to actuate the headset. Suddenly, at about half-past twelve, the air conditions seemed to improve. My strength increased. Unmistakably three scant clicks, corresponding to the Morse code letter "S" were produced. They sounded several times as Marconi listened intently. A smile crept over his face, but he would not be satisfied without corroboration.

SUPERB RESPONSIVENESS

He handed the phones to his assistant and asked, "Can you hear anything, Mr. Kemp?"

Kemp heard the same three clicks as Marconi and they were convinced that wireless had succeeded in traversing the sea, serenely ignoring the curvature of the globe and with sufficient strength to be detected and deciphered.

They were convinced that the day on which wireless would be able to carry full messages without wires or cables across the Atlantic was not far distant. As Dr. Michael Pupin, the celebrated Serbo-American scientist rightly said soon afterward, "The faintness of the signals had nothing to do with it." The point was that distance had been overcome, and Marconi had proved that further development of the sending and receiving apparatus was all that was required.

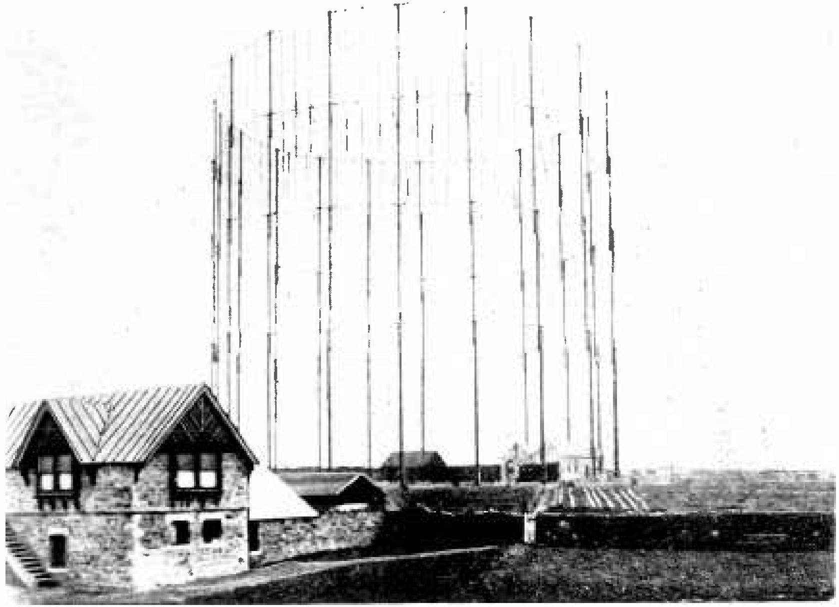
THE ENCORE

On the following day, December 13, 1901, signals again jumped across from Poldhu to St. Johns, although not quite so distinctly. However, there was no further doubt that the ether was destined to play an important rôle in communication. No one seemed to realize in those days that wireless had other great possibilities in the field of music and picture transmission.

A JUSTIFIABLE DELAY

As in many instances when things are new and struggling to grow, Destiny or Fate placed an obstacle in the path of wireless following the first triumphant transoceanic signal. Marconi was notified on behalf of the Anglo-American Telegraph Company, that as they held a charter giving them the exclusive right to construct and operate stations for telegraphic communication between Newfoundland and places outside the colony, the work upon which he was engaged was a violation of their rights. He was asked to stop all work immediately and to remove the apparatus or legal proceedings would be taken.

Marconi was absolutely astounded at this affair, which, however, at least gave satisfactory assurance that one of the great telegraph and cable companies not only believed in but also feared the possibility that wireless might



Herbert Photos.

A LANDMARK OF WIRELESS

Poldhu, on the southwest tip of England, from where the first transatlantic message was broadcast. A gale wrecked this aerial before Marconi had a chance to use it and another network of wires and masts had to be erected before the tests could begin.

be an important factor in communication and give the wires and cables competition.

This cut short the tests on that occasion and Marconi was forced to abandon a demonstration which he had intended to give on the following Monday on Signal Hill to the Governor of Newfoundland and a number of other men who were highly interested in the results of the experiments.

BETTER THAN EVER

When the reason for discontinuing the experiments became known Marconi was almost deluged with offers of sites for the erection of experimental and permanent stations. Among others, the Finance Minister of the Canadian Government, offered on behalf of the Dominion every facility for the location of a station in Nova Scotia, which he decided to accept.

The inventor then went back to England on January 26, 1902, but did not remain long, as he sailed on February 22 for the United States enroute for Canada where he signed the final draft of an agreement for the erection of a large transmitting station at Glace Bay, which later became famous for the historic parts it played in my development.

Before sailing he arranged for Poldhu to broadcast for reception on the *S. S. Philadelphia* during his voyage to the United States. On this trip he was able to receive complete messages up to 1,551 miles, and single letters at 2,099 miles. Thus, within three months of conveying single letters to 1,800 miles, the ether was carrying complete messages across 1,500 miles.

SUPREME SIMPLICITY

As radio men look back and compare Marconi's first instruments with those in use today, including the simple crystal set, my initial crossing of the sea seems like a dream or a miracle. The apparatus Marconi had at his disposal was very crude compared to modern equipment. In 1901 there were no vacuum tubes, no amplifiers, no sensitive super-heterodyne receivers, no directional beam transmitters and no means of making continuous waves. All he had for transmitting was the means of making crude damped spark waves, which did not permit the accurate and sharp tuning methods which are in vogue today.

Marconi and his assistants were obliged to depend upon the action of the old-fashioned coherer, unfamiliar to the modern broadcast listener. The coherer was the heart of the receiving system—the detector! It consisted of a glass tube filled with iron filings, with silver plugs at each end of the slender container. The current intercepted by the antenna passed through the coherer and magnetized the iron filings, thereby shifting their position so that the feeble currents might pass through to the headphones. This in turn created a condition, however crude, that caused a local battery to act and sent more current into the circuit, operating the phones in accordance with the incoming dots and dashes. There is no doubt that the most enthusiastic radio fan today would soon become tired and discouraged of listening-in if he had to depend upon a coherer instead of a vacuum tube detector and the associated amplifiers.

About a year later, on December 16, 1902, I carried the first transatlantic ethereal message to travel east from Glace Bay, Cape Breton, Nova Scotia, to England.

Senator Marconi invited as his guest at this event, the late Sir George R. Parkin, a Professor at Upper Canada College and correspondent for the *London Times,* and gave Sir George the privilege of sending the first message, which was one of congratulation to England and Italy.

The message was scheduled to speed on its way immediately after 1 o'clock, an appointed hour at which the operators at Poldhu were scheduled to be on duty to pluck me from the air.

A MIDNIGHT PARTY

A little after midnight the entire party sat down to a light supper. Behind the cheerful table talk of the young men on the staff, one could feel the tension of an unusual anxiety as the moment approached for which they had worked, and to which they had looked forward so long. It was about 12:50 A. M., when the group left the cottage and walked over to the operating room. Incidentally, Sir George Parkin was the first outsider allowed to inspect the building and its machinery.

It was a beautiful night, the moon shone brightly on the snow covered ground. A wind which all day had driven heavy breakers on the shore had died away, and the air was cold and clear. All the conditions seemed favorable for me to make my first dash eastward across the Atlantic. I knew from experience that success would depend to a great extent upon the atmospheric conditions. I had more confidence than I had the year before when I crossed from England to Newfoundland, and my spirit was buoyed up by the fact that it was after midnight; and darkness, ideal for ethereal transit, covered the sea.

The machinery was carefully inspected, some adjustments were made and various orders were carried out with trained alertness. All put cotton wool in their ears to lessen the force of the electric concussion, which was not unlike the successive explosions of a Maxim gun. As the current was of the most dangerous strength those not engaged in the actual operations were assigned to places free from risk of electrocution.

It had been agreed that at the last moment before transmission Sir George should make some verbal change in the message agreed upon, for the purpose of identification. This was done and the message thus changed was handed to Marconi, who placed it on the table where his eyes could follow the contents. A brief order was given for the lights over the battery to be switched on, another for the current to be turned into the circuit, and the operating work began.

HAPPY LIGHTS IN HIS FACE

An instant change from nervousness to complete confidence passed over Marconi's face the moment his hand was on the long wooden lever or key. He explained that it would first be necessary to transmit the signal letter "S" in order to attract the attention of the man at Poldhu, and enable them to tune their instruments. For several minutes the impulses continued to flash across the sea carrying nothing but a series of the letter "S." Then with one hand on the paper from which he read and with the other hand on the key, Marconi released the first complete sentence to pass through space from the New to the Old World. Outside there was no indication, of course, on the aerial wire from which the message was projected, of what was going on. The aerial wire did not glow nor were there any sparks to be seen in the air around the masts as some expected. But inside the operating room the words seemed to be spelled out in short flashes of lightning. It was done slowly, since there was no wish on this occasion to test speed. But it was done with a feeling of awe when Marconi told Sir George that only a ninetieth part of a second elapsed from the moment when the flash was seen in the room until the dots and dashes registered in Poldhu.

What gives it direction? someone asked. Marconi remarked that he had sent the waves into space and that they must find their way to the receiving antenna in Cornwall. Mountains in my path do not retard transmission, and when one remembers that between the point of departure and the point of reception the curvature of the earth represents a mass of land and water more than a hundred miles high, this may be understood more clearly.

IMMORTAL

After the first message had traveled eastward across the Atlantic Sir George Parkin said, "What that means to mankind no one can even guess. The path to complete success may be long and difficult. Between George Stephenson's Puffing Billy and the great mogul engine which swings the limited express across the American continent, there lies three-quarters of a century of endeavor, experiment and invention. But in the great original idea lay the essential thing which has revolutionized the world and conditions of human intercourse."

One writer paid tribute to the inventor by saying, "Marconi's creation, like that of the poet who puts the words of men in a perfect lyric, was none the less brilliant and original."

All were pleased with Sir William Preece's comment upon the oversea achievement: "We all knew the egg, but Marconi showed us how to stand it on end."

A BRILLIANT FRIEND

When Sir Oliver Lodge heard that the ether had made Marconi's dream a reality he said, "The present is an epoch of astounding activity in applied science. Progress is a thing of months and weeks, almost days. The long lines of isolated ripples of past discovery seem blending into a mighty wave, on the crest of which one begins to discern some oncoming magnificent generalization. The suspense is becoming feverish, at times almost painful. One feels like a boy who has been long strumming on the silent keyboard of a deserted organ, into the chest of which an unseen power begins to blow a vivifying breath. Astonished, he now finds that the touch of the finger elicits a responsive note, and he hesitates, half-delighted, half-affrighted, lest he should be deafened by the chords which it seems he can now summon almost at his will."

On the other hand the general public on both sides of the Atlantic accepted Marconi's announcement at its face value and did not become excited by the news, or take it seriously. The impression prevailed that transmission of messages not confined to wires, but broadcast into space, would be of little or no practical value. However, Marconi did not become down-hearted, because he was aware that the telegraph and telephone had been received in their day with the same skepticism. The world had failed to learn any lesson from great inventions of the past and Marconi's apparatus which lifted the ether out of an inert state and gave it life was listed in the average mind as a mere toy. Radiation of intelligence through the air to a point hundreds of miles away, or to a city on the other side of the globe was inconceivable.

CHAPTER III

DRAMATIC MOMENTS

"For I am in distress; answer me speedily."
Psalm lxix. 17

SEVERAL more important advances had been made by the time 1901 arrived, the outstanding development being a self-restoring coherer and the telephone receiver operating in conjunction with each other. The following year Professor R. A. Fessenden introduced an electrolytic detector, consisting of a small platinum wire, the tip of which came in contact with a weak solution of nitric acid. This formed a more dependable detector and permitted more general use of the headphones than had been possible with the coherer type of rectifier, which rendered phones impractical because of the relays and local batteries. Marconi then counterstruck by inventing the magnetic detector and Professor Braun in an effort to adapt the coherer for use with earphones laid the basis for the advent of the crystal detector, which reigned supreme until the vacuum tube was developed for practical use.

It was the duty of the crystal to change the incoming high frequency impulses to low frequencies to which the headphones could respond and produce sound audible to the human ear. It was found that a mineral such as galena, silicon, carborundum, zincite and chalcopyrite had the property of permitting an electric current to flow through it in only one direction, completely checking the flow in the opposite direction. In fact the crystal acts in a receiving system as a valve in a water pipe, allowing water to flow freely in one direction but preventing back-flow. This type of detector can receive spark signals radiated several thousand miles away but in reception of broadcast programs its range under normal conditions is about twenty-five miles.

Dr. James Ambrose Fleming, of England,

in 1904, invented the Fleming valve and applied it to the detection of my waves. Dr. Lee De Forest, of the United States, improved the Fleming valve in 1906, by adding a third electrode and called the "grid," making the two practical for transmission and greatly improving its efficiency in receiving circuits.

Dr. De Forest had upon several occasions noted a novel phenomenon in the flickering of Welsbach gas lights when experiments in wireless transmission were being conducted in his laboratory, and, though serious tests were later made along this line, little was really accomplished at that time. The ground work was laid however, when De Forest discovered that the gaseous ions in flame could be made to detect my weak currents, even though unreliably.

By the end of 1904 I had reached no uncertain point of perfection and stations were "on the air" at Block Island, Point Judith, Coney Island and numerous other coastal points. The St. Louis Fair in 1904 offered a few companies engaged in promoting me, an excellent opportunity to display the devices which were making wireless a reality, and I was one of the main centres of interest at the exposition. It was really the first opportunity that the public had to see me. Up to that time I was more or less of a myth, as far as it was concerned.

FEARSOME LOOKING

The receivers of that period were fearsome looking instruments, consisting of large coils, with a multitude of brass switches and bulky condensers. The transmitters were represented by huge transformers, in many instances as tall as the average man, and they produced a spark several inches across that cracked between the gap points with sufficient noise to be heard outside the exposition hall in which I was on display. The transmitter's key was controlled by a "pump" handle several feet long and the key's contacts generally sparked and arced almost as badly as the spark gap itself.

The Danish inventor, Valdemar Poulsen, in 1903 designed an arc transmitter capable of generating undamped or continuous waves, which succeeded in sending messages over greater distances than a spark transmitter of twice the power output. This development was a great stimulus to transatlantic and other long distance communication.

On January 18, 1907, Dr. Lee De Forest was granted a patent on the audion, or first practical three electrode vacuum tube. This was the outcome of more than five years of experimentation and research. Going by difficult stages through these years he arrived at an evacuated glass bulb in which were sealed a filament, a square platinum plate and a nickel grid fashioned on a jeweler's vise with a pair of pliers.

Incidentally it might be of interest to mention that one of the first De Forest evacuated tubes utilized a piece of sodium to produce the necessary flow between the elements. This was discarded in 1903 on account of practical difficulties in maintaining a means of heating the sodium and also in view of the fact that the operation of the tube containing sodium

Herbert Photos.

A FAMOUS KITE

On December 12, 1901, this kite sailed up to an elevation of 400 feet and held aloft the antenna that picked up the first transatlantic signal at Signal Hill, Newfoundland. G. S. Kemp, Marconi's first assistant in the test, is holding the strings.

at that time was deemed, "tricky and unreliable."

AN OCEANIC BOAST

The years 1906-8 might be called the true critical ones in my life because from that time on there was a certain positiveness about my performances which overcame finally all assertions that I was only the dream of visionary scientists. It is also notable that during these years the thoughts of inventors turned to a more difficult field, that of developing wireless to carry voice and music through the air.

Further than this, the shipping world had now definitely recognized my possibilities and many of the large steamships boasted a "wireless telegraph receiving and transmitting station aboard."

By the time 1907 had arrived, wireless was being used in a regular press dispatch service between America and Europe and was occasionally an allegedly "twenty-four hour service."

Dr. De Forest made numerous experiments

in voice and music transmission throughout 1907, which promised much for the future. This work was done by modulating the wave-train of a small transmitting arc and the experiments were moderately successful. It is a notable fact that at this time the amateur experimenter, the man and the boy, who merely played with me as a hobby, now entered the field, and a small number of these operators scattered across the country formed the neucleus of what was later to become one of the largest independent non-commercial amateur fads—"the hams," organized as the American Radio Relay League.

PROGRESS AND APPROVAL

Between the years 1908 and 1909 the majority of first-class ships adopted wireless as a communication service and a life-guard. It was also at this time, in Europe, that I gave the first practical demonstration of my ability to carry voices and music through the air. This was over a distance of 300 miles after three months experimenting, using the Eiffel

Tower in Paris as a support for the aerial. The broadcast program on this occasion consisted of playing phonograph records over and over again throughout the night and then waiting the next day for reports from the various French wireless stations as to how the Tower had been heard and how faithfully the ether carried the melodies.

The amateurs began to use the vacuum tubes on a limited scale in 1913. This was the beginning of the end of the crystal detector, which most of the amateurs and commercial stations were still using at that time.

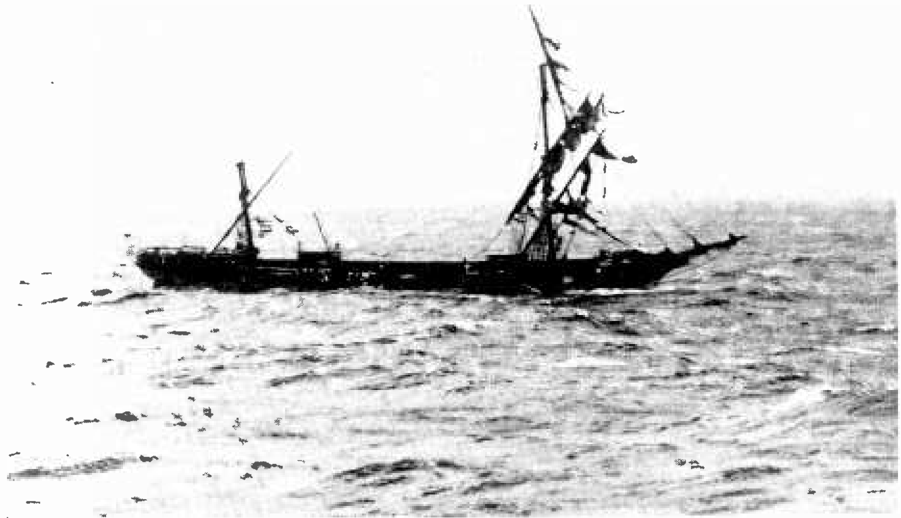
In 1914 the World War broke out, and wireless immediately came to the front as a reliable and rapid means of communication carrying a continuous stream of messages back and forth across the sea and from ship to shore and shore to ship. All of the amateur stations were closed and sealed by the Government.

During the second year of the war, 1915, I made a new record for voice transmission from Arlington, Va. A special transmitter consisting of 500 audions was used to generate the oscillations to set the ether in vibration and I established oneway communication between Arlington and Paris, and between Arlington and Honolulu. This experiment without a doubt demonstrated that the three-electrode tube could be used much better than the arc type of transmitter to set the ether in vibration with music and voice.

In 1917 Dr. E. F. W. Alexanderson designed a 200-kilowatt high frequency alternator, which made world-wide wireless possible. This was not the first radio frequency alternator, however, as Professor R. A. Fessenden of the University of Pittsburgh, in 1906, had invented such a device to produce continuous waves enabling a continuous radiation of energy, instead of power in short groups, as was done by spark sets. Fessenden's apparatus was installed and tested at Brant Rock, Mass.

AN URGENT NECESSITY

During the remainder of the war, and until 1918, I changed rather rapidly, as events com-



Wide World.

WHEN THE S O S COMES IN HANDY

The three masted freighter "Skolgrom" as it appeared to the crew of the S.S. "Roma" which responded to the radio distress call, 650 miles west of Gibraltar.

ing up directly after the great conflict proved. It was the urgent necessity for a short wave receiver to intercept the German short wave signals used in trench and submarine warfare that led to the invention of the super-heterodyne circuit by Major E. H. Armstrong of the American Expeditionary Force while in France. It was discovered that American vacuum tubes had too much capacity between the grid and plate for efficient use as radio frequency amplifiers on short wave lengths. The grid to filament and plate to filament capacities also caused trouble and this excess capacity created a short circuiting of the transformers used to couple the tubes. Radio engineers were put to work on the problem and the superheterodyne resulted.

In May, 1919, the United States Navy's NC-flying boats, in a trans-atlantic flight, made good use of the ether for communication to and from the ground stations and between each other. They were equipped with radio direction finders and found them extremely useful. I was radiated from antenna wires dropped beneath the machines and my messages flashed from the planes were picked up at Otter Cliffs, Bar Harbor, Maine, until the birdmen were close to the Azores.

After the war there followed the usual lull necessary for readjustment. Then came November 2, 1920, when KDKA, Pittsburgh, the pioneer broadcaster, radiated the Harding-Cox Presidential election returns to the countryside. The ether was heralded as a most useful medium for broadcasting news and I was overjoyed with the comments regarding this broadcast, because it showed that I had greater fields to conquer.

At that time there were two receiving circuits in general available to the public, or rather two circuits whose simplicity made practical their common adoption—the crystal set and the one-tube regenerative receiver. Naturally, these sets were home-made, because with the possible exception of five manufacturers who were making apparatus for the amateurs previous to the war, and who continued after the war was over, no one in the field was in the least prepared for the work of furnishing the instruments for broadcast reception. In this form I had appeared too suddenly—no previous warning was given and I swept the country like wild-fire. Radio gained in popularity as a medium of entertainment and won world-renowned musical organizations and artists of distinction to send their talent into millions of homes.

A DEAN OF THE AIR

Overlooking Washington from the Virginia side of the Potomac, on the southern corner of the Fort Myer reservation, is station NAA, the dean of American wireless. Hundreds of transmitters have triumphantly wafted Hertzian waves into space, only to fade out of existence after several years of service and most of their famous calls, such as "OHX," the old *New York Herald* station, are forgotten except by old-time knights of the wireless key.

But Arlington has broadcast faithfully, day in, day out, since it first went on the air back in 1912. The apparatus has been kept constantly up-to-date by continually replacing old equipment with new as rapidly as improvements have been made. So today the famous old spark transmitter and its big rotary gap, the pride of my life in "the good old days," have been replaced by the modern vacuum tube as a means of generating the electrical oscillations, which set the ether in vibration for the United States Navy, the owner of NAA.

Arlington is dedicated to service on land and sea. Daily from 11:55 A. M., to noon, and from 9:55 to 10 P. M., Eastern Standard time, the 2,650 meter waves radiated from Arlington, carry the ticks of the master clock of the nation in Washington, to mariners, to watchmakers and to thousands of homes. When time is broadcast each second's tick of the clock in the Naval Observatory forms a dot in the ether, which is reproduced by receiving sets as a shrill whistle-like note. The twenty-ninth second of each minute is omitted to make clear the passing of the half minutes. The last five seconds of the first four minutes are also dropped to denote the passing of the minutes. The last ten seconds of the fifth minute are not broadcast, leaving ten seconds of silence just before noon and 10 P. M., when a dash is radiated to signify the hour.

THE CHAMBER OF TIME

There are three standard clocks in a vault below the Naval Observatory building. An even temperature is maintained in this compartment and air currents are avoided by double doors, the outer entrance being closed before the inner door is opened, whenever anyone goes into this Chamber of Time. The clocks stand on solid piers so that no errors in time will be caused by earth tremors, and to insure further accuracy the master clock is sealed in a glass cylinder. The pendulums are of invar, a metal little influenced by changes in temperature. Thermometers inside the glass case show that the temperature varies less than one-tenth of a degree Fahrenheit in a year.

The clocks are wound electrically every thirty seconds so that no adjustments of the pendulums are required.

A timepiece, known as a "transmitting clock," is located on the first floor of the Naval Observatory, and by wire connection it actuates the sending apparatus at Arlington. The transmitting clock is set to the correct time by slowing or accelerating the pendulum by an electro-magnet, in accordance with the time of the master clock in the subterranean vault.

DISASTER AT SEA

Since Marconi lifted me out of the primeval state in which I existed for so many centuries, sparks have pierced the air with two three-letter combinations which have created more anxiety and thrills than any other vibrations. These are what man terms "distress calls."

Shortly after the initial transatlantic performances wireless was installed as a lifeguard and carrier of messages on board ships, and this led to the necessity of some call for help which could be flashed quickly when a vessel was in danger.

The first suggestion for an international distress signal was made by the Italian delegates at a preliminary meeting on wireless telegraphy at Berlin in 1903. The adoption of "SSSDDD" was suggested, but the final choice was left to a special conference. Shortly after this the Marconi Company instituted "CQD" as the first call for assistance.

IT'S A DANGER SIGNAL

I could not understand why they selected this combination because it contained letters comprised of more dashes than dots and therefore required more time to transmit. This is the way it happened. In my youth my promoters adopted a number of rules from the telegraph, which, on account of its higher state of development, was governed by regulations established by international agreements. Among the rules was a double-letter symbol used by the operators to rush traffic over the wires. The call "CQ" heard on the wire meant that the operator sending it desired everyone along the line to listen to the message he was about to transmit. The letter "Q" was used, because it is one of the least used in the alphabet and is therefore easily recognized. When "CQ" flashed through the air it was also a signal for all operators within range to stop sending and listen. It was important, but not a cause for alarm. But, if the sending operator added the letter "D" to "CQ" it became a signal of alarm, danger, distress, a plea for help. The Marconi Company issued a general order on January 7, 1904, establishing "CQD" as the official distress signal on and after February 1, 1904.

At the radio telegraphic conference held in Berlin in 1906 the German delegates suggested that "SOS" be used instead of "CQD," which required several seconds longer for transmission, and generally when it was necessary to use the signal, seconds were precious. German ships had previously used a general call "SOE," when they wanted to communicate with all vessels in their vicinity. Since the

THE SYMPHONY OF MIGHTY WATERS

Broadcasting the thunderous roar of Niagara with radio's "ear" suspended over the brink on the end of a bamboo pole.

letter "E" in the Morse code consists of only one dot, and therefore, is easily susceptible to loss in interference, the Germans suggested that "S" be used as the last letter in the combination.

Accordingly "CQD" was superseded in July, 1908, by "SOS," chosen as the distress signal by the International Radio Telegraphic Convention held at Berlin. The acts of the convention were not ratified by all nations until about a year later, so "CQD" remained in force long enough to prove the value of wireless when wrecks occurred at sea. It was on January 23, 1909, that I had my first real test as a life-saver when the steamship *Florida* and the *S.S. Republic* collided. Jack Binns the operator on the *Republic* released the call for assistance into space and within a few minutes other ships were on their way to render aid, with the result that all the passengers and crew of the *Republic* were rescued before she slipped below the surface of the sea.

Since that day waves vibrating with SOS have wafted through space and across the horizon to serve notice that a vessel was on fire, or torpedoed, torn by an iceberg, swamped by mountainous waves, drifting minus a rudder, or with engines disabled and the ship battered by wind and wave.

IN THE MIDDLE OF THE NIGHT

Then came April 14, 1912, one of the busiest and most thrilling nights in wireless history. On that date the *S.S. Titanic,* the pride of the sea, sailing in all splendor on her maiden trip to America, struck an iceberg in mid-atlantic and quickly went to a watery grave almost before I had a chance to call for help. It was then that the "CQD" blended into "SOS!" The big ship came to a sudden stop. It was 2:20 A. M.,—the dead of night, when the biggest of liners foundered in latitude 41.16 north and longitude 50.14 west.

She drifted for 34 miles before going down, four hours after hitting the iceberg. There were 2,223 souls on board and I was anxious for operator Philips to touch the key that would let me broadcast the call for help.

Shortly after the collision at 10 o'clock, on April 14, Captain E. J. Smith ordered that the distress call be put on the air and this is what the dots and dashes carried through the ether, "Come at once. We've struck a berg. It's CQD, OM."

A NEW PHANTOM

Then the junior operator, Harold Bride, suggested, "Send SOS. It's a new signal and it may be your last chance to send it."

So Philips interspersed "SOS" with "CQD" and the ether vibrated with, "CQD, SOS from MGY. We have struck iceberg. Sinking fast. Come to our assistance. Position Lat. 41.46 N., Long. 50.14 W. MGY."

My impulses were beginning to grow weaker and I realized that the current supply was being affected by the water entering the radio room. I succeeded in attracting the attention of other ships, including the *Carpathia,* the Leyland liner *California,* the *Virginia, Parisian* and the *Olympic.* But they were too far away and the *Titanic* went down too fast. I carried messages from these ships saying that they had turned in their course and were rushing full steam ahead to the scene of the disaster. Ere long the *Titanic's* apparatus was conquered by the sea and I was silent as far as the big ship was concerned. The operators had done their best at the key and lived up to the traditions of the sea by remaining at their posts until Captain Smith's orders to abandon ship were signalized by the piping of the Bosun's whistle and by word of mouth passed along the deck. It was a case of "Every man for himself." Philips was lost. Bride was picked up by the rescue ship.

BREAKING SAD NEWS

My calls brought the *Carpathia* to the scene of floating wreckage dotted with lifeboats and rafts, just as the dawn of another day lighted up the Atlantic revealing a real tragedy. It was a sad message that I carried from the *Carpathia* to the *Olympic* for relay to the land station at Cape Race, "Loss likely total 1,800 souls."

The rescue ship picked up 706 survivors and returned to New York, while the *California* remained to search the position of the disaster. The final figures disclosed that 832 passengers and 685 of the crew had perished.

Incidentally, CQD had no particular meaning such as "Come-Quick-Danger," nor does SOS mean "Save Our Souls" or Save Our Ship." The latter signal consist of three dots, three dashes and three more dots easily recognized among other calls and interference.

CHAPTER IV

ENROLLED FOR WAR

"Every one shall receive thy words."
Deuteronomy xxxiii. 3

WHEN intrigue and war swept Europe in August, 1914, the nations embroiled rushed to use the ether for communication, because unlike wires the invisible channels could not be ripped down by shot and shell. Waves radiated from the lofty towers at Nauen, Germany, announced to the world that war had been declared and that the War Lords were mobilizing millions of soldiers and sailors throughout the Old World for the bloodiest of conflicts.

German ships rushed for neutral ports to escape capture. The *Kronprinzessin Cecilie* with a cargo of $10,000,000 in gold, $1,000,000 in silver and 1,200 passengers was 850 miles off the Irish coast bound for Germany on August 4, 1914, when a cryptic message in code from Nauen told her skipper to dash for a neutral haven and to evade the British. The big ship swung in its course and made a mad dash across the Atlantic, surprising the inhabitants of Bar Harbor, Maine, by sailing unannounced into that peaceful harbor, which seldom protects ships of such large tonnage. The big ship was later seized by the United States Government and renamed the *Mount Vernon,* and later acted as a transport carrying thousands of troops across the sea.

It is violating no confidence to tell that all nations involved in the fray had receivers tuned to every wave length in order not to miss a single message. In fact it was unwise and dangerous to put anything of importance in the ether unless wrapped in secret code.

A GLORIOUS ACHIEVEMENT

Reports revealed since the war contend that the allied nations were masters of the German code just as much as the Germans themselves. In this connection the story is told how the

Russians, after the stranding of a small cruiser, discovered an iron safe sunk near the vessel, containing German secret documents, including a clue to the code, signal books and charts. This collection was increased in January, 1915, when the submarine U-31 was driven ashore at Yarmouth with all the members of its crew dead, leaving their code books and mine charts unguarded.

Lord Fisher, Admiral of the Fleet and First Sea Lord for the greater part of the war, said that the deciphering of the enemy's code by the Admiralty was one of the most glorious achievements in the war. Thus it can be understood that it was dangerous for a ship to use a transmitter. If it did, it might be betrayed, since a submarine could easily spot the location by means of a direction finder.

It must not be assumed, however, that because of the restrictions imposed upon it, the ether was of no use. There were times when silence was not absolutely essential, especially when contact was already established with the enemy. Tactical manœuvres of the battle fleets were made by utilizing my waves. One effective plan was to broadcast just enough power to carry the message to its destination and in that way it did not overspread a wide area and attract as great attention as would a loud signal. The Allies had to be careful too, because, the Germans might have deciphered their code by finding a key to it.

The Sea Lords found that in the case of a large fleet, the divisions of which are separated from each other and dependent upon intercommunication, full silence is difficult to maintain. It is understood that when the German fleet advanced on the east coast of England in 1914, the British learned of the movement through direction finders in time to meet the oncoming attack. The roof of the Admiralty building was a spiderweb of copper wires and all strategic points along the coast were listening posts, where operators were constantly eavesdropping in hopes of catching some signal from the enemy.

AN ENEMY IN THE SKY

The Germans did not get their direction finding stations in operation as quickly as did the British, and when the Teutons finally trained their finders upon the waves, they discovered that only in rare instances did they hear anything, because the Allies' vessels were restrained from using their transmitters and every precaution was taken to maintain absolute silence. Ships moved through the war zone like phantoms, camouflaged in color, with all lights out and with wireless silent!

The Germans used me more frequently to carry orders to airships and Zeppelins sailing at high altitude to drop bombs on England, and owing to the lack of practice on the part of the air pilots in making exact observations, the signals generally warned the British in advance that an attack from the clouds was impending. This afforded time to send up fighting planes, get the anti-aircraft guns into action and the populace had time to run into their cellars before the uninvited guests of the air arrived. In order to locate their own position, at times the airships had to take bearings on German stations, and this helped the British find the enemy in the sky when the transmitters flashed a message back to the Deutschland asking for a bearing.

When the German submarine first invaded the American waters it was a great puzzle why receiving stations never heard a message from the undersea craft. Finally it was discovered that they were talking on the 75-meter wave length, far below the range of American receiving instruments. Needless to say it was not long before the listening-posts along the Atlantic seaboard were tuning-in the short waves.

A WARTIME SOS

Many vessels and even fishing boats were attacked off the New England and Jersey coast and the toll of life and property was growing day by day because of the activities of submarines. It was found that the operators on the undersea boats would send an SOS and when a ship responded to the call at the given position the U-boat would pop up and torpedo the vessel. This led to the adoption of a wartime distress call in code, and an allied vessel would not respond unless the SOS was accompanied by the code, which was a four letter combination.

Early in the war several big transports were torpedoed and many others caught at least a glimpse of a periscope on the voyage toward the trenches. Some were of the opinion that German spies in America notified U-boats when the transports sailed so that they would be prepared to attack. This was discovered, and the ships after leaving port would lay off the coast perhaps for a day or more, before proceeding on their dangerous journey. When they were out from the shore for twenty-four hours they might get a code message from the big station at New Brunswick, N. J., telling them to change their course, because messages radiated from Nauen had ordered submarines to be in a definite position on a certain day, and apparently these instructions were based upon information that the transports had sailed. The Nauen orders were in code but once deciphered by experts in Washington they revealed their mission in advance so that a warning could be sent to the troop ships to alter their route.

The Germans had another trick which puzzled American listeners for quite a long time. When Nauen signed-off it would say "Walter Johnson" or some other name. What these names signified no one knew until finally an operator at one of the naval receiving stations discovered that each name was code indicating to submarines that Nauen would continue broadcasting, but on a different wave length. For example, "Walter Johnson" might mean that POZ, for that was Nauen's call, would stop sending on 12,000 meters and drop to 7,500 meters.

DESERT MOUNTAINS

"The same day we passed also near an island about four or five leagues long. . . . It is very high, notched in places so as to appear from the sea like a range of seven or eight mountains close together. The summits of most of them are bare of trees for they are nothing but rock. . . . I named it the Island of the Desert Mountains."

These words recorded in metallic letters and riveted to one of the thousands of rocks which make the Maine Coast famous for scenic beauty, give the first white man's impression of the barren island he had discovered. Little did Samuel de Champlain realize as he sailed along the rocky coast of the Pine Tree State that he had found a spot which in years to come would serve more superbly than any other place on the American continent as a connection in the turmoil of war between his native land and the country whose shores he was exploring; a country destined to serve and to fight as an ally to France in battle.

To the French adventurer the high rocky cliffs of Mount Desert Island seemingly appeared as merely a barren mass covered in places with pine trees, but when war ravaged France several centuries later, for four long years, it was this barren high notched formation in Maine, known as Otter Cliffs, which acted as one of the ears of Uncle Sam, keeping him in constant communication with his Expeditionary Force as it crossed the Atlantic, and with the battle fronts, and finally with the Peace Conference.

A MESSAGE OF FAREWELL

Think of the little sailing vessel of Champlain having passed nearly out of sight of the desert island he had seen for the first time, when a column of smoke curled skyward forming the farewell signal from some friendly Indian on the cliffs. Surely the Frenchman and his brave little crew observed the goodbye message despite the distance of their ship at sea, for the headlands of Otter Cliffs are the most abrupt and loftiest along the Atlantic seaboard from the St. Lawrence to the Amazon. Such lofty cliffs were ideal signaling stations for the Indians on the land, but a little vessel just a speck on the horizon was at a disadvantage for communication. In those days a visible reply to messages from the sea to the land was impossible over any great distance.

Time changes many things; the explorer has passed on with the smoke messages and the Indian, to an undiscovered country from whose shores no message has ever been received. The Island of Deserted Mountains, as far as topography is concerned, may still be seen as first observed by white men, but when the great world war spread over Europe, a new signal took the place of smoke in Maine, a naval clad radio operator replaced the Indian warrior, and a far different craft sailed the sea.

ENDOWED BY NATURE

The section of the Desert Mountains known as Otter Cliffs seemed to be endowed by nature to act as a most attentive ear for Uncle Sam, and it was there that a commission of radio experts of the United States and the allies chose to erect the tall steel towers and install the most sensitive apparatus with which to detect ether waves; and there assembled the best skilled wireless men in the country. The new warriors in navy blue had as their chief the late Alessandros Fabbri, the man who built the world renowned radio station, Otter Cliffs, through which most of the official communication between Washington and the trenches, the armistice meetings, and the Peace Conference was exchanged through the air over the Atlantic.

The passing of two hundred years had wrought a tremendous change in modes of communication and ocean transportation. In place of the slow sailing craft of an adventurer, one spring morning in the year 1918, just as the distant rays of the sun were beginning to color the eastern sky, a subchaser dashed boldly out of the cove to the channel which led from Bar Harbor to the open sea. The wartime speed of the little craft soon carried it far from the shore, smaller and smaller it grew, at times invisible in the troughs of the waves. Soon its gray hull became a tiny cork-like speck on the water. A sailor, the radio operator of Otter Cliffs, was watching it from his station on the shore. He pressed a key of highly polished metal and a new kind of message flashed into the air, "GB OM" (Good-bye Old Man)—a signal of dots and dashes originating as did the smoke message of yore from a spark, but the new form of signal was invisible as it sped through the ether to the little ship at sea.

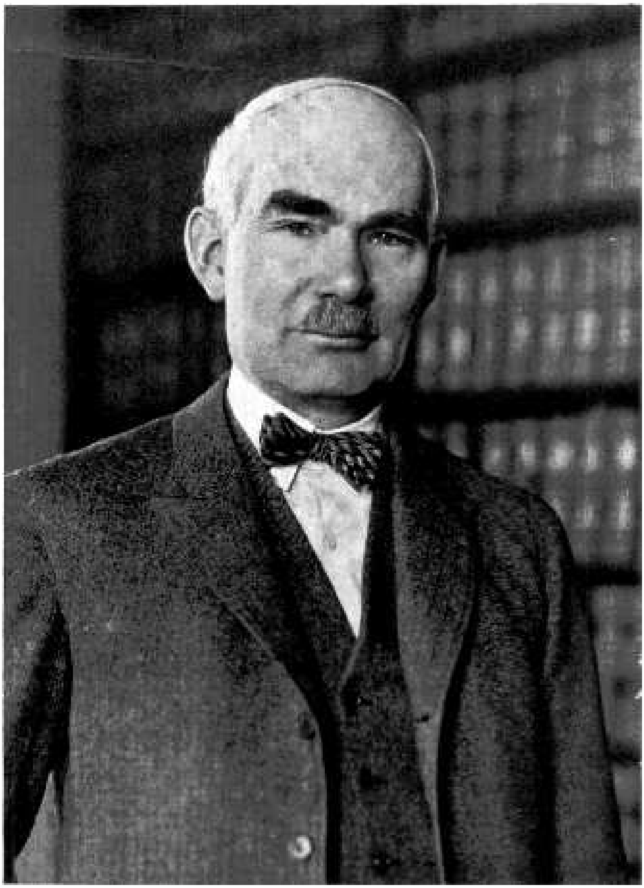
CHANGES WROUGHT BY TIME

Time showed that it could be kind in making its changes, for the land operator now received a reply to his signal of farewell while the Indian of the past neither observed nor heard an answer from the sea. Scarcely had the Otter Cliff naval operator bid good-bye to his seafaring pal on the subchaser and added the radio touch of affection, "Old man," when the sailor sent back his answer. This time the response from the Atlantic even surpassed the message from the rocky cliffs for there was music in the air! The subchaser had disappeared. Rumors were that it was bound for the port of Boston, but, in reply to the land's "GB OM," the electric impulses radiated from its aerial were in the form of music from a phonograph: "I May Be Gone for a Long, Long Time."

The stations' crew numbered some two hundred officers and men, a little naval village, made up of hospital apprentices, yeomen, machinist mates, carpenters, cooks, seamen, a marine guard and a radio force of seventy-five rated men, not trained while war was in progress because it takes a long time to develop a good receiving and transmitting operator. They were old wireless men, mostly amateurs who had trained themselves in the attics of their homes.

There were seven receiving stations, three of which were located in the main traffic or Morse building. The other four were little shacks painted green for protective coloring, placed in a clearing among the pines. On the door of each station was a sign indicating the origin of the signals being copied by the operators inside. The sign was removed if the transmitting station "went bi," that is, when it signed-off. At times of displayal however, it warned anyone near to be quiet so as not to interfere with the reception of the messages.

The first station bore the name "Lyons." It was in this little building that thousands of words during the war entered the United States from France. The most efficient operators could copy by hand or typewriter, at an average rate of thirty words per minute for a period of several hours. The best record of hand copying was 5,600 words during a six hour watch. Messages from Lyons, France, were not only recorded in this manner but when favorable atmospheric conditions permitted, a high speed or photographic machine, was used. The automatic receiver could picture from forty to one hundred words per minute, thus making it possible to complete the communication in much shorter time than by tedious hand copying. This high speed recorder, invented by A. Hoxie, an electrical engineer of Schenectady, N. Y., was based on a simple electrical engineering principle—a light weight mirror fluttering in electromagnetic tune with the impulses picked up by the receiving antenna. The length and dura-



De Forest Radio Co

DR. LEE DE FOREST

Inventor of the audion.

tion of the mirror's oscillations varied according to the extent of the dot and dash of the transmitting station. The mirror reflected a beam of light on a moving sensitized tape which was propelled through vertical pipes holding the developer and fixing chemicals. The time to record, develop, fix and dry was about three minutes. The tape was taken by messenger to the traffic room, where typewritten transcriptions were made and the Morse operator sent it over the land line to Washington.

WITH THE PRESIDENT AT SEA

The next shack in line contained the apparatus which listened to Rome, Italy; then came the station bearing the sign "Carnarvon, Wales," and next to that a little house with "Nauen" on the door looked almost like enemy territory. In this station Uncle Sam listened to and recorded the thousands of words which went into space from the powerful transmitter at Nauen, Germany. In one month alone over 77,000 words were copied, submarine orders, military messages, propaganda, pleas for an armistice and finally the acceptance of peace terms.

The next and last receiving station in the line was marked "Special," and it was here that all messages were received from the Presidential ship, *U.S.S. George Washington.* During the initial and second trip, messages were relayed via the convoy *U.S.S. Pennsylvania* and the *U.S.S. Mexico,* due to the fact that the ship with President Wilson on board was not equipped with an arc transmitter, and the spark apparatus was not strong enough to keep in constant touch with American shores and the White House. For the last trip, however, the *U.S.S. George Washington* had an arc transmitter installed and messages were sent direct to Otter Cliffs throughout the voyage. Late one day just as twilight was settling over the Maine mountains the *Washington* reported she was entering the harbor of Brest, and from that position a six hundred word message was received at Otter Cliffs on an aerial which resembled a clothes line rather than an important radio conductor, and not a single word was lost in the transatlantic transmission. The arc and spark were in the heyday of their glory. The vacuum tube was soon to replace them.

The spark station was one of the most interesting places on the reservation for it was through the instruments in the spark room that messages from the majority of transports and hundreds of other craft plying the ocean were received. The receiving set consisted of a Navy tuner and a three stage audio amplifier, used with a 300-foot antenna, supported by two steel towers, two hundred feet high. The transmitting set, with a power of 5 kilowatts was located at Sea Wall, Maine, twenty-six miles away. It was operated from the Otter Cliff's spark room by remote control. This system of transmission was resorted to in order to eliminate local interference with reception from European stations. If it was the desire of the spark operator to transmit, he would signal over a land line to the man on watch at Sea Wall, who would start the generator and shift to the desired wave length. A feature of this arrangement was that the sending operator at Otter Cliffs could listen in continually and hear his own signals, distress or general calls, as well as any others that might be directed to him.

During the war, of course, the spark station was more or less silent because the best policy in wartime was to be a good listener rather than a talker. The spark transmitters on the ships were silent too. If they stirred up the ether the direction finders on enemy submarines could easily judge their latitude and longitude. Silence was golden!

NEWS OF THE ARMISTICE

While the entire United States was celebrating the false rumor of the Armistice late in the day of November 7, 1918. Otter Cliffs knew nothing about it. To the men on the radio reservation in Maine, war was still in progress on the other side of the sea. Their ears had no definite news that an armistice had been signed. The dots and dashes from France for several days told of the proposed meeting in the woods near Spa, but the sunset of November seventh found Otter Cliffs without a report as to the result of the armistice gathering, while the rest of the country celebrated. It seemed as if the cables had scooped the ethereal route across the sea. On the happy day of November 11, 1918, the watches shifted at Otter Cliffs as usual, replacing tired ears with rested ones. Alfred Ball of Hubbard, Ohio, relieved the operator on the Lyons, France, watch. Shortly after Ball donned the receivers the mighty arc of Lyons broadcast a message of less than two hundred words and as the pencil moved across the naval message blank at Otter Cliffs it recorded the first authentic news to reach America that the war had ended. The last shot had been fired. Quickly the words formed by the French transmitter were put into code and forwarded over the land telegraph to Washington where the good news was released to everyone throughout the United States. Soon after the Lyons message had been received the operators on watch in the Nauen shack reported that Germany's transmitter had announced a general armistice on land, water and in the air.

HOMEWARD BOUND

When the transports began to return the triumphant troops to America the spark business increased many fold. My waves carried thousands of messages from soldiers homeward bound telling their arrival date and requesting that a big beef steak dinner or some favorite food be in readiness for the occasion. Hundreds of the other messages, mostly government, related to the number of men on board, time of arrival, quarantine cases and orders for supplies. Clearing the air of this traffic made the spark men the busiest operators on the Atlantic coast. When the big *U.S.S. Leviathan* with her thousands of homeward bound soldiers came within range her spark would say, "Hr 1000" or "Hr 1500" meaning that her operators had that number of messages on file for folks in America. The operator at Otter Cliffs would signal "QRV" (I am ready)—and the *Leviathan's* spark would begin immediately to peal forth the radiograms in groups of fifty. After several hours of continuous communication the "Mistress of the Sea" would signal "SK"—the end of transmission. Often it happened that as soon as one vessel had her radio file cleared up another would call for Otter Cliffs with "Hr 300" or "Hr 400." And so it went on day after day, the number of messages diminishing as the troop movement decreased.

THE WAR WAS OVER!

Late in June, 1919, the majority of troops had reached home, with the result that the messages from transports and from Europe could be handled by a smaller force. The game was about over. Like the last few minutes of the final period in a football game, when the reserve players begin to leave the field for the club house, June 25, 1919, saw the Naval motor truck of Otter Cliffs leave the radio reservation for Bar Harbor with twelve men bound for Boston Navy Yard to be released from active duty. It was shortly after noon that the sailors waved farewell to Otter Cliffs, but the last few minutes of the game were still to be played. The final whistle sounding the end of Otter Cliff's wartime history had not blown. Three operators sworn to strict secrecy were on watch in the little station which received the signals from Nauen, Germany. A certain message was looked for as is a touchdown in the final seconds of many a gridiron struggle. Soon after two o'clock that afternoon, before the first draft of operators to be released had left the Island of Deserted Mountains, the long looked for message fluttered through space from Germany to Maine—the ear of Uncle Sam. It was coded and rushed over the land telegraph to Washington. The Allies had scored the winning "touchdown"—the Peace Treaty had been signed at Versailles.

CHAPTER V

WITH PIONEER BIRDMEN

"Let thy glory be above all the earth."
Psalm lvii. 11

DRAMATIC moments in airship flights across the Atlantic have been made highly colorful by tidings which wireless brought in from the sea. SOS calls and bits of messages telling of an intrepid aviator's plunge into the icy waters of the North Atlantic have added the romance of early transoceanic flying and to the excitement of the ether's work.

The year 1919 stands out vividly in history for attempts to conquer the air lanes between America and Europe, perhaps because the World War developed the daring in birdmen. The spring of 1919, five months after the Armistice was signed, found Harry G. Hawker, an Englishman, and his companion Lieutenant McKenzie Grieve, on the banks of

Newfoundland studying weather conditions and getting their big Sopwith plane in shape to make a dash across the 1,950 miles of sea to their mother country—Britain. For many days rain, fog and adverse winds detained the biplane team at St. Johns.

On May 18, at 1:51 P. M., Eastern Standard Time, the shining plane circled skyward and winged its way toward its destination, Fermoy, Ireland. The lookout on Signal Hill, where Marconi picked up the first transatlantic signal, viewed the plane ten minutes longer than those gathered in the streets and on the housetops of St. Johns, and he heard the last faint drone of the motor as it sped the machine seaward at 100 miles an hour.

News that Harry Hawker had hopped off was sent by telegraph to the naval station NBD, Otter Cliffs, Bar Harbor, Maine, and operators were assigned to comb the ether for a spark from the Englishman's flying machine. All that day and night the naval radiomen carefully revolved the dials from wave length to wave length searching for even a faint whisper from the Sopwith pilots. But no dots and dashes came back from the flyers. Intensifying the anxiety, ships reported that they had caught no sight of the plane nor did they hear a signal from its transmitter.

GIVEN UP FOR LOST

The undercarriage and wheels, which Hawker dropped to conserve weight after getting into the air, were picked up by a schooner and towed to a Canadian port. Days passed without news of Hawker and Grieve. The world gave them up for lost and memorial services were held in London.

Three days after the aircraft had left Newfoundland vessels in mid-ocean reported a cyclone in which it was doubted if an airplane could fly without disaster. A bottle containing a message signed "Hawker" was picked up off Narragansett Pier. Surely the sea had claimed the pioneers.

Two weeks after the lookout on Signal Hill had seen the plane vanish over the sea, the Danish steamer *Mary* reached England with the two air pilots, having rescued them in mid-ocean on the day after they had departed from the Canadian coast. The *Mary* did not carry wireless and for that reason no word was heard from the aviators until the ship docked in Scotland. It was then that Hawker explained the silence of his plane's wireless voice.

The transmitter was designed to cover a radius of about fifteen miles. The wireless generator was driven by a small air propeller, but it proved to be too small and only a little amperage could be obtained.

Hawker said, "I was sending messages every half hour. My chief object was to let ships know we were still in the air. During the last few hours when the engine was throttled, the speed of the machine was not sufficient to drive the wireless and no spark could be generated, but I made an SOS every quarter of an hour on the off chance of the spark operating."

The Sopwith plane was later picked up in Lat. 49.40 North, Long. 29.08 West by the

American ship *Lake Charlottesville* and taken to Falmouth.

The next attempt to fly across the Atlantic was made by Captain John Alcock and Lieutenant A. W. Brown, both from England. They ascended from their aerodrome in Newfoundland at 12: 10 P. M., June 14, 1919. Sixteen hours and twenty minutes later they landed in Ireland and are recorded in history as the first aviators to make a non-stop flight between the New and the Old World.

A HATRACK IN IRELAND

On the night before they left Canada a reporter asked them where they hoped to land. Alcock is said to have replied that they expected to hang their hats on the aerial towers of the big wireless station at Clifden, Ireland. True to the prediction the plane almost struck the aerial masts as it came down and crashed into the mud. It was reported that they had a radio compass on board and had guided the plane according to the bearings taken on the waves sent out from Clifden. They did not try to send or receive messages during the trip, in fact there was no transmitter on board.

Two other transatlantic flights which proved the value of radio on aircraft were the transoceanic voyages of the U.S. Navy's NC-boats and the British dirigible *R-34*. The NC-planes were winging their way to Europe in a series of hops when Hawker was lost. The *R-34* crossed from England in July of the same year.

The NC-boats were equipped with radio telegraph and radiophone transmitters as well as direction finders. Weather reports were broadcast to the planes from the time they ascended at Rockaway until they reached Newfoundland, the end of the first lap in their trip. The *U.S.S. Baltimore,* stationed off the Grand Banks, sent weather forecasts to the naval radio station at Otter Cliffs, whence the messages were relayed to the seaplanes bound up the New England coast. As the flyers approached Canada the *Baltimore's* operator established direct communication with the planes.

FINDING A SEAPLANE

During the flight north from Rockaway, about four o'clock in the afternoon, naval operators at the shore stations noticed that the *NC-4* was silent and the sister ships in the air reported that they had lost sight of their companion. Radio compass bearings taken on the *NC-4* earlier in the day aided greatly in finding the airship about five o'clock the following morning, traveling under its own power on the surface of the sea off Chatham, Mass. The sister ships waited in Newfoundland and several days later the trio took flight bound for the Azores. Signals from the planes were heard at Otter Cliffs until the flyers were within one hundred miles of the mid-atlantic islands.

When the British dirigible *R-34* crossed the Atlantic in July, 1919, the fuel supply was fast becoming exhausted as it neared America. Urgent messages calling for assistance were detected at Otter Cliffs and Glace Bay, when the big bag was floating high over the Bay of Fundy. The "sub" chaser attached to the Maine radio reservation was loaded with fuel and sent across the lower end of the Bay to meet the *R-34,* and refuel it so the pilots could reach the Chatham air station or Mineola flying field on Long Island. Other vessels put to sea from the Boston Navy Yard. The "sub" chaser from Otter Cliffs talked to the airmen continually and after reaching the point where the huge air cruiser sailed overhead, about 100 miles off shore, the British operators reported that they could reach Chatham for refueling if necessary. The "sub" chaser returned to Bar Harbor and the *R-34* sailed south, finally arriving safely at Roosevelt Field on Long Island. It later made a successful return trip to its home port in England.

ANXIETY RELIEVED

The voyage of the *ZR-3,* renamed *"Los Angeles"* after its arrival in the United States,

DRAMATIZING EVENTS OF THE DAY

Broadcasting radio drama; "The March of Time" goes on the air with sound effect machines to inject realism into the performance.

gave radio another opportunity to demonstrate its usefulness to transatlantic aviation. On this occasion, Hertzian waves spread high over the sea on the 1,510 meter wave length furnished bulletins for shop windows in German towns and cities, keeping the nation posted regarding the big Zeppelin's progress.

America, too, learned of the airship's approach. As soon as the *ZR-3* departed from its hangar in Germany the ether enabled its crew to maintain communication with the powerful station at Nauen, and as dispatches were received they were relayed to the United States on the 12,600 meter wave.

As the Zeppelin sailed through the sky messages were exchanged with marine operators below. The *ZR-3's* wireless man after landing at Lakehurst, N. J., told how the airship flew over a British vessel and inquired the steamer's position. The reply indicated that the airship had drifted about sixty miles southward of the assumed course. The route was shifted accordingly and soon the Island of San Miguel was sighted.

THE LIGHTS OF BOSTON

Shortly after the Zeppelin passed the Azores messages relayed by ships were detected at receiving stations along the Atlantic coast more frequently. The powerful transmitter at Chatham, Mass., established direct communication with the operators in the sky, and as the big ship shifted its course toward Newfoundland the navy station at Otter Cliffs talked back and forth with the Germans. As the hours slipped by, the increased intensity of the signals radiated from the sky was an indication that the airship was nearing the American coast. Then broadcasts told that the *ZR-3* was skirting Nova Scotia; later that it was passing Seal Island and headed toward Boston. The next reports described the lights of Boston disappearing in the early morning mist and notified listeners that Cape Cod was looming up ahead.

Station NEL, Lakehurst, N. J., picked up the dispatches from the *ZR-3* at 3:15 A. M., on the day scheduled for its arrival at the Lakehurst air-port. Numerous stations along the coast called to the airship and the German operator told them that he did not have time to answer all of the stations. At 5:40 A. M., the Lakehurst operator asked when the ship would land and this was the answer, "Zed Rogers three will arrive between 9 and 10 A. M." This was on October 16, 1924.

The Zeppelin used the call letters NERM assigned by the Department of Commerce. The main transmitter had a power of approximately 400-watts, several hundred less than that of the average broad-casting station. But because of its lofty position in the air, and over the sea, where there are no obstructions such as steel buildings, electric wires and trees to absorb energy, the waves could cover 1,500 miles under favorable atmospheric conditions. The long range of the 400-watt transmitter was revealed at the time New York receiving stations picked up code signals direct from the *ZR-3* when its operator asked the *S.S.*

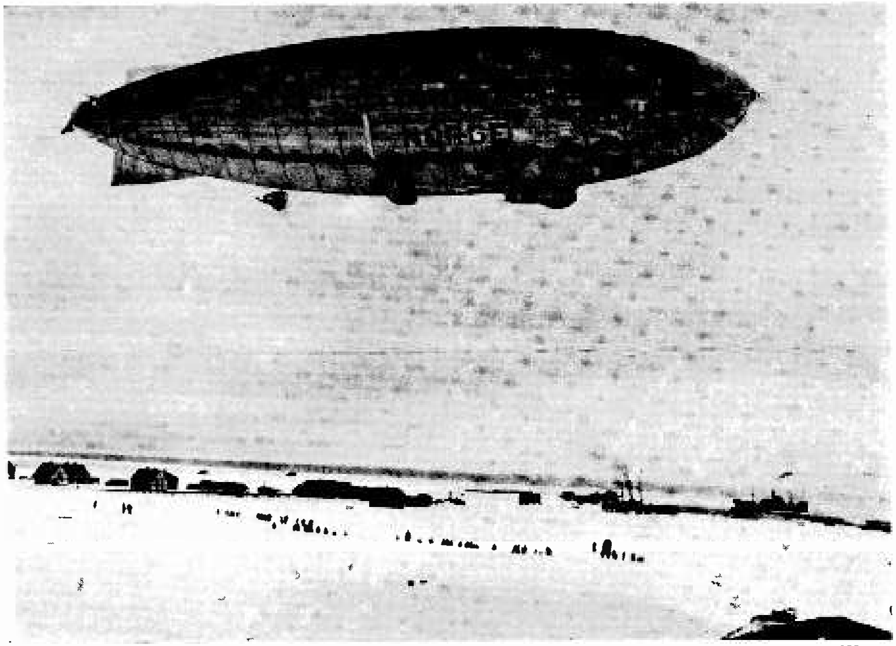
Stuttgart radioman, "How are you getting me?" The airship was then two days out of New York.

These messages sent down from the clouds throughout the trip made a sharp contrast with the long silence that led many to believe 432 years ago that Columbus and his little fleet of caravels had reached the end of the world and dropped off. Unlike the ships of Columbus, the *ZR-3* maintained communication with its native town, Friedrichshafen, after the dirigible had turned its back on Cape Ortegal, the northwestern tip of Spain, and was soaring far out over the sea.

SERVICE IN THE CLOUDS

Leo Freund, the *ZR-3's* radioman, explained that radio had proved one of the most essential parts of all equipment on the transoceanic flight, because it enabled communication with vessels and land stations to be maintained throughout the voyage.

"Picture yourself," said Freund, "in an air-



Wide World.

THE *NORGE*

The first radiogram sent from the North Pole was radiated from the aerial hanging below the "N" near the bow of this ship.

ship for three days sailing over the ocean, and the navigator, unable to make use of his sextant to determine the position, not being able to see the stars, sun or moon. It would be dangerous to make a trip of this length without radio apparatus. With a radio you can determine the exact point of the ocean above which you are located by establishing communication with a sending station either on land or on a ship at sea. By means of a radio direction finder the Zeppelin can determine its exact position by obtaining a bearing from a station on a line with its progress forward."

SIGNALS FROM THE POLE

There is a tide in the affairs of the ether as well as in the affairs of men, which if taken at the flood leads on to victory. May, 1926, was a month of golden opportunity for me, and it was fitting that I should link the North Pole with civilization before I celebrated in December the silver jubilee of my crossing the Atlantic.

A real opportunity to prove my value as a carrier of news from even the most remote spot on the earth came when it was announced that aviators would wing their way across the top of the world and that they would use the ether to run their news dispatches back to newspaper offices where the machinery was in readiness to put the words in print to make one of the most interesting stories ever written!

You may have greater appreciation of the part radio played when you are reminded that it took Admiral Robert E. Peary 153 days to reach the northernmost telegraph station at Indian Harbor, Labrador, after he and his colored follower, Matt Hanson, stood on the top of the world on April 6, 1909. Peary did not utilize the ether waves because wireless was not sufficiently developed at that time, hence the delay of 153 days in his announcement. I was just a husky infant in those days, but much too heavy and cumbersome to be dragged across the ice.

A VIVID CONTRAST

It was on September 6, 1909, that Peary reached Indian Harbor after his long march to the Pole and back. Upon arrival he sent this message by telegraph to the *New York Times*: "I have the Pole, April 6th. Expect arrive Château Bay September 7th. Secure control wire for me there and arrange expedite transmission for big story."

In contrast with this, seventeen years later, I brought the first dispatch from the northern axis of the earth to cities and towns thousands of miles away and in less time than is required to wink an eye.

Lieut. Commander Richard E. Byrd, of the United States Navy, was to fly to the Pole from Spitzbergen in an airplane named *Josephine Ford,* and Roald Amundsen and a party of explorers were to sail over the northland in a dirigible, the *Norge.* It was a race to see which one would reach the goal first and I was to furnish the communication for both expeditions.

The *Chantier,* Commander Byrd's base ship, was equipped with short wave equipment and a standard commercial transmitter, both of which kept the ship in touch with coastal stations, other ships and amateurs, without any difficulty on the trip from New York to King's Bay.

When the *Chantier* proudly crossed the Arctic Circle and entered the land of the Midnight Sun the ether acted as if under the influence of a tonic. The 40-meter waves had no difficulty in flying back to New York to report the progress of the expedition. However, the 20-meter signals did not give as good account of themselves. They behaved badly and failed to reach their destination in the States, although English and Belgian amateurs reported that they were very strong. There was no luck on 13-meters and no signals were heard below 18-meters throughout the entire trip.

NO SIGNS OF LIFE

Inasmuch as the *Josephine Ford* was the first airplane to dash up to the top of the earth and back it is interesting to know what sort of a "voice" was used to set the ether in motion as the airmen sped northward with the deep drone of the high powered engines and propellers disturbing the dead silence of the arctic, which had known only peace and quiet since the creation of the world. There were no signs of life. I was glad that my waves could pass through the polar sanctity without causing even a ripple or a whisper, in the white, peaceful beauty of the Northland, which Nature seems to hold so sacred, clothed in its robes of purity.

The transmitter and receiver naturally had to be compact. The vacuum tube was designed to furnish 50-watts of energy to produce the waves, which were to rush silently through the bleak, cold air, back to the *Chantier* with tidings of success, or failure, and in the latter event in the form of an SOS. The power plant consisted of a wind-driven generator equipped with a special hand gear to be used in case of a forced landing on the icy wastes.

It all weighed about 50 pounds, and occupied less space than a can of gasoline.

The receiver was a portable type and could tune in waves from 10 to 200-meters, but could only be used in case of forced landing, as ignition noises stirred up by the engines while the plane was in flight caused too much interference.

A COMPETITOR APPEARS

While preparations were being made at King's Bay for Byrd's dash, the *Norge* loomed up on the horizon, its dark hulk silhouetted against the white background of Spitzbergen. The *Josephine Ford* realized that she had competition. The race was on! Byrd's plane could develop much greater speed than the clumsy dirigible. The airplane could fly to the Pole and back in the time needed for the *Norge* to reach the goal. Taking no chances that this flight might emulate the race between the hare and the turtle, Byrd rushed final preparations. The plane taxied down the icy pathway and leaped into the air before the dirigible had a chance to leave King's Bay. This was on May 9, 1926. The plane disappeared. The anxious crew of the *Chantier* and also the men of the *Norge* awaited ethereal news from Byrd and his pilot, Floyd Bennett.

The *Chantier's* radiomen listened intently on the 44-meter channel, an invisible thread of electric energy strung through the cold, polar air, on which they were hopeful of hearing glad news. But no news is said to be good news, so they had to live patiently with that in mind, until Byrd and Bennett had a chance to operate their transmitter. They were busy at the controls, and it took most of one man's time to keep the tanks filled with fuel. Finally, Bennett had a chance to reel out the antenna wire. Then he pressed the key and the tiny transmitter showed signs of activity. Up and down the little key moved, forming the dots and dashes. I leaped off into space from the trailing wire and rushed back to the antenna hung between the masts of the *Chantier* harbored in the ice of King's Bay.

HISTORIC DOTS AND DASHES

This is the message I carried: "We are making fast speed and are about to pass Amsterdam Island." This cheered the crew of the *Chantier* because it meant that the plane was well under way.

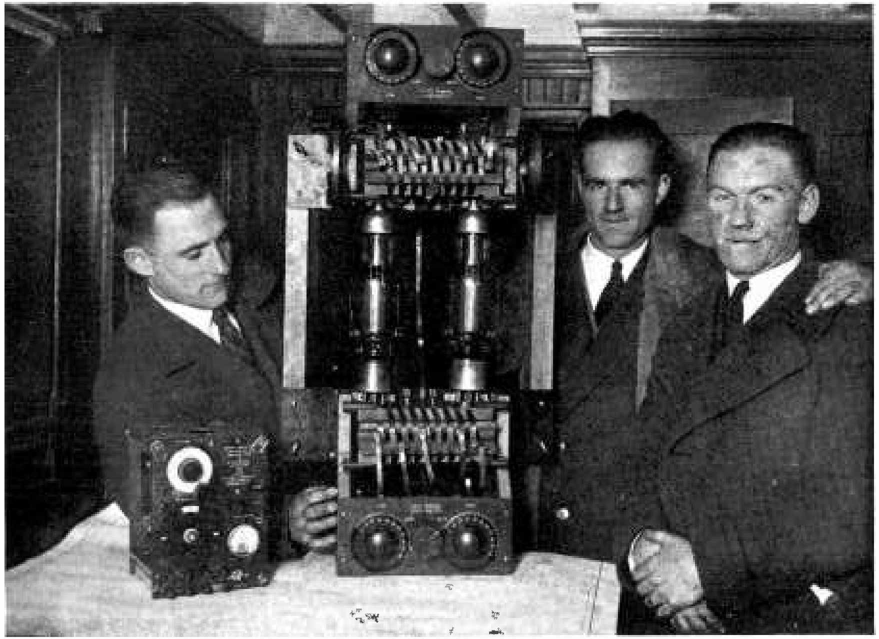
Then came the message: "We are eighty-five miles due north of Amsterdam Island; got over ice pack just north of land."

The plane was travelling rapidly, so every few minutes furnished news for another report. The next dispatch read, "We are 240 miles due north of Spitzbergen."

Then the ether flashed, "We are 230 miles from the Pole. Nothing but ice everywhere; no signs of life; motors going fine."

Next was the message of messages, "We have reached the Pole and are now returning with one motor with bad oil leak, but expect to be able to reach Spitzbergen."

This was a signal of a wild celebration on board the base ship and all eyes were ready to catch sight of the pioneers coming back



Wide World.

VOICES FROM THE LAND OF THE MIDNIGHT SUN

The tiny transmitter on the left was used on the plane that carried Commander R. E. Byrd to the North Pole. The larger set was used on board the base ship, Chantier, whose operators are at the right.

through the air from the one point on the earth where there is no north, east or west—all is south!

Transmitters at King's Bay kept the ether busy flashing dispatches to more powerful wireless voices in Norway, that had sufficient power to shout the news across the sea. The most notable message of all, flashed to the *New York Times* said, "Byrd returned four twenty Greenwich welcomed Amundsen, Ellsworth, population Kings Bay pitchpins." The last word "pitchpins" was code to indicate that the plane had actually reached the Pole.

BOUND FOR ALASKA

Only a few hours passed after the triumphant landing of the American aviators, when the *Norge* slipped out of its hangar and vanished in the direction of the far North. It was not long before the radio expert, Captain Birger Gottwaldt, began to operate the key, which released cryptic bits of news from the 300-foot antenna dangling through an insulator in the cabin deck. The first dispatch told that the big ship was flying north of Danes Island. This was at 10:40 A.M., May 11. Throughout the day the ether brought back news of the progress, so that newspapers could print a running description of the advance northward.

Then on May 12 at 1:00 A.M., I rushed a message south to King's Bay, thence to Norway and across the sea to the *New York Times.* It was the first message ever sent direct from the North Pole! The wireless reported; "North Pole, Wednesday, May 12, 1:00 A.M. (on board the dirigible *Norge*). We reached the North Pole 1:00 A.M., to-day, and lowered flags for Amundsen, Ellsworth, and Nobile."

Several hours passed and the waves carried this more detailed account through the polar air and across the Arctic Circle: "Lowering the three flags, Norwegian, American and Italian, when the *Norge* was over the North Pole, was the greatest of all events of this flight. Riiser Larsen's observations showed that we were over the Pole. The *Norge* descended and speed was reduced, when the flags were lowered over the wastes whose edges gleamed like gold in the pale sunlight, breaking through the fog which surrounded us. Roald Amundsen first lowered the Norwegian flag. Then Ellsworth the Stars and Stripes; finally Nobile, the Italian flag."

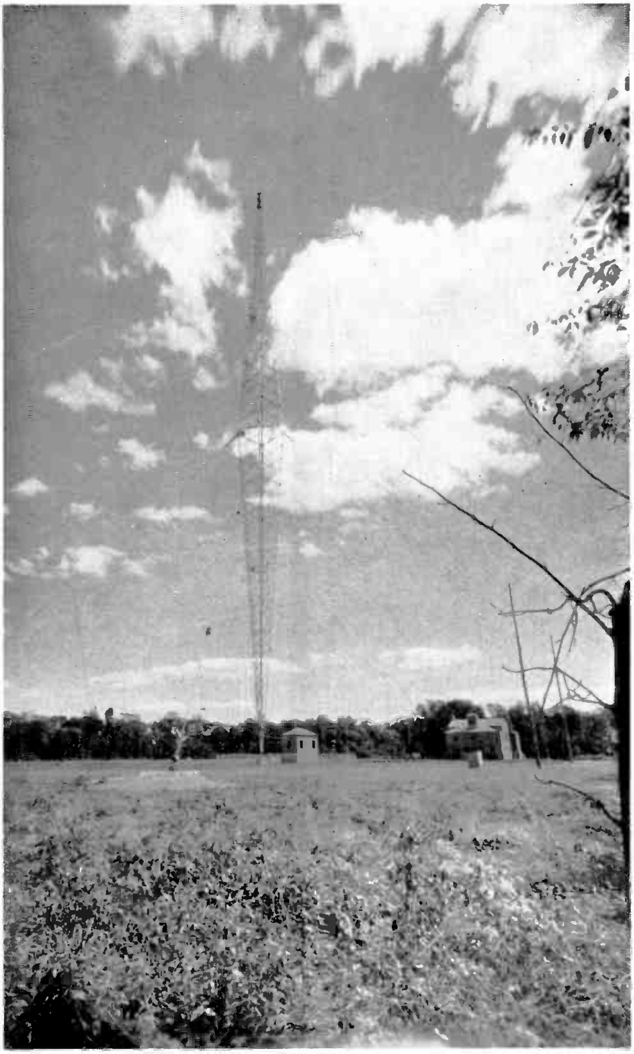
So faithful were the waves that newspapers printed maps showing the advance of the *Norge* hour by hour, making a vivid contrast with the long silence of Admiral Peary after he vanished from Cape Columbia to begin his 423 mile hike over the ice fields of the arctic.

LOST IN THE ARCTIC

Soon after the *Norge* encircled the top of the world and resumed its journey on over the "undiscovered continent" toward Alaska, icing down began and it was impossible for the operator to transmit or receive, because of an ice coating on the aerial and windmill screw that nearly stopped the charging of the batteries. The aerial bumped on the icy wastes below when the big ship went down to a low altitude in an effort to find her position. I was unable to carry a message south to civilization where the press reported no word from the *Norge* and some were beginning to think that the big craft and its crew had dropped, possibly to perish after their triumph in crossing the Pole.

Sixty-one hours after leaving King's Bay, Gottwaldt heard two Alaskan stations and trained his direction finder on them. Ten hours later the *Norge* came to earth at Teller, Alaska, with a crew safe and happy. The flight from King's Bay to Teller required 71 hours. But there was so much ice on the wires before the ship landed that I could not get off into space with a message. As soon as they landed an old spark station at Teller was fixed up and communication was established with Nome, Alaska, twenty-four hours having elapsed since the dirigible nestled close to the earth and slid across the icy fields.

This is the first message that I carried to Nome on May 15: "*Norge* landed on Thurs-



A JUMPING OFF PLACE

The modern broadcast aerial is a vertical mast which radiates the waves in place of the old-style wire aerials stretched between two towers. This is the 620-foot mast of WABC at Wayne, N. J.

day, May 13, at 8 o'clock in evening, Alaska time, (3 A. M., Friday, New York time), at Teller, 91 miles west of Nome after 71 hours of flight from King's Bay, Spitzbergen and across North Pole. *Norge* will be demounted here. All crew are safe."

This message was directed to and made public by the *New York Times,* and was signed by Lincoln Ellsworth, the American member of the expedition.

Transatlantic flights seem to come in eight year cycles. It was in 1919 that a flock of birdmen gathered in Newfoundland, but there was an absence of this type of bird until 1927 when they appeared again on flying fields on Long Island and France. Captain Charles Nungesser, the French Ace, who distinguished himself in the World War, and Captain François Coli, hopped off in their biplane *White Bird* at sunrise on May 8 from the LeBourget flying field. They discarded radio to save weight. The *White Bird* sailed away from the escorting planes over the English channel. Several hours later observers in Ireland reported that the French albatross was seen flying northwest bound out over the sea. That was the last seen of the *White Bird*. The two intrepid pilots were lost. The world at large and the searching parties regretted that the plane carried no radio transmitter to send out a clue where the craft alighted on the sea.

Twelve days later, on May 20, at 2:30 o'clock in the morning, preparations were being made at Curtis Field, L. I., for Captain Charles A. Lindbergh to take-off in his Ryan monoplane *Spirit of St. Louis.* Shortly after dawn the lone flier vanished in the East, bound over the Great Circle route with no radio to send an SOS should the sea claim him as it did Nungesser and Coli. Fortunately he won the battle with fog, sleet and distance and landed 33½ hours later at Le Bourget Flying Field on the outskirts of Paris where 150,000 people gathered to cheer the conqueror of the Atlantic.

On June 3, the Bellanca monoplane, *Columbia,* with Clarence Chamberlin as pilot and Charles Levine as passenger, took off from Long Island headed for "somewhere in Europe." Late the next afternoon the *S.S. Mauretania,* about 300 miles off Land's End, England, reported by radio that the *Columbia* had circled around the big ship and then dashed madly off toward the continent. After 42 hours in the air the plane was forced down at Eisleben, Germany, because the fuel supply was exhausted. The plane had flown 273 miles further than Lindbergh and was the first to travel over the air route between the United States and Germany. There was no radio equipment on the plane, despite the fact that apparatus was originally installed; it was discarded to save weight.

On June 29, 1927, the *America,* a three-motor Fokker monoplane, flown by Commander Richard E. Byrd and three companions, hopped off from Roosevelt Field for a trip to Europe. The plane carried an elaborate radio installation featuring an automatic transmitter which flashed the call letters WTW at regular intervals, when the operator was not sending messages. This afforded a running story of the machine's progress, since ships at sea could report hearing the signals even though dense fog prohibited them from seeing the plane. When the plane approached Paris it was lost in a thick fog and a rain storm that made it impossible to land. Radio messages, however, told that the craft was in the air over France. It also said that the compass was not working. Finally, lack of fuel to continue in the air after 43 hours forced a landing on the sea off the shore of Ver Sur Mer, France, and Radio instantly flashed the news to America that the airmen were safe. The daylight range of the transmitter on this plane was 1,000 miles in communicating with Roosevelt Field and 1,600 miles with Chatham, Mass., a new record for radio communication from an airplane.

CHAPTER VI

SECRETS OF MARCONI'S MAGIC

"Let us cast off the works of darkness,
And let us put on the armor of light."
Romans xiii. 12

As I pause today to review my growth it is less appalling to me that the the public did not accept wireless as more than an inventor's dream, or the working of his imagination. When one stops to think of the claim of one man, and a stranger to most of the world, that he can actually stir-up a wave motion across 3,000 miles of space and talk through the air without wires, it is difficult to believe, and it would be doubly hard to conceive, if no such communication had been effected previously. Radio was magic in those days and Marconi was the magician. He knew how he did the trick, just as the stage magician knows how he can take a live rabbit or a bouquet from an apparently empty hat! Few in the world's audience could see how Marconi picked messages out of the air, and invisibility is the very soul of the art of magic. The public would have to hear the clicks of the dots and dashes, as did Marconi and his companions, before they could be convinced that the sending machine was not "down cellar," or hidden in the "scenery" instead of being on the other side of the earth.

Famous magicians have died without revealing how they did their marvelous tricks. However, unlike the actor who cherishes his secrets and takes them to the grave, I am going to tell you how Marconi, the master magician of the ether, snatched me from the air, and you will conclude that this wizard had absolutely nothing up his sleeve.

IT'S SIMPLE

Ethereal radiations are like other types of waves, including heat, light, water and sound, in that they are produced in a medium which will vibrate or oscillate when disturbed. All waves are vibratory motion. The water wave analogy is a good one to explain the action and formation of radio waves because it is much easier to understand things that can be seen. Picture a pond of smooth water as the ether of space. When a stone is thrown in the water, it starts a series of ripples or waves, which spread in all directions, but at a speed sufficient to cover only a few inches a second. If there are any little pieces of wood floating within range of the waves, they bob up and down as the waves strike them. These bits of floating material may be contrasted to receiving sets, because both intercept the waves and are affected by the wave motion.

DO YOU KNOW?

Hertzian waves, as well as waves of light, heat, sound and water travel in ever-increasing circles. Incidentally, do you know this is why the seats in a theatre are usually arranged in a semicircle? Heat from a fire also radiates in all directions from its source. The farther one moves from the fire the less intense is the heat. The waves of light, heat, sound and those of the ether become weaker and weaker as they travel out from the source.

A match will create heat and light waves; a cricket will stir-up sound waves, and a pebble dropped into a pond, or a puff of wind, will set the water in motion. However, to produce radio waves it is necessary to have an electrical circuit carrying a vibrating, or, to use the electrical term, an alternating current capable of setting the ether in motion. A condenser, two or more sheets of metal, separated by an insulating material called the "dielectric," serves as the basis for putting me into action just as a match will start a fire. One of the metallic plates requires a positive charge of electricity and the other plate a negative charge. These two plates are connected by a conducting wire and a discharge takes place, giving rise to radio frequency currents, or ether waves.

The aerial and the ground form the enormous condenser. The aerial acts as one metallic plate and the ground as the other plate, with the air between serving as the insulating material. When connected with the transmitting apparatus, this big condenser receives an electric charge which it quickly discharges, setting the ether in vibration, and the effect created is similar to that of the stone striking the water.

Behind all this is the microphone in the studio which picks up the music and sends it in the form of electric current over the wires to the apparatus room, where amplifier tubes give it increased strength; modulator tubes vary the current in accordance with the sound vibrations, and power tubes give it impetus, which sends radio frequency currents into the aerial wires. Then the large condenser formed by the aerial and the ground gets into action and the waves shoot out in all directions at the speed of sunlight.

FROM CREST TO CREST

Despite their velocity, the invisible waves maintain a certain distance between each other. The distance from the crest of one wave to the crest of the wave ahead or behind is called a wave length. If the distance from crest to crest is 500 meters, then the station is said to operate on the 500 meter wave length. A meter is equal to 39.37 inches.

The distance the waves travel does not depend upon the length of the wave; that is, a wave 15,000 meters long will not necessarily travel farther than a 20-meter signal. Wave length has no more to do with the area a transmitter will cover than the distance from the crest of a wave in Boston harbor to the peak of the preceding wave has to do with the mileage across the Atlantic. The power of the transmitter and the sensitiveness of the receiving instruments govern to a great degree the distance the signals may be heard, and atmospheric conditions also play an extremely important part in facilitating or retarding the flight.

You will observe that the larger a stone and the greater the force with which it strikes the surface of a pond, the larger will be the waves. In the case of radio the more amperes in the aerial circuit and the greater the pressure in volts between the aerial and ground, the more powerful will be the waves.

When a Hertzian wave strikes an antenna in tune with its particular wave length, a current corresponding to the transmitter's current, but of decreased intensity, is induced in the wire. The receiving instruments put the auditor in tune with the incoming waves; that is, by varying the amount of wire on the coils and the capacity of the condensers, the wave length, or frequency, of the receiver is made most responsive to the wave length of a particular broadcasting station. The receiver and transmitter are then said to be in resonance, or in tune. It is interesting to note at this point that the human ear cannot hear all frequencies. Those below 10,000 cycles are known as "audio frequencies," because they are normally audible to the human ear. All frequencies above 10,000 cycles are termed "radio frequencies." It is the duty of the detector to convert, or rectify the incoming high frequency wave to a frequency low enough to actuate the phones and produce sound audible to the ear.

'MIDST ARCTIC LOVELINESS

The fact that the ether is invisible has surrounded radio with mystery and men have traveled all around the earth in an effort to verify a host of theories relative to how the waves travel, high in the air or close to the earth; why concerts fade; how to get rid of the greatest bug-bear, static, and where it enters the ether's system. So far the radio doctors have found no cure which will separate radio from the electric splashes created by Nature in the clouds. These research men have sought to determine what effect various factors have upon radio, such as moonlight, the aurora borealis, sunlight, fog, rain, snow, cold and heat.

Dr. Donald B. MacMillan, Arctic explorer, spent fifteen months in the polar regions from June 23, 1923, to September 20, 1924, and he brought back with him data of intense interest regarding the action of

Hertzian waves north of the Arctic Circle.

Many radio followers have been of the opinion that the ether is at its best as a communication medium in the cold air of the Northland, but they are mistaken as Dr. MacMillan's observations revealed the truth: "Static was bad, especially during terrific magnetic storms. Some of the disturbances were so violent that the magnetic needle traced like a scribbling pen across the record sheet."

THEY ALL GO SOUTH

Contrary to the theory that the Northern Lights conquer radio, Dr. MacMillan said, "The aurora borealis apparently has no effect on radio transmission or reception. We even passed right through the aurora belt and it did not trouble the radio waves in the least. After we passed through the aurora belt the display was no longer northern lights, as the wavering ribbons of light shifted to the southern sky."

MacMillan's ship, *Bowdoin,* was in the

land of continuous darkness for four months and in continuous daylight for four months, therefore, he had an excellent opportunity to notice how radio performed in the icy region of the world.

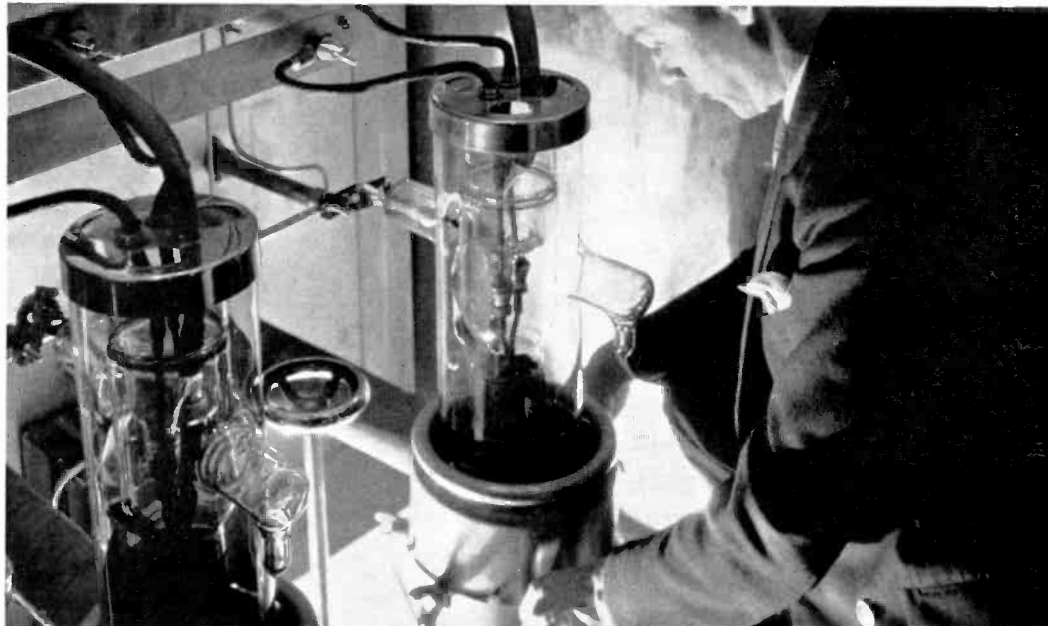
When asked how the two arctic seasons affected the ether waves Dr. MacMillan said, "We heard hundreds of amateurs, many of the powerful transatlantic commercial stations and broadcasting stations in Chicago, Davenport, Los Angeles, Omaha, Oakland and Alberta, during the period of continuous night, but as soon as the sun appeared and circled around and around, day and night, never vanishing from view, we were cut off from the world, because radio faded badly. From the time we sighted Greenland until we arrived at our winter quarters, signals from stations west of the Mississippi river increased in strength, while those along the Atlantic seaboard disappeared. Transmission and reception was best in the southwest direction. The East was 'dead' for us."

TRAVELING EAST

International broadcasting tests seem to indicate that the west to east transmission is the most favored by natural conditions. The exact reason is a subject of speculation. American stations are heard more frequently in Europe than the foreign waves are heard on this side of the Atlantic. The British transmitters do not reach out as far across the Atlantic as they do across the Continent of Europe. It is a rare instance when music radiated from a European aerial reaches America, but the listeners in the British Isles often intercept programs from the United States and Canada.

This has prompted the contention on the part of several that radio travels east with greater facility than west, because the speed is retarded by gravitation, reducing the east to west velocity from 186,000 miles a second to 165,000 miles. Others have suggested that the rotation of the earth really slows-up the broadcast when it travels from east to west, counter to the rotation of the globe. It is assumed by some that the waves have substance and weight, and, according to this theory, the movement of the earth in revolving toward the east serves to strengthen and improve the signals traveling in that direction. More light is cast on this theory by the observations of French experimenters who noticed that messages radiated by a powerful transmitter at Lyons, France, traveled easterly, and over-land, to be intercepted at Shanghai without any difficulty, whereas, the same waves were appreciably weaker when detected at Washington, D. C. The distance east from Lyons to Shanghai is about 8,000 miles, while the distance from France to Washington is less than half as great.

A comparative research by the Marconi Wireless Telegraph Company, Ltd., extended over a period of three years and culminating in a cruise around the world, revealed superior transmission from west to east. On the other hand observations made in New Zealand by means of loop antennæ showed that broadcasts from Nauen, Germany, appeared to



GLASS "BOTTLES" FULL OF TREMENDOUS ENERGY

Station WLW, Cincinnati, uses twenty of these giant 100,000-watt tubes in the mammoth 500,000-watt transmitter.

travel by way of the South Pole, while waves radiated from aerials at Hanover, Germany, seemed to arrive by way of the North Pole. In this connection Marconi once remarked that he did not believe that the waves in spanning long distances retain their direction in one great circle, but reach the receiving stations from various ways around the earth.

A series of tests conducted by engineers of the American Telephone and Telegraph Company, indicated that the earth's rotation has no effect upon the speed of radio. If anything affects the velocity, it is believed by experts to be the resistance offered by the air, the conditions of which vary from hour to hour, and from day to day. Experts say that the problem of resistance is so complicated that a slowing down of the speed may readily be accounted for by the resistance offered by the medium through which the waves pass.

On theoretical grounds there is every reason to suppose that Hertzian waves are physically much the same as light waves and that their action is similar. The speed of light, however, is maintained in traveling through the emptiness of space, which offers no resistance until the light rays enter the atmosphere of the earth. Practically all mediums tend to retard the speed of light, and it is concluded that this action is the same on radio. In fact, it has been found that electro-magnetic waves are slowed down by the resistance of some mediums to one-third their speed. In traveling direct through the air between New York and San Francisco the broadcasts apparently travel at the speed of light, but when the impulses are conducted through an underground cable their speed is retarded as much as 50,000 miles a second.

Broadcasts across the surface of the earth move through a stratum of air varying from ten to thirty miles above the earth's surface This air is a medium offering varying degrees of resistance, depending to a great extent upon atmospheric conditions. Just what effect the stratum of air, and streaks of air at different temperatures, have upon the waves is not definitely known, but those who have studied it believe there is a very definite effect. The way to overcome this resistance is to give the transmitters more power!

LONGING FOR AN IDEAL

Radio men have often wished there were such a medium as a perfect insulator in which no absorption would take place when signals traveled through it. That would be ideal because the impulses would be much stronger when they arrived. But Nature has seen fit to fix it so that the waves in moving across the earth's surface encounter conditions both favorable and unfavorable to their propagation. Moisture, dust and sunlight absorb radio's vitality. If the conductivity of the earth is low the waves lose power in overcoming the resistance, and that is one reason why they travel much greater distances over water. On land, large conducting objects, such as buildings, wires, trees and mountains containing metallic deposits steal the radio energy. However, if the objects are good insulators I shoot right through without surrendering power.

When I encounter skyscrapers such as those that project into New York's upper atmosphere a short-circuiting effect takes place. For example, when a wave strikes the Woolworth Building a gap is left in the wave front, but as the rest of the wave continues in its flight the gap is closed up, although some of the energy at that point is lost forever. It is similar to the effect that takes place when the wave strikes an antenna, but in such a case only a tiny fraction of the power is intercepted. A good illustration of this effect is a bather in the surf. After striking the person, the wave rolls on toward the beach and there is no visible gap in the wave front because it is quickly healed by the rest of the water. That is precisely what happens to radio waves when they strike the antenna.

HERE IS REAL EVIDENCE

Now I suppose you are wondering what pathways I follow in the air; whether I go through the air at high altitudes or cling close

THEY STIR POWERFUL WAVES

Charles Singer, engineer at WOR, examines one of the high power water cooled tubes that comprise the "heart" of a modern 50,000-watt broadcaster. Each of the six tubes is rated at 35 kilowatts.

to the ground. Sir Oliver Heaviside, an English physicist, who died on February 4, 1925, was one of the first to suggest radio routes through space. In June, 1902, he wrote for the Encyclopedia Britannica: "Sea water, though transparent to light, has enough conductivity to make it behave as a conductor for Hertzian waves, and the same is true in a more imperfect manner of the earth. Hence the waves accommodate themselves to the surface of the sea in the same way as waves follow wires. The irregularities make confusion, no doubt, but the main waves are pulled around by the curvature of the earth, and do not jump off. There is another consideration. There may be possibly a sufficiently conducting layer in the upper atmosphere. If so, the waves will, so to speak, catch on to it more or less. Then the guidance will be by the sea on one side and the upper layer on the other. But obstructions, on land especially, may not be conducting enough to make waves go round them fairly. The waves will go partly through them."

FOLLOW THE GREEN LINE

The existence of a conducting surface caused by ionization was postulated by Professor Schuster of England in 1887, almost ten years before Marconi gave me life. Sir Oliver Heaviside and Professor Kennelly of Harvard, in 1900, suggested that an ionized region in the upper levels of the atmosphere might be responsible for some of the tricks that I played, especially when signals faded. However, they did not know exactly how high waves had to travel to reach this "mirror" that reflected the impulses back to the earth with a waxing and waning effect, until a peculiar green line was discovered in the upper levels of the atmosphere, which gave an indication of the track that broadcasts followed. It was Professor J. C. McLennan of Toronto University, in observations he made of the aurora borealis who found that the green line spectra apparently originated in highly rarefied oxygen, and the intensity of the emerald hue was increased considerably by the addition of helium. He told the British Association for the Advancement of Science that his experiments revealed that the aurora light comes from a region at least 60 to 100 miles above the earth and at that height the air contains twenty to thirty times as much helium as oxygen.

A WORLD-WIDE ROOF

So now when you are listening-in and a faraway broadcaster dies out before you can catch the call letter, blame it on Nature's "radio roof" which tops the world. It is not merely a myth. The Naval Research Laboratory at Bellevue, D. C., cooperating with the Carnegie Institution at Washington, confirmed the Heaviside-Kennelly theory in 1925. Secretary of the Navy Curtis D. Wilbur, in making the announcement, spoke of the region as "a ceiling in the sky, at a varying distance above the surface of the earth, rising and falling as atmospheric conditions vary."

There are numerous strata rather than a

single surface, or smooth "ceiling" in the upper altitudes and changing electrical conditions of the ionized region affect various wave lengths differently. Reginald A. Fessenden, in 1906, estimated the height at which marked absorption of radio takes place to be roughly 300 miles at night and 100 miles in the day, and further, that the surface along which I travel is not smooth but is broken up into clouds of ionized air.

Sir J. J. Larmoor, an English physicist, showed that the altitude of the conducting level varies for different wave lengths, and this presents an explanation of the differing character and distances covered by short waves and at various hours.

H. W. Nichols and J. C. Schelling, of the Bell Telephone Laboratories, New York, in March, 1925, told of a theory which they had developed to account for fading. They explained that the earth's magnetic field has an effect upon wave propagation in that the plane of polarization is rotated as the wave advances through space. Dr. E. F. W. Alexanderson demonstrated experimentally this change of polarization, that is the "corkscrewing" of the waves high into the upper air, instead of sending them horizontally.

COMPARED WITH A GUN

Dr. J. H. Dellinger, of the Bureau of Standards, has given a good description of what actually happens to waves up in the clouds. He pointed out that the rarefied higher portions of the atmosphere, which during the World War permitted a German long-range gun to bombard Paris from a distance of 75 miles, with little "resistance," play the same rôle in broadcasting, because certain conditions of ionization allows signals of particular wave lengths to travel enormous distances around the globe. Just as the Germans aimed the gun's muzzle at a very high elevation in order to put the projectile quickly up into the little-resisting portions of the air, so radio engineers have found that the principle of shooting waves upward instead of radiating them horizontally is often a good idea, especially in the short wave field, that is, below 100 meters.

Dr. Alfred N. Goldsmith has pictured the Heaviside surface as a mirror or copper sheet suspended in the sky for, owing to natural causes, the reflecting power of the conductive sheet varies from time to time in much the same manner that a mirror reflects well at one minute and then becomes dim when a person breathes upon it. A mist or layer of air forming over the surface of the ether's great mirror mars its reflecting properties and therefore signals wax and wane. Supporters of this theory contend that during the day the powers of reflection from the Heaviside surface are considerably impaired by the rays of Old Sol; therefore, daylight reception is by means of waves that travel close to the earth's surface instead of by way of the race track in the sky.

THE HIGH AND LOW ROAD

So you see I have two distinct wave routes. One wave known as the "horizontal" clings close to the ground and the "vertical" wave reaches your antenna by way of the "ceiling" or ionized surface. When you pick-up a concert in the daytime from stations within a fifty-mile radius you are hearing a "ground" wave, which moves along the surface of the earth quite as a fly crawls around a baseball. The ground waves die out quickly and do not travel far because objects on the earth absorb the energy. The sky wave is what is needed for long distance reception; but that is not in effect in the daylight, so you must wait until night to pick-up the music from far-away cities. There are no absorbing objects along the pathway in the clouds and therefore waves travel much further at night, aided also by the fact that the sun has gone to bed and its rays do not rob the ether of power.

Broadcast reception of local stations is not bothered by the rarefied region because when you hear them the ground wave is bringing the music to you. If the waves of a local transmitter fade, Nature is not to blame, but probably a loose connection in the receiver, wornout batteries, with their current fluctuating, or perhaps a defective vacuum tube. If one antenna is too close to another, and especially if the wires are parallel, the waves may fade or entirely vanish spasmodically. This is caused by the owner of one set, who in tuning changes the capacity of the antenna system, and that affects the nearby antenna and its associated receiver. When either set is tuned it throws the other out of tune. The remedy is to run the wires at right angles to each other and keep them as far apart as possible.

MOMENTS OF SILENCE

Dawn has a greater effect upon radio than any other period of the day, because of the rapidly changing conditions of the atmosphere. Operators will tell you that the ether seems to "go dead" for about an hour at daybreak. The signals swing and fade more at that time than at any other time of day or night. Just as a person stops reading for an instant when he turns the page of a book, so it seems that Nature turns a page in the book

WHERE ONCE THE INDIANS ROAMED

The 52-acre radio research plot of the General Electric Company, nestled in the Mohawk Valley, has established communication with all parts of the world.

of time each day at sunrise. For example, I have often carried messages all through the night from ships far out on the Atlantic to the naval station at Otter Cliffs, Maine, but just as soon as the first faint trace of dawn streaked the East I was powerless and the ships were cut off from communication with the land until darkness fell again. But when dawn silenced the voices of the sea, waves radiated from Miami, Milwaukee and Buffalo had no difficulty in making themselves audible in Maine. Thus you see I am what the old wireless operators call a "freak" at times.

SUN DRENCHED

Since broadcasting began many radio enthusiasts, chiefly those more than 100 miles from a transmitter, have imagined that in the spring there is something radically wrong with the source of current supply or with their receiver, because the music and voices lose their volume and the distant stations audible throughout the Winter disappear. However, it is not the ether's fault nor the fault of the instruments. The weakened signals are caused by Old Sol's summer cruise into the northern section of the world. The light rays are so strong that they absorb radio energy and the heat helps Nature to create thunder storms and static, which is difficult to overcome unless high power outputs are used at the transmitters. In September I begin to regain strength as the sun travels southward taking with it my great enemy—static. Then as Winter approaches the waves travel further and further. Someone remarked that radio is in its glory from Columbus Day to St. Patrick's Day.

Observations made at night during the winter show that when broadcasts sweep across long overland distances on wave lengths between 200 and 600 meters the night is preceded by a cloudy day in the region across which the waves travel. Out of sixty cases of good transmission forty-four followed a generally cloudy sky over the area in which the tests were conducted. Of the remaining sixteen cases, the majority fell during the shortest days of the year when sunlight was at minimum intensity in the northern zones.

Signals broadcast at twilight on waves between 200 and 600 meters when the sky was cloud bedecked, have covered a radius of 300 miles, and an hour later, after darkness washed away the twilight, the signals from the same transmitter were clearly audible more than a thousand miles away. The barometric pressure is generally low on the day before records of good transmission have been established with spark transmitters.

Here is a tip for radio fans who are anxious to hear long distant stations operating between 200 and 600 meters—the ideal night is one having the cold, clear atmosphere of November, December, January or February, just after a storm has passed with its low hanging clouds.

IN THE LIGHT OF THE MOON

I have never noticed that my waves lose strength when they pass through the moonlight, although some ship operators say that in the tropics the lunar glow has a slight effect upon signals produced by a spark transmitter used in the early days of my life. However, today, with the powerful vacuum tubes and increased power outputs, the silvery light of the moon merely brightens the pathway around the world and does not absorb ethereal power.

Fog has a tendency to weaken signal strength because dampness makes various objects better conductors of electricity and causes them to lead the Hertzian waves astray to the ground before they can reach the receiver. The same is true if ice coats the antenna, insulators and masts.

The waves in transit across forests relinquish considerable energy especially in the Spring and forepart of the Summer when the sap and fresh foliage make the trees better conductors of electricity and the multitude of branches just so many antennæ. In fact if you drive a nail into the trunk of a tree about two thirds of the way up and attach it to the antenna binding post on the receiver you will find that the tree is a good antenna substitute, which often proves to be very handy for campers. If a copper wire ranging from 50 to 100 feet in length strung around the molding of a room can intercept sufficient energy from passing waves to produce sound, which can be heard several hundred feet from a loud-speaker, you can imagine how much of power is absorbed by trees, steel structures, electric wires and pipes all connected directly with the earth.

However, when waves are long, that is, from five to twenty miles from crest to crest the objects on the earth are more easily overcome as far as absorption is concerned. These waves are long compared with even the bulk and height of skyscrapers, which are less of an obstruction when the waves are longer than 1,000 meters. But it is another story with waves from 200 to 900 meters. In this wave band the steel structures and mountains cast a "shadow" or "dead spot" in the radio highway.

PERTURBED FLEETNESS

Radio is badly treated when traveling across New York where the lofty buildings reflect, diffract, refract, re-radiate and distort the waves. The skyscraper area in any large city is not only a mountain of steel but is divided by deep criss-crossing cuts formed by the streets into a group of lattice pillars, which have natural wave lengths of their own corresponding to the wave lengths of some transmitters, and therefore, are excellent absorbers of the waves because they are in tune with them. When an antenna is in tune with a transmitter it intercepts more of the energy and the same principle applies to a building in tune with a particular wave length. For example, it is impossible to operate broadcasting stations with aerials atop certain buildings because the natural wave of the building is so close to that of the station that most of the power is absorbed by the building before the waves have a chance to get out into space. This is one reason given to explain why WEAF stopped using the aerial atop 24 Walker Street, New York, and moved to West Street and then to Long Island.

The "dead spots" do not extend over a very wide area, because wave fronts, rising to great heights, shoot forward like the surf with an irresistible sweep, rapidly healing up the gaps, or "shadows," as the great store of energy above fills in the "holes" just as the waves of the sea quickly mend the tiny gaps caused by bathers in the surf. Tests in the vicinity of New York show that radio strength over the East River and Hudson River is much greater than over the adjacent city and that there is a continual feeding-in of energy from the rivers to the land.

16,000,000 STORMS

As far as perfect reception is concerned, the "dead spots" are insignificant compared to the atmospheric disturbances known as "static." There are at least 100 lightning flashes every second, year in year out, Winter and Summer, somewhere in the world according to the

Meteorological office of the British Government. Is it any wonder that static is a bug-bear in the ether's system of communication? Static is the weed of space. It is estimated that Mother Earth experiences 16,000,000 thunder storms a year, or an average of 44,000 a day, so in any given second there is released from the clouds more electric energy than the world's water power plants produce in six months!

Static interference is most bothersome in the northern zones during the summer, but from Columbus Day to St. Patrick's Day the strays cause little annoyance north of the Mason Dixon Line. Radio egnineers have noticed at least three kinds of static intermingled with broadcasts. The most common type introduces itself in loudspeakers with a frying or grinding noise. The best name for it is "grinder." The second type is produced by lightning flashes and it sounds like a sharp click. Thus it is called "click" static. The third type often occurs during snow storms and stirs up a hissing noise, and accordingly it is called "hissing" static. The latter two cause comparatively little interference, because they are usually local and do not hold sway in the ether more than a few hours at the most.

Grinding static is what radio has to combat. It is apparently born in the upper levels of the atmosphere and over land rather than over the sea. In 1922 Marconi sailed across the Atlantic in his floating laboratory, *Elettra;* he made a study of static and by means of loop antennæ observed in which directions it originated. He reported that up to about half-way across the ocean the static appeared to come from the African coast and after his ship passed mid-ocean the disturbances seemed to fly out from the American continent.

Up to very high wave lengths the increase in static intensity is proportional to wave length. It is estimated to be about twenty times as strong on 17,000 meters as at 3,000 meters, but above 25,000 meters the strength of the static decreases.

A MULTITUDE OF SINS

Unfortunately, this type of annoyance consists of a multitude of disturbances originating in various sources and on all wave lengths, although it is worse on some than on other channels, so to whatever wave you tune, static at some time or other is likely to say "Hello" with its frying noise, clicks and hisses.

Along the Atlantic seaboard, if heavy static jumps about in the air during the afternoon and night it seems to originate in the southwest and some say that Mexico and Central America are the home of Nature's static machine. Disturbances in the morning and those of cooler months are evenly distributed in regard to direction whence they come. The maximum strength of static is reached between 10 P. M., and midnight and the minimum interference is caused about 1:30 A. M., and just before dawn, unless there is a thunder storm in the neighborhood of the receiving station. If the static is very noticeable from about 6 A. M., to 10 A. M., or at 4 P. M., it can be considered nine times out of ten that an electric storm is not far distant, or that a radical change in weather is about to take place. The static intensity not only varies from hour to hour but from year to year. The average disturbances during August, 1917, were about three times as strong as those of the same month in 1918 and 1919. It is always heavy in the tropics, probably because of the intense heat, humidity and powerful rays of the sun, which seem to play an important part in the manufacture of the atmospherics.

WHEN THE SNOW FLIES

Contrary to what might be expected static frequently visits broadcast listeners during snow storms, especially during blizzards or when the snow is wet and heavy as it falls.

Some day undoubtedly man will find a simple arrangement that will filter the static from the radio waves after they reach the receiving antenna. But the average strength of Hertzian waves is one millionth of an ampere and the lightning flashes represent hundreds of thousands of amperes so is it any wonder that radio cannot always be distinctly heard without interference? The best way to fight static is to give the waves more power until someone discovers how to separate them from the pest of pests.

NOT GUILTY!

Some experimenters and publicity seekers have at various times contended that ether waves are to blame for chilly, unseasonable weather in the Spring, or that the waves in transit through space cause an excess of rain and snow or a drought. However, I am not to blame and will quote several authorities to vindicate myself as far as the weather is concerned.

"I am decidedly a skeptic," said James H. Scarr, Chief of the New York Weather Bureau. "The fact that radio is blamed for extreme weather conditions does not really mean that it is true. If you were to ask a man on the streets of New York what he thought was the cause of extremely cold Spring weather east of the Rocky Mountains he would probably tell you radio. If you were to ask a man in San Francisco what he thought was the cause of extremely warm Spring air west of the Rockies, he would probably give you the same answer.

"Although the cause may be the same the effect may be different. This is caused by the motion of the winds. Traveling from the east they may bring rain, while from the north they may bring snow. Even though it is the same thing that sets the winds in motion, the effect is different.

"It is a very remote possibility that radio is even slightly responsible. I for one am inclined to be skeptical about it. The more I study weather conditions throughout the country the more positive I become that we will never be able to control the weather."

Mr. Scarr expressed faith in the old song:

Whether it's cold or whether it's hot,
We're gonna have weather, whether or not;
The weather we get and the weather we've got,
We're gonna have weather; whether or not.

In reference to radio influencing weather, Dr. Alfred N. Goldsmith, Broadcast Engineer said, "I do not think that the human race can affect the weather. Electrical radiation can influence moisture and precipitation, but not to the extent of covering the entire country, unless we had electrical energy available for such a purpose.

NO USE WORRYING

"However, the electrical energy that is within our power as compared with that necessary to affect the weather, is comparable to a fly and the world's fastest express train. Sometime in the future we may have within our grasp enough energy to affect the weather, but there is no use worrying about it now."

When asked his opinion of the theory that ethereal impulses affect the weather, Hugo Gernsback, editor of *Radio News,* said, "Nothing could be further from the truth, and the little amount of energy given out by broadcasting stations is so infinitesimally small that there is no known instrument that can directly measure the amount of energy received three miles from the transmitter. Only by amplifying the microscopic energy and by using local "A" and "B" batteries or some other source of current, such as the house lighting mains, are we able to make a loudspeaker reproduce.

"Careful observations made during fog, rain, during the night and in clear weather, have failed to show any action caused by radio waves. Physicians and scientists who use X-rays, which give off a gigantic amount of energy as compared to a broadcasting station, find that even with the tremendous amount of ionizing power inherent in the X-ray, no action on the atmosphere is ever noted.

"The plain truth is that the cause of unseasonable weather lies in the sun, which passes through an eleven-year sun-spot cycle, one minimum of which occurred in 1922, during which year radio reception was extraordinarily good."

EYES THAT SEE NOT

The *S.S. Antinoe,* badly crippled, with rudder torn away and position unknown, because of the fury of an Atlantic blizzard and high seas, used Hertzian waves to carry an SOS to the *S.S. President Roosevelt* on January 26, 1926. The big ship turned in its course and after a strenuous effort in battling the blinding snow storm and heavy seas, steered directly to the sinking ship and rescued the crew despite the fact that the position broadcast by the *Antinoe's* skipper was inaccurate by 100 miles, because of the adverse weather conditions.

It was the radio compass, the instrument which can determine the angle along which the waves travel, that saved the *Antinoe's* crew. The direction finder consists of a loop antenna which is rotated by means of a hand wheel to the position of maximum signal intensity, at which point the plane of the coil lies in the direction of the transmitter. At the extreme lower end of the loop's shaft is attached a pair of sighting wires by means of which the angle of the plane of the coil with relation to North is directly indicated on a degree scale.

There are several methods of taking the angle readings. The usual system is to install the radio compass indicator directly over a magnetic compass and binnacle. The bearings in this case are with respect to magnetic North. If the vessel is equipped with a Sperry gyro-compass and a Sperry repeater in place of the magnetic compass, the bearings are with respect to true North. On small ships, where the expense of the additional compass, or repeater, does not seem warranted, a simple degree scale, or "dumb compass" is used, which can be set by reference to the ship's compass each time a radio bearing is taken.

The latest method of taking bearings dispenses with the headphones and sounds, which are often misleading. The new system is visual. Instead of producing an audible signal in the headset, the incoming currents cause a visible line to be traced on a florescent screen of an oscillograph. If signals are being received from two or more stations simultaneously a visible line is traced on the screen for each arriving wave, and from their direction, relative to a scale marked on the screen, the position of the vessel can be quickly plotted. The length of the line increases with the proximity of the transmitter, thus the instrument provides an additional safeguard against collisions.

Ether waves have the property of setting up electric currents in any conductor they may encounter, and this is the principle upon which the radio compass, or direction finder is based. When a signal of maximum intensity is received the loop is so placed that the plane is pointing at the transmitter. If the plane of the loop lies at right angles to the direction of the transmitter, no energy is picked up and no signal is heard. The position at which the signal disappears, is much better defined as far as the human ear is concerned, than the maximum point, so the "null point" is used to read the direction of the transmitter.

The loop is generally mounted above the chart room or pilot house, connected by a shaft passing through the deck to the indicating device, which allows bearings to be taken directly from the compass card or gyro repeater.

CREDIT WHERE DUE

At times several have tried to take credit for discovering radio, but Guglielmo Marconi will go down in history as the inventor. After a chronological review of the events prior to the taking out of Marconi's first patent in 1896, the United States District Court, Eastern District of New York, on March 7, 1914, in an opinion handed down by Judge Van Vechten Veeder, upheld the validity and priority of the inventor's patents.

In the words of the court: "To sum up the results of this period of speculation and experiment, the conclusion is reached that no one had described and demonstrated the system of wireless telegraph apparatus adapted for the transmission and reception of definite and intelligible signals by such means. This was the state of scientific knowledge and practice, when in 1896 Marconi applied for his first patent."

CHAPTER VII

TURNING POINTS

"Then I spake with my tongue."
Psalm xxxix. 3

If I were to award medals as tokens of appreciation to those who have done much to help my growth I would most certainly present one to that body of experimenters known as the amateurs. They discovered the true value of short wave lengths and as a reward they found that they could chat around the world by means of simple apparatus, which consumed less power than an electric flatiron or toaster!

In the course of my development man did not begin at one meter and work up, but he selected waves in the neighborhood of 600 meters, which seemed to be the best ethereal channel on which to handle marine traffic and this was adopted as the universal commercial wave. Even today, if a ship sends an SOS it pulsates through the air on 600 meters.

The development of high power commercial transatlantic stations was the next step and they were tuned to operate on longer waves, some as long as 20,000 meters. Then broadcasting began and the entertainment type of station was assigned channels between 200 and 600-meters, thus forcing the amateurs to use the 200-meter wave or lower. Broadcast listeners complained that amateur transmitters operating on 200-meters were interfering with the concerts, so the Department of Commerce opened up several wave bands below 100 meters and suggested that the amateurs experiment. The amateurs, many of them boys between the ages of 12 and 18 years, redesigned their equipment and moved down to the neglected channels and greatly to their surprise discovered that with low power, less than consumed by an ordinary electric lamp, they could talk with amateurs in foreign lands, direct from the attics of their homes! It was a revelation. They had found the key of ultra-long distance communication.

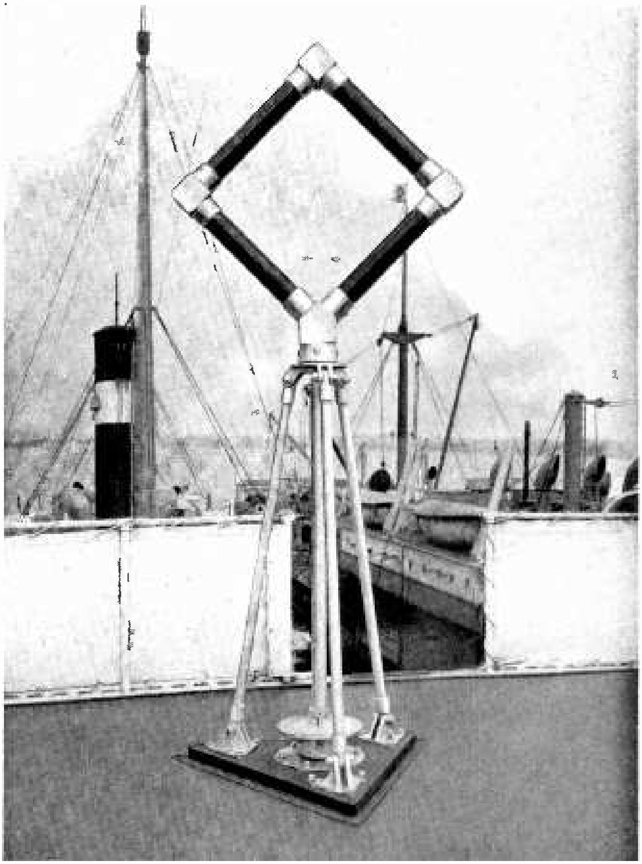
In the Autumn of 1923 a special test was arranged between a French station and an American amateur, both operating on 100 meters. For the first time in amateur history messages were sent back and forth across the sea between these two simple and inexpensive stations. Other amateurs were inspired. There was a rush to build short wave transmitters and receivers. They found that they could talk across the United States in broad daylight when using short waves, an undertaking which had always been considered as a wild dream. Today there is no earthly distance over which amateurs cannot communicate while utilizing channels between 15 and 60 meters. Science still has many secrets wrapped up in the short wave field.

A THREE-CORNERED CHAT

The following incident discloses the world-wide activities of the amateurs, and shows how international radio is in scope when short waves are projected into space: An amateur in Massachusetts was operating his station late one night, and he happened to hear two amateurs talking, one in England, the other in New Zealand. The New England amateur put his transmitter on the air and a three-cornered conversation ensued, which encircled the globe and continued for more than two hours. The three operators finally bid each other "CUL" (See you later), so that the Britisher could go to his morning's work; so the lad in Massachusetts could get some late sleep and so the New Zealander could eat his lunch!

Hiram Percy Maxim, President of the American Radio Relay League, once said that the question most often propounded to him in connection with my host of amateur followers is, "What is it about amateur radio that maintains such a hold on its enthusiasts?"

"It is a question, which I have often asked myself," said Mr. Maxim. "What peculiar force is it that affects alike the boy of 16 and the man of 70; the wealthy man and the poor



Radio Corporation of America.

A SENTINEL FOR MARINERS

The direction finder which enables a ship to obtain its position. The loop antenna is concealed in the weatherproof square at the top and it is rotated by a hand-wheel on the shaft which extends through the deck.

man; the college graduate and the uneducated boy? What is it about their common interest that can bind together such diversified classes and types?

"Perhaps the 'urge for distance' has something to do with it. Perhaps the pleasures that come from friendships made over the air. However, there is something bigger that constitutes the charm of amateur radio—the Spirit of Adventure!

HIGH ADVENTURE

"Many a time, as I have sat down before my own set, I have paused to wonder where my signals would go and into what countries of the world they would carry my thoughts," said Mr. Maxim. "Each night has been an adventure into space. No two nights are the same; today I talk with a friend whom I have never seen, on the Pacific coast; tomorrow it is an explorer deep in the heart of a tropical jungle; the next night it is someone in Europe, or South America or Australia. Perhaps, instead of calling someone else, I listen for other signals and hear an amateur in France, Germany or Japan. Sitting in my study, I answer the calls and by internationally agreed upon code groups I converse with the Frenchman, the German and the Japanese. Here, surely is high adventure!

"Today the amateur can truthfully say that there is no earthly distance over which it is impossible for him to communicate. What of the future?

"It is a difficult question to answer. In the line of scientific development it would appear that the next immediate step is a further investigation of the properties of the waves on the order of five meters and less. Beyond this point, however, it is difficult to predict with any degree of assurance. To me amateur radio has a more important destiny to fulfill than mere scientific attainment, and that destiny is the furtherance of world peace."

A WORD FROM MARCONI

In speaking of the amateurs, Senator Marconi said, "The results obtained by amateurs in the field of short wave endeavor possess only limited facilities for experimental work. It should not be forgotten that amateurs were the first to carry on two-way communication between England and New Zealand for brief periods. Their observations have often been of value in helping us to arrive at a somewhat better understanding of the very complex phenomena involved, but I think it is sometimes dangerous to attach too much importance to all their observations, especially when they concern what might be termed 'negative results.'

"For example, I read a statement by an eminent authority that, according to amateurs' observations the daylight range of a 100-meter wave did not exceed 200 miles, and for the 50-meter wave, 100 miles. I have carried out tests on the 100-meter wave length for months on end and have never found its daylight range to be below 1,000 miles. With a 47-meter wave, which is close to 50 meters, we have never observed any skip distance commencing at 100 miles, or at anything like so short a distance. It may well be that some of the observers were not particularly skilled or were using insensitive receivers, or that their stations happened to be situated near buildings or structures which unfavorably affected reception. I therefore think it would be unfortunate if, in consequence of some reports, the theory of skip-distances, for example, should become unduly generalized and extended."

HOP, SKIP AND JUMP

Radio plays more tricks in the short wave field than in any other wave length band, in fact the ether stages so many odd performances below 80 meters that the waves are called erratic! A statistical staff at station WGY, Schenectady, N. Y., tabulated thousands of reports regarding radio's actions on a variety of wave lengths extending over a period of eighteen months, during which time observers in all parts of the world took notes on the reception.

A small percentage of the total reports dealt with the 15-meter wave broadcasts. On this wave no reports were received regarding daylight reception within a radius of 900 miles, indicating an apparent skip distance of this magnitude, that is the signals were projected up to the Heaviside surface in the sky but were not reflected back to the earth until they had traveled 900 miles. At night the skip distance of the 15-meter wave was found to be 1,000 miles.

Approximately 900 observations were made on the 26.38 meter transmission, indicating a day skip of 100 miles, which at night increased to 450 miles. These limits, however, are not sharply defined, as they vary considerably from day to day. Although the signal characteristics beyond the limits of the day and night skips were not as erratic as those on 15 meters, the reliability was low at a distance of 3,000 miles. Beyond this region of uncertainty, the signal strength became more consistent in its behavior. It was noted that at 2,650 miles the night signal audibility was low on the 26.38 meter channel, which might lead to the erroneous conclusion that the useful range was not greater than 3,000 miles. As a matter of fact, reports from New Zealand and Australia verified better reception than at most points in the United States when signals were radiated on 26.38 meters.

ENCIRCLING THE GLOBE

Reports of the 32.77 meter wave numbered about 5,000, analysis of which showed the day skip of this wave to be 100 miles and at night 400 miles. The limit of the daylight range for the 32.77 meter transmitter could not be established definitely because of insufficient reports beyond 2,650 miles. Reports on the night transmission were received from all parts of the world, indicating fairly consistent high average strength for the maximum distance obtainable, i. e., one half of the earth's circumference. If a transmitter has sufficient power to send a signal half-way around the world it really encircles the globe, because the wave travels in both directions and meets at the Antipodes.

The day and night audibility characteristics of 50.2 meter transmissions disclosed that no skip distance existed on this wave. The useful day range of this wave was definitely shown to be 1,100 miles, but at night the audibility was good at 2,650 miles. However, the analysis showed that reports from distances greater than 2,100 miles were so erratic as to make it impossible to determine the absolute useful limit of the night transmission on this channel.

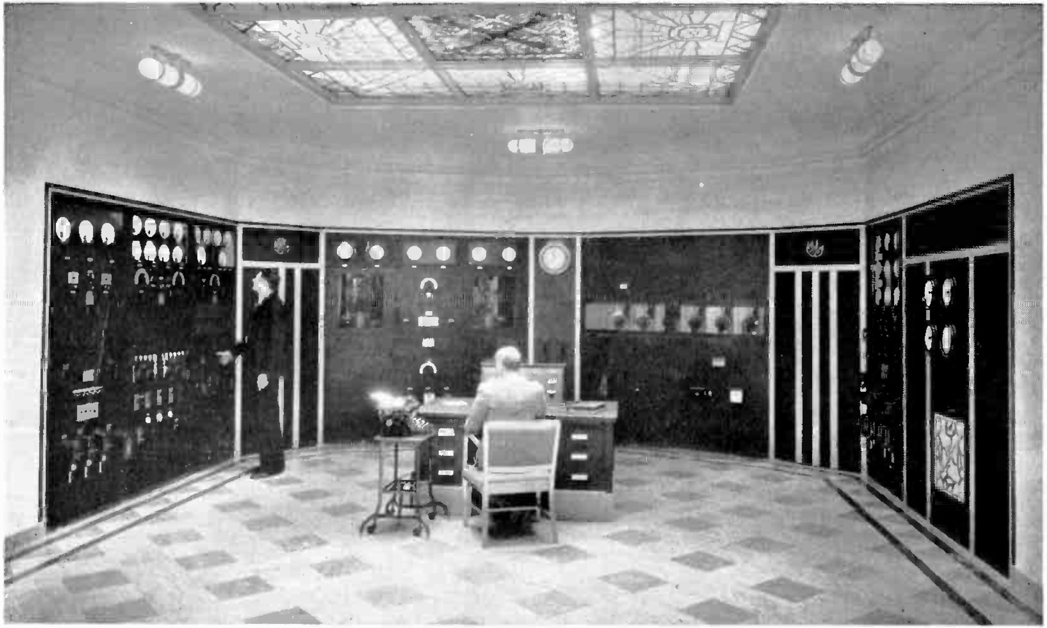
The attenuation of the day signal of 65.5 meter transmission was not great. At 1,050 miles the strength was fairly high, indicating that satisfactory reception might be had for 200 to 300 miles further. Actually this was not true, because fading, static and other factors which proved detrimental to good reception, caused the signals to become unreliable after they had traversed 1,000 miles. The 65.5 meter waves were heard 2,650 miles away at night but the reports showed that the region beyond 1,600 miles must be considered an unreliable zone as far as my 65.5 meter waves are concerned.

The 109-meter waves behaved more in conformity with those of the broadcast and commercial channels than did the shorter waves. Day and night audibilities of the 109-meter signals were quite rapidly attenuated, that is, the intensity dropped off so that the useful daylight range for this channel is placed at 400 miles and 1,000 miles at night.

AN AID TO THE DEAF

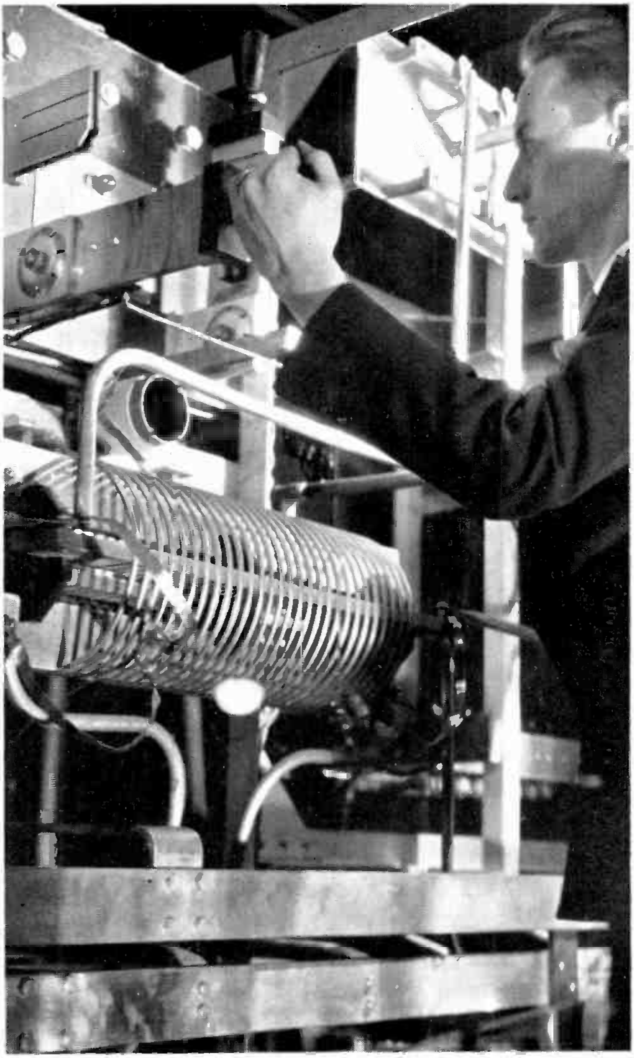
Doctors have discovered that the amplification of a receiving set can be so adjusted, that out of thousands of deaf persons, seldom is one found whose auditory nerve will not respond to my broadcasts. It is estimated that in New York alone there are 100,000 persons suffering from defective hearing, who can enjoy the ether's entertainment, or as one deaf person said, "those pleasures which we have in music, song and speech."

Aurists account for the healing effect of radio "treatment" by the fact that any organ in the human body that is not often used will soon degenerate. This applies to the ear. When



IN THE PARLOR OF BROADCASTING

The "face" of WEAF's 50,000-watt transmitter at Bellmore, Long Island, where human thoughts are electrified for countless listeners.



PATHWAYS FOR HIGH POWER

Radio transmitters utilize big coils for various purposes, but instead of hair-sized wire as used in a receiving set the sending station's powerful currents call for heavy copper ribbon or tubing. Note the huge switches also, at WLW, Cincinnati, O.

it is injured so that it cannot detect ordinary sounds its power of concentration is decreased and the muscles become weak. Listening-in prevents this deterioration. It exercises the ear!

A radio headset is essentially the same as the telephone receiver invented as the result of an experiment designed to relieve deafness. Alexander Graham Bell was working on an instrument intended to enable his wife to hear when he discovered the principle of the telephone. The headphones of radio are based on the principle developed by Bell.

The progress of broadcasting has made it possible to give Bell's humanitarian effort a much wider application than was originally foreseen. By means of a receiving set, sound transmitted through space in the form of ether waves can be amplified millions of times with great delicacy of control to suit a defected ear. An ear may be sealed by years of inaction but if the slightest shreds of hearing remain radio can generally be depended upon to pierce the barrier of silence, and often, when conditions seem hopeless, the headset enables persons once more to hear.

FEW ARE STONE DEAF

A patient whose auditory nerve is uninjured, nine times out of ten can tune a radio set and apply amplification until the broadcasts are audible. Few people are totally, or "stone" deaf. If the auditory nerve has been missing since birth, or an accident has completely destroyed the nerve the case is hopeless. Such cases, however, are rare. It is said that anyone who retains seventy per cent. of the normal hearing qualities of the ear will benefit by listening-in. Constant listening for several hours a day, off and on, stimulates hearing by strengthening the muscles of the inner ear and aids in the power of concentration on sound. However, a person should not listen-in too long or the ear's mechanism will become tired and injured further from overwork.

The action which enables the deaf to hear on the radio was admirably described in a broadcast by Dr. James A. Fleming, inventor of the Fleming valve, which formed the basis of the present day vacuum tubes. Dr. Fleming, who was afflicted with deafness studied the subject thoroughly. He explained that the ear comprises two main compartments and an entrance tube. The latter opens to the external air, but is closed at the inner end by a delicate membrane like the wing of a fly, called the "ear drum" or "tympanum."

"When sound is created," said Dr. Fleming, "the air particles swing to and fro like little pendulums, and the motion is handed on from particle to particle, traveling away from the source with a speed of about 1,100 feet a second, or about 700 miles an hour. In the case of a loud sound, the extent of the to-and-fro motion of the air particles is large, but in the case of feeble sound it is small."

When a sound wave enters the ear it causes the drum to swing to and fro in accordance with the motion of the air. Behind the drum is a hollow space known as the middle ear. It is connected with the back of the mouth by a tiny pipe called the Eustachian tube.

A HARP OF 10,000 STRINGS

Dr. Fleming called attention to a chain of three little bones stretched across the cavity of the middle ear. "These bones are attached on one side to the ear drum," Dr. Fleming continued, "and on the other to a thin partition that separates the middle ear from a second cavity, called the inner ear. In this inner ear is a wonderful spiral chamber like a snail's shell, which contains a sort of harp of 10,000 strings, called Corti's organ. The latter is connected by innumerable nerve fibres with a part of the brain recognized as the auditory centre.

"It is in this last named place that merely physical vibrations are converted, in some incomprehensible manner, into sensations of sound with its various attributes of loudness, pitch and quality. The normal ear possesses a remarkable power of appreciating quality and instantly analyzing a sound into its components. Deafness consists of any derangement of this complicated mechanism of the ear, either middle, inner or nerve centre, which prevents it from being set in vibration sympathetically and transmitting and appreciating all of the complicated air movements, created by human speech or musical instruments. There are, therefore, many varieties of deafness."

One of the common causes of temporary or permanent deafness is the closing up of the Eustachian tube by a common cold or influenza. In this case, the pressure of the air is no longer exerted equally on both sides of the ear drum, with the result that when the air in the middle ear is absorbed, the drum is pressed in, the small bones displaced and the mechanism for transmitting the air vibrations to the brain is thrown out of gear. As long, however, as the nerve centres and inner ear remain healthy, a person suffering from middle ear deafness may be able to hear, fairly well, sounds transmitted through the bones of the head. When listening-in on broadcasts the sounds are received through a receiver pressed against the ears. That is one of the secrets why deaf persons hear radio programs. The vibrations of the diaphragm of the phones produce sound which is transmitted to the inner ear through the skull or bones of the head.

HELLO LONDON!

A quarter century passed from the time that I first crossed the Atlantic until man used my invisible waves as a "talk-bridge" between New York and London. This service opened officially on January 7, 1927, and before the "bridge" was closed to traffic at sunset that evening many had chatted with friends across the sea with no more effort on their part than is consumed in making an ordinary local phone call, and business houses did $6,000,000 worth of transactions over the channel during the first day of operation. In fact this branch of the ether's service was heralded as "the most remarkable communication yet devised by man."

Shortly after 8:30 o'clock on that morning, the voice of Walter S. Gifford, President of the American Telephone and Telegraph Company, in a low conversational tone, spoken into the mouthpiece of the standard desk telephone said, "Please connect me with Sir Evelyn Murray in London."

Those eavesdropping on the international circuit heard a switchboard operator say, "Hello, London."

And within a few seconds a man's voice said, "Hello, is that you, Mr. Gifford?"

Then these two men separated by the Atlantic ocean extended greetings over the 7,150 mile circuit and hung up their receivers so that others could put in a call for London, or New York.

The telephone rang in the office of the *New York Times* where Adolph S. Ochs, publisher, picked up the receiver and heard the operator say, to "wait a minute," that Geoffrey Dawson, editor of the *London Times* was calling. This was the first private conversation that traveled across the long distance telephonic channel. The rates were seventy-five dollars for the first three minutes and twenty-five dollars for each additional minute.

The engineers began to weave this invisible "bridge" in 1915, but the World War held up their tests. After the war, when they resumed their gigantic task, they found radio further advanced because of the more powerful vacuum tube transmitters, and more sensitive receivers; they knew more about the single-side band method of transmission and the piezo crystal with ability to hold a station on its exact wave length. These developments aided in a great step forward and in 1922 operations were resumed.

WHITTLED TO A STRIP

When the ordinary broadcasting station goes on the air a carrier wave and two side-bands are sent out from the aerial wires. You may picture the carrier wave as a red ribbon extending through space in much the same manner as would a ribbon if tied between the transmitter's aerial masts and the receiver's antenna support, with the side-bands represented by green borders on both sides of the red ribbon. In the broadcasting of a concert program sixty per cent. of the total power is in the carrier wave but it does not convey any music. The side bands transport the concert. But the engineers, in developing the transatlantic telephonic circuit, eliminated the carrier and one side-band, thereby, conserving electrical energy and also space in the ether. They actually whittled the wave to a narrow strip!

Then they found that the amputated wave was of little use at the receiver unless they grafted back the parts that they cut off at the transmitter. So they used what is called a heterodyne oscillator, an instrument which combines the received current with locally generated alternating current, forming a receiving process called "beat reception." The frequency supplied by the oscillator interacts with the incoming side-band and produces the original audio frequencies spoken across the sea.

TRAFFIC COP APPOINTED

The engineers discovered that if the wave strayed even slightly off the exact channel it was difficult to tune at the receiver, so they applied a principle, known as the piezo electric effect, discovered by J. and P. Curie of France in 1880, which acts as a traffic "cop" of the ether and keeps the transmitter on its exact wave length. This same principle was also applied to the broadcasting stations so that they could not ramble off their paths to mix with other waves to produce howls and whistles that sound like a peanut stand's high pitched, waxing and waning melody.

"Piezein" in Greek means to "squeeze," or "press." Piezo is derived from this Greek word and refers to the ability of certain crystals to develop electrical polarization when subjected to stress, chiefly twisting. These crystals also have the reverse property, that is, when electrical charges are applied to them at certain points they dilate and produce stress.

You may find it of interest to know that crystals having this property are called "piezo crystals," and they qualify as traffic police along the ethereal lanes. There is a noticeable piezo action in quartz, cane sugar, camphor, silicate of zinc, boracite, Rochelle salts and other asymmetric crystals. However, quartz is generally used because its natural vibrations are quite constant and it is not affected greatly by temperature changes.

The quartz is ground to a thin wafer and as soon as it becomes active it is master of the circuits and prevents the transmitter from sliding off the assigned wave length.

MORTALITY OF WORDS

The big problem in transatlantic radio-telephony was to reduce the mortality of words in their flight through space. In the reception tests, disconnected words were used so that there was no chance for the operator's imagination supplying missing links in sentences. During the summer of 1923 the engineers could get about 15 words out of 100 across the "bridge" and by the summer of 1924 the record was 60 words out of 100, and in 1925, 90 out of 100 survived the transoceanic trip.

Static and the "sunrise" and "sunset" walls are obstacles in the transoceanic path. The words can get across in fine shape until dawn or sunset creeps out across the sea, acting as a great curtain on the international stage.

Now suppose you are in New York and you wish to talk with a friend in London over this $5,000,000 installation. I will tell you just what happens from the time you speak until the Englishman hears your voice.

You ask for "Long Distance" and the toll operator connects you with the terminal of the transatlantic circuit in the long distance telephone headquarters of the American Telephone and Telegraph Company at 24 Walker Street, New York. From there the voice is sent over seventy miles of land wire to Rocky Point, Long Island, the western gate way of the invisible bridge. A powerful transmitter gives the words impetus sufficient to hurl them across the 3,000 miles of ocean to Wroughton, England, where a receiving antenna plucks the words from the ether and forwards the electric impulses on a land telephone wire to the British Postoffice Building in London, 90 miles from the receiving point. From there a connection is made to the local telephone central office of the party desired.

INTERNATIONAL DOORS

Now, if a Londoner wishes to talk with New York, his words are sent over a land wire link of eighty-five miles to Rugby, the Eastern terminal of my "bridge," thence the words are flashed across 2,900 miles of sea to Houlton, Maine, where the land line completes the circuit by forwarding the conversation 600 miles to New York. The wave length used is 5,000 meters.

Sensitive relays, or one-way doors, as they are called, play an important part in both legs of the circuit. When a New Yorker speaks and the voice leaves for Rocky Point, one relay is opened by the voice wave. Another relay is automatically closed at Houlton, Maine to prevent any signals from Rocky Point being picked up to create a short circuiting effect with New York. When the New Yorker stops speaking, the two "doors" operate in converse fashion, so that the words from London can reach the New Yorker, and the relay at Rocky Point prevents the voice of the Britisher from being rebroadcast from the American end. At the London terminal, similar one-way "doors" quickly switch from the incoming to the outgoing speech wave, opening and closing with such speed and facility that the conversation is uninterrupted and the speakers are unaware that they are swinging to and fro in the circuit.

MARCONI'S BEAM

Several months before the "talk-bridge" was opened my old friend, Marconi, introduced me in a still different form, in which my waves were termed a "beam." He built a reflector system consisting of a row of lattice steel masts, so arranged that the great circle bearing to the distant station with which that particular transmitter is intended to work is at right angles to the line of the masts. The design of the aerial and reflector systems are identical at both transmitting and receiving stations. These reflectors act as the reflector on a lantern or searchlight, but they concentrate the electric energy and shoot the waves in a desired direction in much the same way that a searchlight casts a beam of light. This method conserves power and inasmuch as the energy is not broadcast in all directions it tends for secrecy. For example, eavesdroppers in Spain, or Italy, are not within range of the beam if it is projected from England to America. The beam is shot through space on a short wave, between 2 and 26 meters. The initial tests added to the glory of the inventor and by the end of 1927 he had linked England with Canada, Australia, Africa and India by means of the beam. It was less subject to fading and static bothered it less than on higher wave lengths. Marconi showed that the shaft of energy was capable of handling traffic at high speeds and that it was an excellent channel for picture and voice transmission. This beam was really another "talk-bridge" and one of vast possibilities.

SEEING BY RADIO

Three days after the "talk-bridge" linked New York with London, members of the Institute of Radio Engineers gathered in convention in New York to listen to Dr. E. F. W. Alexanderson describe his apparatus designed to shape the waves in the form of pictures and television, that is, transmission of moving ob-pects, or motion pictures!

There was great applause when Dr. Alexanderson projected through a series of lenses a cluster of seven light spots on the screen. They were sent through a revolving drum on which twenty-four mirrors were tipped at a variety of angles. Then he rotated the drum and the little spots of light gyrated and blended as they fled across the silver screen and as the speed increased the white curtain was flooded with light. He passed to the audience samples of half-tones, which he had transmitted by means of my waves from WGY to his laboratory two miles distant. The audience agreed that they were as perfect as the originals!

Dr. Alexanderson called attention to the fact that it required a number of years to develop broadcasting to a practical point and that ten years would probably pass before stations would utilize the ether to send radio motion pictures into millions of homes.

CHAPTER VIII

LOOKING THROUGH SPACE!

"For he looketh to the ends of the earth
And seeth under the whole heaven."
Job xxviii. 24

PROGRESS of such a definite nature has been made in the perfection of apparatus for sending photographs and pictures of moving objects along the radio airways that it can be safely predicted, without being too visionary, that the day is not far distant when millions of people will look-in as well as listen-in on remote scenes and concerts. Radio waves will carry action pictures or movies of World's Series baseball games, Presidential inaugurations, coronations, football games, stage and operatic productions to silver screens in many lands and on board ships at sea. At first the scenes will be in black and white. The next step will be to transmit colors.

In reference to the ether's ability to carry pictures of moving objects, C. Francis Jenkins, an ardent radio-photo experimenter in Washington, D. C., said, "Let's see whether there is really any mystery in the thing, after all. Let's analyze the problem; take it to pieces and examine it in detail.

"These are the essentials. We want a picture of a remote scene; we want it repeated fast enough to reproduce the motion and we want it carried into our homes from distant ball parks. That's the problem, a picture of distant activity!

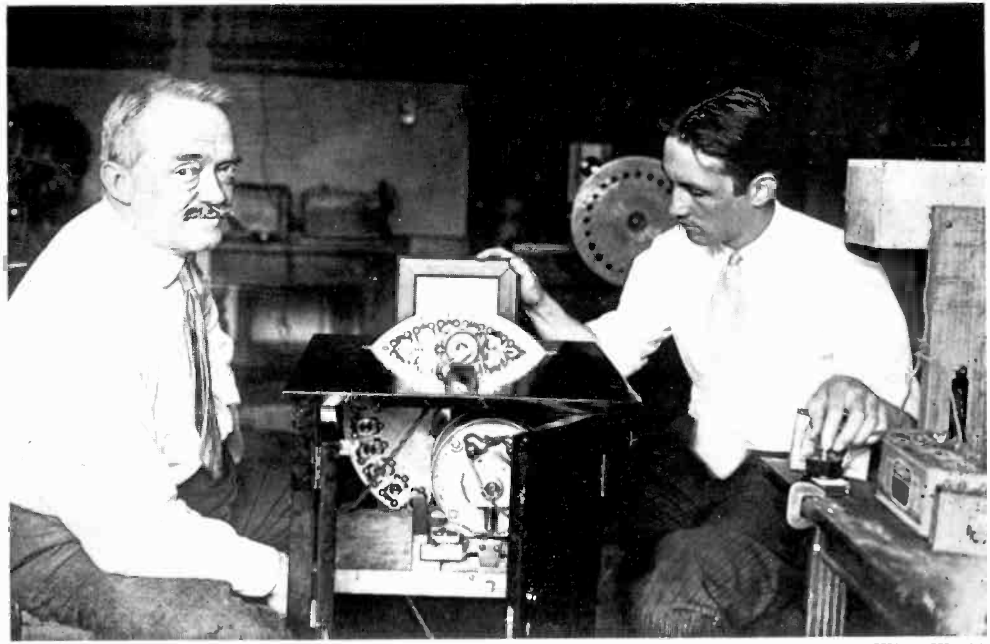
"If you put your head under the black cloth of an old-fashioned camera pointed at a baseball game you see a miniature on the ground glass—an exact reproduction of the contest as it is played. The moving picture is carried by light from the ball diamond to the ground glass screen in the back of the camera. That is exactly what we want in television, but we want it in our homes. Therefore, light working alone will not do the trick, because light travels only in straight lines, and obstructions cut it off. So we must have some sort of a carrier which can go around obstructions and through the walls of our homes. A copper wire would do, but a wire carries only to one place. Let's adopt radio, that carries everywhere!

"Now we come to the consideration of the picture, which is nothing but some black and white mixed up together in a definite order. Pick up a modern photographic portrait, which, by the way, is the most perfect example of the delicate blending of light and dark and half-tones, examine it analytically, and you will see what I mean. The problem is to transmit such a work of art through the air with entire fidelity.

BROADCASTING A BALL GAME

"But how are we going to make radio reproduce a ball game as a motion picture in our homes?

"That's easy. Don't you remember that when we were little tykes mother entertained us by putting a penny under a piece of paper, and, drawing straight lines across the paper,



Wide World.

C. FRANCIS JENKINS

This televisor received pictures broadcast from the Naval Air station at Anacostia, D. C., two miles from the Jenkins laboratory.

she made a picture of the Indian appear. Well, that's the basic principle of television," said Mr. Jenkins.

"So, in our homes we take a desk square of white blotting paper and we move across it in successive lines an image of a small light source. If this little light spot moves across the screen swiftly the eye sees it as a line, similar to one of the pencil lines that helped to trace the Indian's head.

"Now when these successive lines are numerous enough and are made so swiftly that the entire screen surface is illuminated or covered, in one sixteenth of a second, we have motion picture speed. If, then, the incoming radio current is put through a lamp the strong signals will make the spot of light on the screen very bright, the weaker signals less bright and when there are no signals the lamp goes out and the screen is no longer uniformly illuminated, but the light is dabbed about over the surface of the screen. And because a picture is only a collection of little dabs of light put around in different places on the screen it will readily be seen that these radio-light variations, when they follow a predetermined order, make up a picture of the ball game, just as the humps on the penny make up a picture of the Indian, although the pencil moved across the paper in straight lines.

"That's the way we make radio pictures and radio movies. The incoming ether waves actuate instruments which make the light run up and down as it moves swiftly over the screen and you see the distant scene. Easy, isn't it?"

THE RANGER SYSTEM

Captain Richard H. Ranger, developed a system whereby the same transmitter that enables man to fling radiograms across the ocean is likewise employed to send dots and dashes which assembled at the receiving end form photographs, drawings and facsimile reproductions. It was not long after this system was in operation in the spring of 1926 that a check broadcast from London was cashed in New York.

No change is required in the receiving circuit itself for pictures or telegraphy, although obviously, certain instruments must be employed at the transmitting and receiving ends, supplementary to the regular equipment that sends and receives code signals.

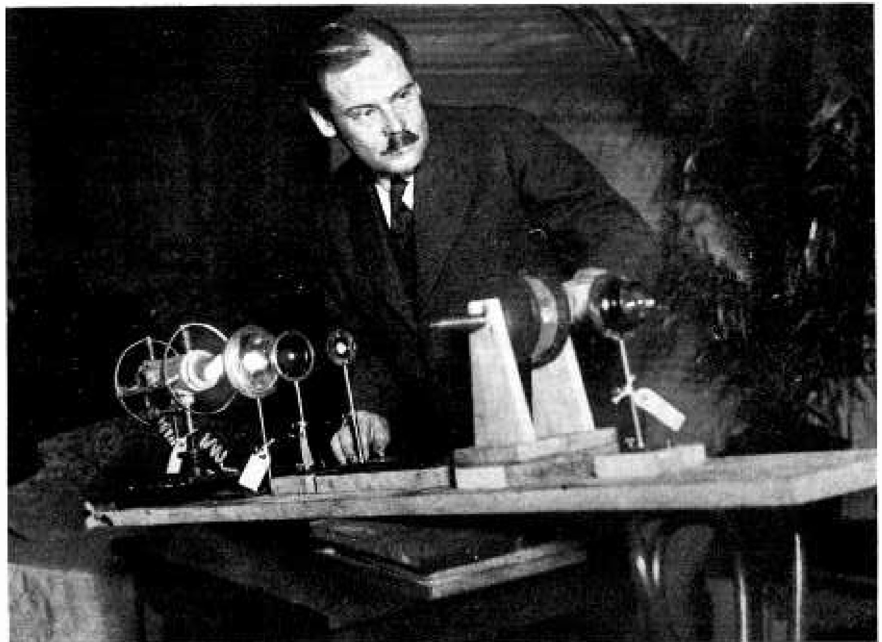
Captain Ranger has explained that image transmission over ethereal channels is a matter of picking the original apart into many unit areas, translating each unit area into electrical values, transmitting those electrical values from place to place, and retranslating them back into pictorial values bit by bit so as to reconstruct a facsimile copy of the original.

The basis of the interpretative action of the radio-photo system is an electric eye, otherwise known as a photo-electric cell, which interprets light values in terms of electric current, just as the microphone interprets sound values in terms of an electric current. A unique circuit arrangement translates the light action into terms of relay closing, which can be used to actuate the recording instruments which register the lines of the picture.

The photograph or image to be broadcast is made in transparent form and wrapped around a glass cylinder containing a powerful electric lamp. A beam of light is concentrated on a tiny portion of the unit area of the transparent image, such as a film, and passes through it to the electric eye, which transforms the light values into an electric current which passes through the transmitter and off into space as ether waves.

A STREAM OF HOT AIR

At the receiver the incoming impulses are made to control the flow of a tiny stream of hot air which brings out marks on a sensitized paper in accordance with the electrical values of the received current, which correspond to the original broadcast. The illustration is, therefore, reproduced in the form of thousands of tiny dots and dashes blending into one another. The sensitized paper at the receiver is placed on a revolving drum and it must rotate at the same rate of speed as the glass cylinder at the transmitter, in order that the unit



Underwood & Underwood.

DR. E. F. W. ALEXANDERSON

A system of lenses and a revolving drum containing twenty-four mirrors is used as the basis of the Alexanderson televisor.

area of the picture at the transmitting end will correspond exactly with the unit area of the recorder at any given moment. This synchronization has been achieved by tuning fork regulation.

An air brush was first used by Captain Ranger as a means of recording the dots and dashes, but was later discarded in favor of a fountain pen. When the pen was adopted the first problem arising was to find a way to keep the pen from becoming dry in the middle of a picture. This was accomplished by a small pump that supplied ink to the reservoir at the rate of one-ten-thousandth cubic inch for every cross stroke of the pen.

The fountain pen worked all right when it was continually making dots and dashes, but when it remained idle for any length of time the ink dried and clogged the golden nib. Then the idea of having a roller skid along the paper similar to an automobile skidding in the street, suggested itself but experiments proved it impractical.

After trying many substitutes for ink that would not clog the recording instrument, paraffin was tried. Although in a liquid state when warm it dried almost instantly when it reached the point of the pen. This was overcome by attaching a small coil of wire to the pen's point which, when carrying a slight amount of electric current, kept the nib warm until the paraffin flowed through. But in striking the film, it dried almost as quickly as it left the pen.

A CURE FOR "FRECKLES"

Shortly after this difficulty had been encountered Captain Ranger sailed for Europe to install some minor improvements on the photo-transmitter at the London end of the transatlantic circuit. It was while in London that Will Rogers saw one of the pictures which had been broadcast from New York and said that a man would have to get smallpox in order to have his picture transmitted accurately.

"The so-called 'freckles' was one thing we wanted to get away from," said Captain

Ranger, "and it was not until one day in Italy, when watching a religious celebration, that the idea of eliminating the 'freckles' came to me. During part of the festivities a number of firecrackers were buried in the sand at a beach. A man with a torch ran along and touched off the fuses, causing the firecrackers to explode.

"Working on the same principle, we tried to devise a sensitive paper with a chemical solution impregnated into it that would bring out the coloring when touched with the recording pen, which might be called a discriminating torch.

"The 'singing flame' idea was used for the torch. This was composed of two pieces of carbon with an electric current running through them, producing a flame or arc. Following a few attempts it was found that the spark from the 'singing flame' spread too much, causing the dots and dashes to blur. After experimenting with more than a hundred varieties of recorders and sensitized paper, we discovered a paper that would not blur when the recorder touched it. By using this paper it meant that we would have to amplify the incoming signal and when this was done the 'singing flame' became useless for our purpose.

"Going back to the original idea, it was found that the improved sensitivity of the new specimens of paper would bring out the tonal values of the pictures in such a manner that the reproduction was washed free of 'freckles' and did not blur, if a stream of hot air was used to 'paint' the picture instead of a pen. This was a great step forward and it resulted in the establishment of four photo-radio equipments at New York, London, San Francisco and Honolulu."

RADIO MOVIES

A television projector based upon a revolving drum carrying twenty-four mirrors which threw a cluster of seven light beams on a screen was introduced by Dr. E. F. W. Alexanderson late in 1926. These light beams were called upon to do the same trick as the pencil which traced the head of the Indian, when the penny was placed beneath the piece of paper.

Dr. Alexanderson said, "Our work has already proved that the expectation of television is not unreasonable, and it may be accomplished with means that are in our possession at the present time. How long it will take us to attain practical television I do not venture to say."

Hertzian waves had carried a single photograph from the aerial of WGY to Dr. Alexanderson's laboratory, two miles away in two minutes, before he brought the model of his machine to New York for a demonstration in January 1927, when he explained that television requires the transmission, reception and reproduction of a single picture in one-sixteenth of a second. This high rate of speed was one of the fundamental difficulties in the way of experimenters who attempted to develop a projector to enable any one to see on a screen the movement of objects many miles across the horizon. In other words it requires 300,000 brush strokes per second to produce motion pictures and in broadcasting a picture in motion, beams of light must act as the "brush."

"It is easy enough to design a television system with something like 40,000 picture units a second," said Dr. Alexanderson, "but the images so obtained are so crude that they would have no practical value. Our work in radio photography has shown us that an operating speed of 300,000 picture units per second will be needed to give pleasing results. The speeding up of the process is, unfortunately, one of those cases where the difficulties increase by the square of the speed."

PAINTING THE PICTURE

Dr. Alexanderson has devised a method of speeding up the process of moving mechanical parts by the use of seven distinct light sources, the lights converging in a cluster of brilliant beams which scan the picture, each beam painting a crude picture, but all seven interlacing optically to produce a single good picture.

Thus the Alexanderson televisor consists of seven light sources converged by an optical system to a revolving drum carrying twenty-four mirrors each tipped at a slightly different angle. These mirrors reflect the light cluster to the screen. Seven lights are utilized instead of one so that the useful illumination is increased forty-nine times.

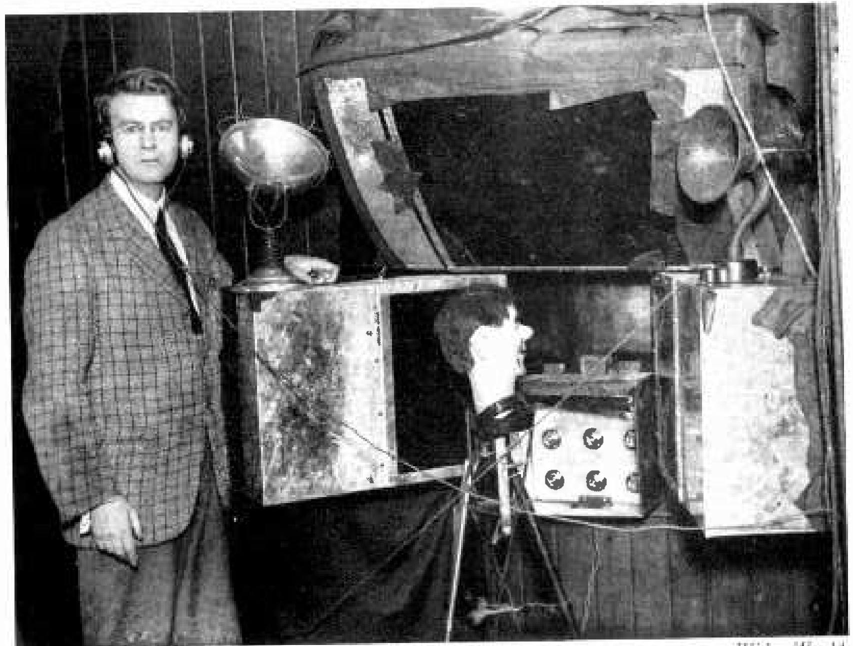
The transmitting machine automatically at every moment selects the shade that comes nearest to one of five shades as white, light gray, medium gray, dark gray and black, and sends out a telegraphic signal, which chooses the corresponding tone value in the receiving set. This may seem more complicated than it really is, because the telegraphic code by which different shades are selected depends upon the synchronization of the transmitter and receiver, which is absolutely necessary under all circumstances.

Thus black in the picture is produced by exposure of the sensitized paper to the recording light spot during four successive revolutions of the receiving drum, whereas light gray is produced by a single exposure during one of the four revolutions and no exposure for the three succeeding revolutions. The overlapping exposure is progressive and the whole works as a continuous process.

LIGHTS THAT GYRATE

The projector itself consists of a source of light, a lens and the drum carrying the mirrors. When the drum is stationary a spot of light is focused on the screen and this spot is the "brush" that paints the picture. Then when the drum revolves the spot of light gyrates across the screen and as each mirror comes into line, the light spot passes over the screen again on a track adjacent to the first, and so on until the whole surface is covered with a flood of light. There must be 10,000 separate strokes of the light brush to paint a picture of fair quality.

Furthermore, the light must be of such brilliancy that it will illuminate the screen effectively, although the beam stays in one spot only one three hundred-thousandths of



Wide World.

JOHN L. BAIRD

A Scotsman and television experimenter in London. The dummy head was used as the subject in the tests.

a second. This presented a serious difficulty, because even if the most brilliant arc light is employed and no matter how the optical system is designed it is a problem to figure out sufficient brilliancy to illuminate a large screen with a single spot of light. Alexanderson's television projector was built in order to study this problem and to demonstrate the practicability of a new system which overcame this obstacle and moved television nearer to its goal.

A SCOTSMAN'S IDEA

John L. Baird, a Scottish inventor, developed a televisor utilizing a whirling disk, which attracted considerable interest in 1926 when he sent pictures of moving objects across London. When he transmits a still picture the disk whirls only once, when he sends a moving picture the disk is kept whirling and the successive pictures are traced at the receiver.

One of Baird's most startling advances was his discovery of "seeing in total darkness." When he transmitted the image of a person over his regular televisor the person had to be subjected to an intensely brilliant light in order that sufficient light could be reflected to the eye of the system—the photo-electric cell. Baird devoted his attention to the reduction of the brilliancy necessary at the transmitter, and achieved such success that it is now possible for the receiver to reproduce the features of a person sitting in total darkness in the transmitting studio. In other words, the sensitive eye of the transmitter can actually see in the dark.

The Scotsman accomplished this by "illuminating" the face of the person at the transmitter with ether waves outside the visible spectrum, namely, those just outside red and violet light rays. Actually the waves employed are of the infra-red band, which are vibrations in the band between heat and light waves. These infra-red waves are directed upon the object in Baird's television apparatus by submitting powerful white lights to color filters which shift out all of the vibrations except the desired red rays, and while the human eye cannot see these rays the photo-electric cell has no difficulty in detecting them. It is a case of certain light rays being out of range of the human eye just as certain sounds are too high pitched or too low to be detected by the ear.

The infra-red rays have a tendency to distort the image somewhat because the photo-electric cell will not respond to all of the colors of the face when it is subjected only to infra-red light. Furthermore, the ultra-violet rays, which have also been used to obtain the same result, are injurious to the person whose image is being broadcast because these rays cause a headache and sore eyes. Therefore, it is not feasible at the present time to use these ultra-rays and furthermore, there is not much to be gained by having the person sit in a dark room in order to have the image broadcast. However, his application of the rays may be useful in other fields, possibly in locating airships.

Baird in a lecture on "Seeing by Wireless" at a meeting of the Royal Institute of British Architects, told how the picture of a hand makes a rattling sound as it passes through space; a face gives a softer tone, and by listening-in on an ordinary receiving set it is possible to recognize objects and persons by their image sounds. Each face has its characteristic note, and every movement causes the note to change in pitch. If a man before the televisor transmitter nods or opens his mouth the tone is changed in the headset of anyone listening-in on the picture transmission.

One man's face often used in the experiments across London makes a humming sound; one sounds rip-rip-rip and another zur-zur-zur.

THE BELL SYSTEM

Herbert Hoover, Secretary of Commerce, made a speech on the afternoon of April 7, 1927, in Washington and an audience in New York heard him and saw him in action. He was sitting in front of a television transmitter which projected images by wire from Washington to New York at the rate of eighteen pictures a second. A loudspeaker reproduced his voice and the pictures were flashed on a screen like a motion picture, showing the changing features of his face and lip movement as he spoke. He looked down as he read his speech and held the telephone receiver up, so that it eclipsed the lower part of his face. Then he moved and the expression of his face became clearly distinguishable, and full of detail.

When the television reproduction was thrown on a screen two by three inches, the likeness of Mr. Hoover was excellent. Those in the New York audience remarked that it was as if a photograph had suddenly come to life and begun to talk, smile, nod and look about in different directions. When the screen was enlarged to two by three feet, the reproduction was less perfect. Nevertheless, 200 miles of intervening space had been annihilated by television apparatus developed by the Bell Laboratories of the American Telephone and Telegraph Company.

After Mr. Hoover had completed his speech, Vice President J. J. Carty of the American Telephone and Telegraph Company in the studio in Washington stepped before the transmitting device and conversed with President Walter S. Gifford of the Telephone Company. The speaker at the New York terminal looked the Washington man in the eye, as he talked to him, because on a small screen in front of him appeared the living image of the man to whom he was talking.

The audience in New York were something like a thousandth part of a second later in seeing the changes in his countenance than those at his side in Washington, so quickly did the electrical impulses wing their way over the wires to New York.

That faces and voices could be projected by wire simultaneously was considered remarkable, but then the question came up whether the same trick could be done by radio or had the land lines gone a step ahead of the ether?

A few minutes later the mæstro of the affair announced that the wire circuit had been replaced by a radio "bridge" operating between Whippany, N. J. and New York.

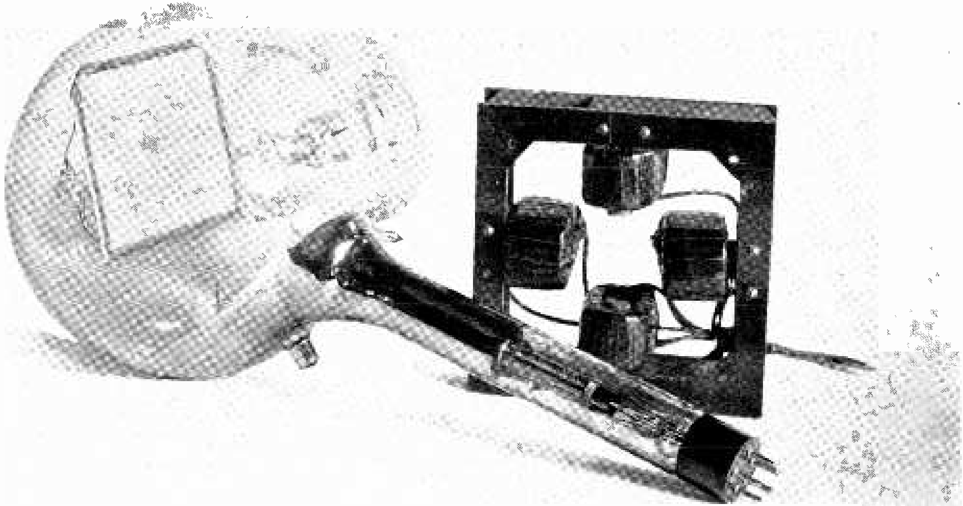
HISTORIC VAUDEVILLE

A comedian stepped in front of a televisor projector in the Whippany studio and his act will go down in history as the first vaudeville to be shot through space as a talking image, with possibilities comparable with the Fred Ott sneeze, the first comedy ever recorded on the motion picture film. A. Dolan, the first television actor, made his initial appearance as an Irishman, with side whiskers and a broken pipe as he broadcast a monologue in brogue, simultaneous with the transmission of his action-picture.

Then the audience over in Manhattan, thirty-five miles from Whippany, looked-in and listened-in on a brief humorous dialect talk, with the announcer in the Whippany studio making a television appearance in New

York between each act. He was heard as well as seen.

All television systems are fundamentally alike. The face or object to be broadcast is optically sliced into thousands of fragments of light and shade. The photo-electric cell is the "eye" of the system and as it sees the fragments it converts them into electrical impulses which are in turn converted into Hertzian waves to be reconverted into optical fragments properly assembled and corresponding in light-value and exact position with the originals. The process is practically instantaneous and the eye can not follow it, because sixteen mosaics must appear as a living whole to produce the illusion of reality. Speed and exactitude are the wonder of this process as in all other methods of television, because the dots of light must be assembled at the rate of 45,000 a second to form a motion picture. And each dot must be in its exact place or else the mosaic or square would be a jumble and the picture would be completely spoiled if there



TELEVISION'S ELECTRICAL EYE-BALL

Iconoscope designed by V. K. Zworykin to emulate the human eye. The plate-like "retina" is covered with millions of globules of light sensitive material. The electron gun in the sleeve focuses the cathode ray beam. This device is used in the television camera.

was an error of one ninety-thousandth part of a second in the synchronization between the sending and receiving installations, no matter how far they might be apart.

The operations begin when the sitter takes his position in front of the televisor and an arc light is turned on, but most of the light is shut off from the sitter by a disk in which there is a series of holes. Then the disk is revolved and the light strikes the sitter through the hole nearest the rim. This spot of light moves across the top of his head. The second hole is further from the rim of the disk and the second spot of light travels across the sitter's face just below the first, the third just below the second and so on until the entire face is apparently bathed in a bluish light. There are a total of fifty holes and therefore fifty spots of light travel across the face of the sitter or the scene to be broadcast, one beneath the other.

The engineers explain that if the process could be slowed down infinitely, it would begin with the action of one visible spot of light. In practice, however, the spots travel so quickly that the face or object seem to be flooded by a constant illumination. There is never more than one spot of light on the face at a time, but the entire fifty spots cross the face or object to be photographed eighteen times a second.

Lines, contours and colors of the face create variations in the brightness of the spots they reflect. These variations of light intensity are transformed into variations of electrical current. Three large photo-electric cells, into which the moving spots of light are reflected from the face or scene, are located opposite the sitter and facing him. When the light strikes the photo-electric cells an electron shower is created within the bulbs and the shower is strong or weak, as the light is strong or weak. It is pointed out that electron showers are nothing but electrical current, therefore these cells produce a current which constantly varies according to the characteristics of the object being broadcast.

THE PICTURE GETS WINGS

This current is amplified 5,000,000,000,000,000 times before it is strong enough to do the work required. Then it is sent, either by wire or on an ether wave, to the television receiver. Such current traveling over wires or through the ether is actually a flying picture, the features and characteristics of which are governed by every change in volume, no matter how slight.

Upon arrival at the receiver the incoming current is forwarded to a "brush" or an electrical contact device mounted on a wheel, which revolves enabling the "brush" to make and break the electrical contact approximately 2,500 times. Each contact is made with one of the 2,500 wires mounted on a circle in which the wheel turns. The engineers call attention to the fact that each wire snatches a bit of the electric current or flying picture and to each of these wires must be delivered, eighteen times in a second, exactly the bit of the picture intended for it. Just a trifle of an error would jumble the picture.

Each wire carries its impulse of current to a square of tinfoil behind the television screen. The squares of tin foil are arranged fifty in a row and there are fifty rows. When the impulse of current or tiny bit of the picture reaches one square of tinfoil, it jumps from the tinfoil to a wire and it makes the leap through neon gas, which is instantaneously illuminated by the passage of electrical current through it. Eighteen times a second there is a flash of neon in front of each of the 2,500 patches of tin foil and the flashes are strong or weak in accordance with the light or shadow on one particular part of the face or scene. These little flashes, occurring at the rate of approximately 45,000 a second, "paint" the face on the screen.

The transmission and reception of the picture—that is, the taking to pieces of the picture at the transmitter and assembling it at the receiver, is synchronized by a special system which causes each of the 2,500 squares to fall in its proper place eighteen times a second. This control requires the use of two wires when the system is operated over telephone lines, but when radio is employed one wave is utilized for sending the picture and two waves for the synchronization.

One of the research engineers likened the method to the human eye, which he pointed out was a "television system" utilizing more than a million nerve fibres which carry light impulses to the brain instead of employing 2,500 wires. He explained that as in motion pictures, it is the phenomenon of "persistence of vision" which causes the flickering squares of light to fuse together so that the eye sees them as objects in motion. Moving pictures are really still pictures shown at the rate of eighteen a second, with the eye blending the stills into motion. But television deceives the eye even more because there is only a series of spots of light flashing on and off, but each spot maintains its effect on the human eye long enough for the brain to comprehend all as a complete picture.

Thus the ether vibrates with unseen faces, and invisible waves of music and speech are criss-crossed through space at the speed of sunlight, while millions of receivers, designed to select a particular face, scene or concert out of all the seeming chaos, produce words, melodies and vision.

WAVES OF COLOR

Radio waves are not limited to carrying pictures in black and white but they will carry three or more colors. Pictures in color were sent across the United States and reproduced in their most delicate shadings for the first time in the Spring of 1927, in tests conducted by the American Telephone and Telegraph Company.

The principle of transmission is similar to that employed in sending black and white pictures over wires. The illustration or photograph to be broadcast is usually provided in the form of a negative. From this a positive is made on a celluoid film which is wrapped around a cylindrical film-holding frame at the sending station. An unexposed film is placed on a cylinder at the receiving end. The two cylinders begin to revolve simultaneously at a signal from one end. The time required to transmit a colored picture depends upon the number of colors. A separate transmission must be used for each color. Thus in a three-color print three plates must be sent. The same method is employed in making these plates as in printing. The print is photographed through color screens, which filter out the colors not to be recorded on the photographic plate.

In connection with the television experiments a new phenomenon known to radio engineers as "ghosts" has appeared. These "ghosts" are retarded images which reach the receiving set a few seconds after the first image. Some times there are three or four images which appear in much the same manner as additional figures in "spirit" photographs. The engineers explain that the "ghosts" are caused by the waves taking as many as four or five paths through the ether.

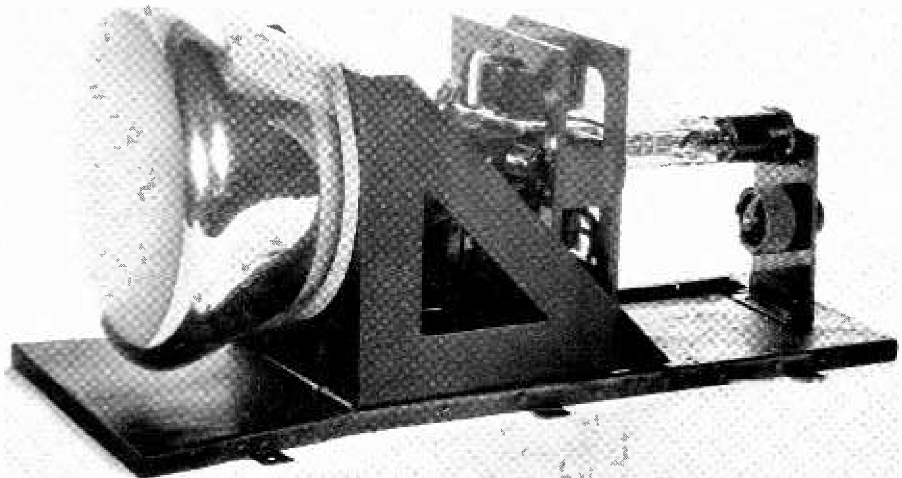
The "ghosts" are much weaker than the first image and they are usually blurred.

What curious sounds and scenes may pass along the ether's wave lengths when inventors perfect their apparatus so that radio can carry motion pictures varying from the cataract of Niagara to the colorful coronation of a Rajah under the glare of the Indian sun!

ZWORYKIN INVENTS AN "EYE"

Television needed a sensitive "eye." Dr. Vladimir Zworykin research expert in the RCA-Victor laboratories at Camden, N. J., invented one in the form of a cathode ray tube. He named it "iconoscope." "Icon" in Greek meaning image, and "scope" to observe. Therefore, the iconoscope tube could be used in a television camera to "see" the scene for transmission.

Dr. Zworykin designed another funnel-shaped tube for the receiving set to reproduce the picture. He called it "kinescope"; "kine" meaning motion in Greek. Both tubes are built to be strikingly like the human eye in perform-



WHERE TELEVISION'S PICTURES COME TO LIFE

Kinescope built by V. K. Zworykin to reproduce the television scene. The flat end of the funnel-shaped tube is covered with a substance which fluoresces when the electron beam waves across it to "paint the image." It is on this "screen" that the picture appears.

ance. The image appears as a motion picture on the flat end of the tube which is covered with a fluorescent substance.

The main Zworykin patent No. 1,691,324 covering the iconoscope was filed July 13, 1925, and was issued Nov. 3, 1928. The June 1933 issue of the Proceedings of the Institute of Radio Engineers described the iconoscope's sensitivity as "approximately equal to that of a photographic film operating at the speed of a motion picture camera—fully adequate for television." Dr. Zworykin expressed belief that television will travel on waves 6-meters in length or shorter. When he first described the iconoscope in June, 1933, it was heralded as "the greatest single step toward making television of practical use to the public."

Dr. Zworykin's contribution to television is summed up as follows:

> The scene is scanned electrically instead of mechanically by a scanning disk, thereby dispensing with a motor and a whirling disk at both sender and receiver.
>
> The inconoscope is an artificial eye with an electrical retina in the form of a wafer-like mica plate covered with millions of globules of light-sensitive material. The

back of the plate is metalized, giving a capacity effect that enables "electrical memory"—that is, the "eye" retains a scene exactly as the human eye when the lid is dropped.

The iconoscope can be used in an outdoor camera, unaided by glaring lights. It requires no moving parts or motors, and in operation is estimated to be 70,000 times more efficient than previous methods of television photography.

A cathode ray unit inside the eye's stem emits a powerful beam of electrons—it is called the optic nerve of the system. The light from the scene televised is fed to the iconoscope through a motion-picture camera lens. The cathode ray element transforms the light impulses into the electron beam that plays across the "retina," thereby being turned into electrical energy and ultra-short waves for broadcasting.

The pictures are 4 by 5 inches on the fluorescent screen of the kinescope but can be projected from there to a wall screen 12 feet square.

There are no streaks or wide lines on the pictures. They are so clear that an ordinary camera can photograph them with the clarity of a half-tone. It is not necessary to darken the room.

The tube has wide applications in many fields as an electrical eye, including aviation. The device is sensitive not only to the visible spectrum but to the infra-red and ultra-violet region, surpassing the human eye in performance.

Television promises new life for the motion picture. From reel after reel of films, scenes of far away places, news events and drama will slide from the celluloid strips into the machines that electrify and whirl the cinema around the globe as easily as a paper tape is tossed across a ballroom on New Year's Eve.

CHAPTER IX

MINIATURE WAVES OR "DARK LIGHT"

"Let there be Light:"

Genesis iii. 1

"THE graveyard of radio"—that is what the short waves were called. They measure from 200 to 10 meters in length. Ultra-short waves, less than ten meters from crest to crest, were forsaken as "no-man's land" in the radio spectrum. Several events proved these ideas and theories false. Research experts have discovered that waves less than a meter in length, which they call "micro-waves," also have intriguing possibilities.

Let us briefly trace the march of the experimenters into the short-wave realm to pick up the trails that lead to the fascinating micro-wave, dramatically called "dark light." Urgent demands for communication during the World War spurred inventors of numerous nations to delve into the short waves in efforts to perfect more directional, secretive and world-wide communication. Necessity was truly the mother of invention. Intense research at the same time greatly improved the vacuum tube; the actual key to short waves. What appeared to be "graveyards" suddenly loomed as "gold fields," rich in opportunities for expansion of wireless.

Amateurs as well as professional experimenters discarded the old spark transmitters and adopted the vacuum tube as a means of generating and detecting short waves. Gloom of the amateurs, who had been ordered to relinquish their longer wave channels, vanished. They were happy again on the international short wave reservation. But not for long.

Commercial interests were quick to realize the value of the new "territory" found in space and rushed in to stake their claims with licenses that sanctioned commercial traffic. Soon the short waves were buzzing with business. The amateur was assigned specific channels upon which he had to stick. All around him high speed transmitters, Marconi beams, police calls, airplanes, ships and international broadcasting encroached on the boundaries of his experimental domain. Globe-trotting by radio became a new sport. All-wave receivers put the home in touch with foreign lands.

JUGGLING THE WAVES

Many nations aware that the short waves were ideal links with the colonies and for spreading publicity, pumped high power into their globe-girdling transmitters. They trained their ethereal projectiles on the "mirror" of the Heaviside layer confident that it would ricochet the signals back to the earth.

Some waves, of course, were more effective in the daylight and others performed their mission better in darkness. The international broadcasters lost no time in arranging the directional aerials to cope with the effects of day and night. They pointed the wires properly to "searchlight" specific waves into the dark areas of the earth. Then to reach the regions of the globe on which Old Sol was smiling, they employed other directional aerials capable of projecting concentrated energy on definite wave lengths adapted to penetrate daylight.

Soon the experts had informative charts of the ether. They logged the waves and learned exactly what channels to use for best results at certain hours of the day and night. Now they can even chart magnetic storms and forecast with such accuracy, that the results of transmission and reception between the hemispheres can be determined several weeks in advance. That is all part of the science of short waves.

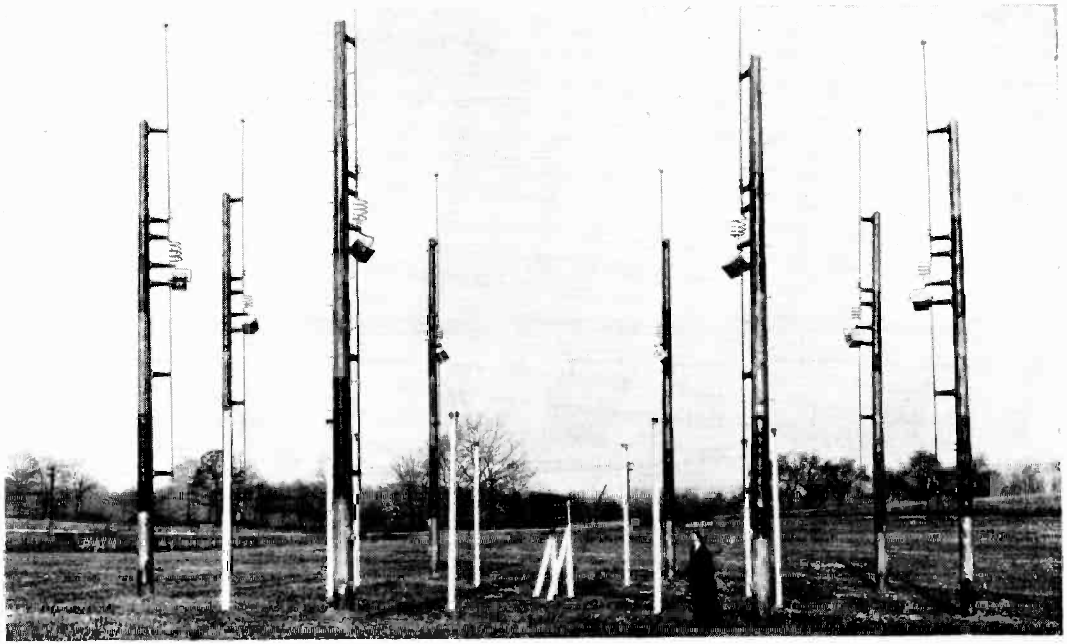
WHERE "ECHOES" ORIGINATE

"Echo" signals appeared to taunt the listeners. Immediately a world-wide trap was set by scientists in an organized effort to solve the mystery of delayed signals. Just as an echo resounds from some natural sounding board such as a cliff or gorge, so these ethereal reiterations register several seconds after the direct or main signal is heard. Lapses between the signal and echo have been sufficiently long in several instances to lead radio experts to estimate that the secondary waves came from beyond the orbit of the moon.

Science is anxious to clear up the mystery or to find some way to overcome the reverberations, because in television these freak antics are more annoying than in wireless. In television the echo becomes "a ghost." After the main image flashes on the screen faint duplicates or "sprites" of the same figure appear a second or two later.

Senatore Marconi once told of intercepting round-the-world echoes. He said he had observed at least seven echoes on the globe-encircling short waves. It will be recalled that radio waves travel around the earth seven and one-half times in a second, so that only fractions of seconds may separate the primary signal and the echoes.

Marconi explained that he had recognized short words such as "no" after they had sped around the earthly sphere more than once. It is difficult, however, to understand longer words after two globe-girdling flights, because



LONG RANGE ETHEREAL "GUNS"

On the short-wave reservation at KDKA many experimental aerials are used to project the international broadcasts into space.

the echo is back at the point of origin before the last syllable of a long word is uttered.

The phenomenon of these round-the-world echoes, however, is not as puzzling as those flashed back from interstellar space. What reflects them? That is the question. The elusive signals apparently penetrate the Heaviside surface or, finding a hole in it, escape into outer space, only to be shot back to earth.

"Long-delayed echoes are a baffling phenomenon," said Dr. J. H. Dellinger of the Bureau of Standards. "Echoes have been heard from one to thirty seconds after the emitted signal. Not enough is known, however, to determine definitely what causes echo signals or how they are propagated."

THEORIES OF "ECHOES"

There are various theories to account for the strange repetition of signals. Dr. Carl Stormer of Oslo University, Norway, who is noted for his observations of wireless echoes, suggests that there are streams of electrons, tiny specks of electricity, lurking thousands of miles above the earth's surface. The radio echoes, according to the Stormer theory, are reflections from this electron stream or "curtain."

Professor Stormer bases his theory upon mathematical calculations in connection with his research of the northern lights. He explained that when electrical particles from the sun, radiating toward the earth, meet the magnetism of the earth, an enormous vacant space is created around the Equator. Through this space the electron particles can never penetrate. But the vacant space grows less toward the Poles permitting the electrical particles to break through, manifesting themselves as aurora borealis.

The idea that the retarded signals are caused by interference of the radio waves in the earth's atmosphere has been generally abandoned. It is pointed out that if this theory were true some of the signals would have traveled from twenty-eight to one hundred times around the earth, because from four to fifteen seconds have elapsed between the first signal and some of the echoes. Encircling the globe one hundred times seems impossible, because in such a prolonged flight the waves would have become so weak as to be imperceptible. Therefore, it is believed the echoes returned from outer space.

There is no "wall" in a material sense that throws the echoes back, according to Professor Stormer. He believes the "wall" is a barrier caused by collision of electrical waves from the sun and the magnetism of the earth. Then, according to his theory, radio waves which escape from the earth's atmosphere and penetrate the upper regions in the lower latitudes strike this "wall" and are echoed to the earth.

It was Jorgen Hals, a Scandinavian radio expert and experimenter, who, in 1928, calculated the distance traversed by remarkably strong echoes as going beyond the orbit of the moon.

When Dr. Lee De Forest learned that Hals had intercepted a radio echo some 2.7 seconds after the signal was broadcast, he remarked: "Imagination totters and reason reels before these possibilities. There are more things in heaven and earth, Horatio, than are dreamed in your philosophy."

ACROSS A NEW FRONTIER

Lured by the short wave magic pioneer experimenters pushed across the ethereal frontiers into the more mystifying spectrum below the 10-meter mark on the dials. There again they found surprises. Strange antics of the ultra-short impulses indicated they might be the key to new miracles in radio. The tiny waves do not fade normally. Static does not bother them, therefore, reception is not dependent on seasonal influences. They are unaffected by fog and offer a high degree of secrecy by virtue of the sharp directive qualities.

It is likely, according to engineering reports, that ultra-short waves will be utilized for facsimile and television broadcasts in which clarity and detail are vital. It is explained that the frequency bands required for television are hundreds of kilocycles wide depending upon the degree of image detail. Obviously this demand for a wide pathway curtails the number of channels available. Therefore, it is believed that the number of ultra-short wave television stations, for example, between two and six meters, in a given area would not exceed five or ten.

One apparent disadvantage gave the engineers much food for thought. The tiny waves seemed to go only so far; they balked at the horizon. That is why they were given the name "quasi-optical" waves. Experts found it difficult even under favorable conditions to intercept the waves beyond the theoretical horizon. They wondered, however, if such waves shot off the earth at the horizon and never came back. Anyway they soon learned that the aerials had to be on high pinnacles for best results. The higher the aerial, the greater the range of "sight." For example, if from the top of a skyscraper man could see sixty miles on a clear day, the ultra-short waves radiated from that lofty site would probably cover that radius.

A MARCONI WARNING

Marconi was quick to warn, however, that it is dangerous to put limitations on radio waves.

"Long experience has taught me not always to believe in the limitations indicated by purely theoretical considerations or even by calculations," said Marconi. "These—as we well know—are often based on insufficient knowledge of all the relevant factors. I believe, in spite of adverse forecasts, in trying new lines of research, however unpromising they may seem at first."

For several months in 1932, he cruised in the Mediterranean, and in December came ashore to report his findings to the Royal Institution of Great Britain. As he told the story scientists saw the pages of radio history turning to a new chapter, "Ultra-short waves."

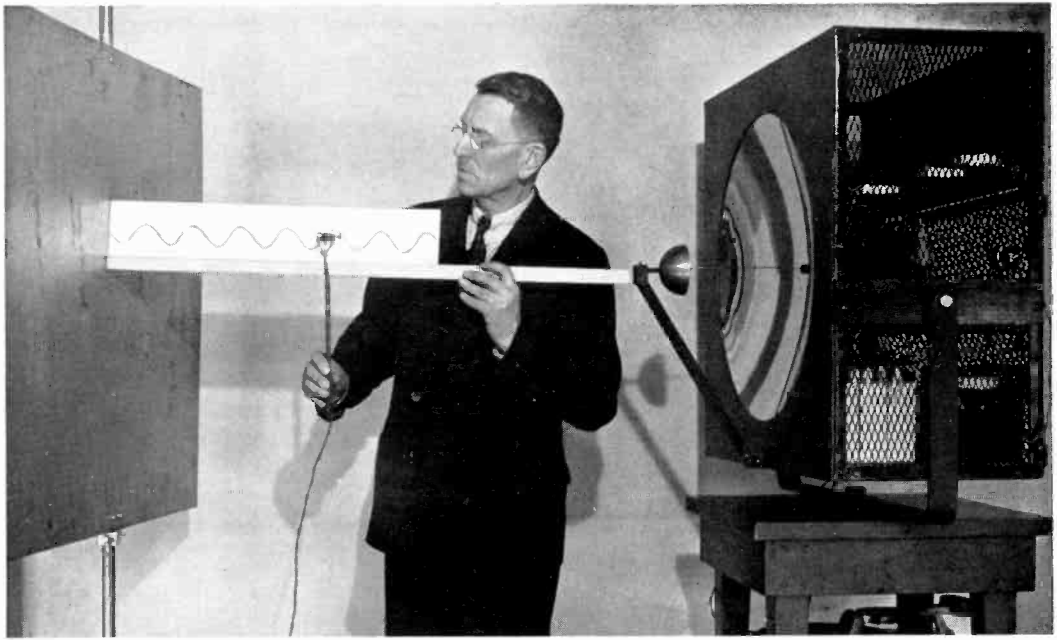
When the *Elettra* was anchored at Golfo Aranci, Sardinia, the ultra-short wave equipment was taken ashore and installed in a tower of a signal station at Cape Figari. The transmitter was at Rocca di Papa, 168 miles distant, and the signals were readable, although the optical distance or theoretical horizon, considering the altitude of the two places, was seventy-two miles. Apparently the old quasi-optical theories were wrong, prompting a London observer to remark: "Marchese Marconi has driven past the warning lights into forbidden highways."

"In regard to the limited range of propagation of the ultra-short waves, the last word has not yet been said," warned Marconi. "It has already been shown that they can travel around a portion of the earth's curvature, to distances greater than had been expected. And I cannot help recalling that at the very time when I first succeeded in proving that electric waves could be sent and received across the Atlantic in 1901 distinguished mathematicians were of the opinion that the distance of communications by means of wireless would be limited to a distance of about 165 miles."

WHAT EXPERTS OBSERVE

American engineers were quick to track down the ultra-short waves. Expert technicians of the Bell Telephone Laboratories cruised around Boston in a mobile receiving station to intercept and study radio's "dark light," which was described as spreading like soft twilight in all directions. The waves were sprayed over an area 55-miles square from an aerial 130 feet above the ground. Never did the engineers completely lose the little waves although many "shadows" were encountered, especially behind buildings and under bridges. Some streets were "brighter" with the ultra-short wave energy than others, because the waves splashed and reflected from the various obstacles in their path. Steel reinforced buildings obviously exert more influence on the signals in the streets, than do frame houses or three-story brick structures.

The presence of a good signal on the side of a building away from the transmitter was noticed, although no signal could be heard in



MEASURING TINY RADIO WAVES

I. E. Mouromtseff, Westinghouse research engineer demonstrates the length of ultra-short waves as emitted from the sender on the right to be reflected by the shield on the left. Note the tiny receiving antenna in his hand.

the center of the building. This is considered evidence of complete absorption of the wave by the building, and reflection from surrounding structures. For example, a receiver inside the tower of the Woolworth Building in New York detected no signal from the duralumin aerial rods of a transmitter atop the Empire State Building. Outside the tower, on the north side of the building toward the sending station the signal was strong. On the south side away from the transmitter the signal vanished.

This is attributed to the fact that there were no near-by buildings high enough to reflect the south traveling signals on the south face of the tower. Furthermore, these observations indicated that the ultra-short waves are considerably diffused. But they consider this diffusion rather fortunate because it may provide signals on the "shadow" sides of buildings, in much the same way that light goes through a window not facing the sun.

Reception of 5-meter waves at distances more than 200 miles below the line-of-sight, and reception behind hills, indicates to the engineers that diffraction or refraction or both do exist to a noticeable degree. But to what extent tests have not disclosed.

An ultra-short-wave receiver in an autogiro, 75 miles west of New York, intercepted the broadcasts from the Empire State Building's pipe-like aerial at practically constant strength from 4,000 down to 3,000 feet. The signals fluctuated slightly down to 1,000 feet, decreasing rapidly during the remainder of the flight, especially below 400 feet.

The engineers confess that the causes of such relationships between signal strength and altitude at distances beyond the line-of-sight are not definitely known. They have observed that at high altitudes the strength of the signals varies essentially inversely to the distance from the transmitter, indicating little or no absorption of ultra-short waves through clear atmosphere.

A receiver on Mt. Greylock in Massachusetts, 3,505 feet above sea level, 140 miles from New York, and 5,000 feet below the line-of-sight of the Empire State Building aerial, received the ultra-short wave signals. So did another receiver on top of Mt. Washington in New Hampshire, 6,290 feet above sea level, 284 miles from New York, and 37,600 feet below the line-of-sight. The wave was 44 megacycles or 6.8 meters; a 61-megacycle or 4.9-meter signal was stronger.

Reception at sea, 170 miles east of New York, utilizing an antenna 60 feet above sea level revealed little variation in signal intensity. It can be seen, therefore, that the range of an ultra-short wave transmitter depends upon elevations of the sending and receiving sites, also the heights of the aerial and antenna, and, of course, upon the elevations and nature of the territory between them.

THE "BABY" AMONG WAVES

The shortest practical, ultra-short waves projected by American engineers are believed to be 9 centimeters in length or 3⅝ inches. Millimeter waves have been produced however, by electric discharge through metal filings immersed in oil but no practical application has been found for them outside of the fact that they are the subject of interesting laboratory experiments. They are extremely feeble.

The 9-centimeter waves have been sent out with a power of 2½ watts covering a line-of-sight of sixteen miles. However, ordinary detectors are not efficient at such high frequencies. That has started an engineering conquest for new detectors, several of which have been developed in the size and shape of an acorn.

Despite the fact that lightning storms have little or no effect on ultra-short waves, considerable interference is noticed from the electric systems of automobiles. An auto starting in the street will generally stir up annoying sharp clicks, and objectionable noises have been picked up from the ignition systems of motor cars accelerating in low gear in the street below the receiver. Of course, suppressors for the spark plugs and shielded wires are the antidote.

These truths the engineers have gleaned from their observations:

Ultra-short waves propagated over unobstructed paths follow the law of optics.

Ultra-short wave reception is better over salt water than over land or fresh water, possibly because of the better conductivity of salt water.

The height of the aerial and antenna above the roof level is more important than the height above the ground.

Overhead electric wires and trolley wires "screen" ultra-short waves; bridges and steel structures are also barriers.

There is little or no sky wave phenomenon to consider below 10 meters. The ultra-short wave travels a "ground" or direct path.

Tests indicate no appreciable difference in reception between vertically and horizontally polarized waves when high aerials are used several thousand feet above sea level.

"MIRROR" IS NOT GUILTY

The engineers are quite convinced that the Heaviside surface does not reflect ultra-short waves sufficiently to be a factor in the phenomena. They believe that the ultra-short wave, as far as earthly reception is concerned, clings closely to the ground and is a direct wave in contrast to the medium short waves that leap off the earth only to be reflected by the "radio mirror." It will be recalled that the billowing up and down of the "mirror" is blamed for fading of short waves. Therefore, since the ultra-short wave heard on the earth does not encounter that unstable "mirror" for reflection, it does not fade.

Experts of the Bell Telephone Laboratories have reported to the Institute of Radio Engineers that even if the surface is rough, it is to be expected that an ultra-short radio wave may be reflected regularly from a body of water. They have observed the existence of regular reflection is less obvious, however, when transmission is over rolling land.

Aside from reflection and diffraction of the waves, the technicians call attention to a third electrical concept—atmospheric refraction. This is their explanation:

"It is a well-known fact that a star, appearing to be exactly on the horizon, is really 35 minutes below it. It is obvious that the 'image' of an ultra-short-wave transmitting aerial will be elevated above its true direction by this same means. The only question is whether the effect is appreciable or not. The answer, obtained theoretically, is that refraction must be taken into account. Unfortunately, we so far do not have quantitative measurements which show the effect of refraction of ultra-short waves in an unmistakable way. Those that we do have, however, appear to be consistent with expectations based on this theory:

"The physical picture to be assumed is one in which the dielectric constant of the atmosphere decreases with the height above sea level and is not a function of horizontal dimensions. In other words, the phase velocity of a wave in this medium becomes greater as the distance from the center of the earth increases. In the case of ultra-short waves, we are almost always interested in waves traveling in a substantially horizontal direction. The wave front, therefore, lies in a plane which is nearly vertical, and since the upper portions travel faster than the lower, there is a tendency for the ray to bend slowly back toward the earth."

RADIO'S RELATION TO LIGHT

As the radio research corps penetrates the micro-wave spectrum, naturally, radio and light waves are found to have a close relationship. For example, the noted scientist, Nikola Tesla contends that light cannot be anything else but longitudinal disturbance in the ether involving compressions and rarefactions. In other words, it can be nothing else but a sound wave in the ether. He calls attention to the fact that experiments prove light propagates with the same velocity irrespective of the character of the source; a candle, for example, can project light with the same speed as the blazing sun, which has immensely higher temperature.

"The waves of light," explained Mr. Tesla, "which are impressed on the medium are due to vibrations of a material structure, which is the same everywhere in the universe, and, therefore, the phenomena are the same in character whether the disturbance is produced by a small or large source of energy. Such constancy of velocity can only be explained by assuming it is dependent solely on the physical properties of the medium, especially density and elastic force.

"As a matter of fact wireless transmitters emit nothing else but sound waves in the ether, and if the experts will realize this, they will find it very much easier to explain the curious observations made in the application of these waves. It being a fact that the radio waves are essentially like sound waves in the air it is evident that the shorter the waves the more penetrative they would be."

THE HOPE OF CENTURIES

Naturally the approach of the radio to the borders of light, and reception of "echoes from the stars" inspired the Jules Vernes of Space to speculate on interplanetary communication on the wings of micro-waves.

Man, of course, has long dreamed of signaling to Mars, 35,000,000 miles away. That planet is usually suggested because its "canals" and indications of vegetation have encouraged astronomers to believe the red-hued sphere to be inhabited.

The discovery of wireless renewed the hope of sending messages to planetary neighbors.

But scientists have had little faith in radio reaching that far because the Heaviside layer's rarefied air always seemed to stop the signals and fling them back to Mother Earth.

In some of his experiments, I. E. Mouromtseff, research engineer of the Westinghouse Electric and Manufacturing Company, discovered a way to make radio waves almost as short as light waves. And he argues if light will come from Mars and even further, then why should these tiny radio waves be stopped by the Heaviside surface, despite the fact that it may be about 100 miles above the earth? The waves produced by Mouromtseff are described as being identical with light in every characteristic except in length.

As a matter of fact, he says there is more difference between long and short radio waves than there is between micro-waves and long light waves. To illustrate this, he says the longest radio wave in use is more than a million times as long as the shortest radio wave ever produced. The shortest radio wave is only 1,000 times as long as the longest visible light ray. Hence, he concludes radio waves are merely "dark light."

"It would be maddening if the human eye and ear could see and hear all the sights and sounds that exist in the world," said Mouromtseff. "Visible light waves, those between the long red and the short violet, constitute a small percentage of the total range, just as audible sounds are a small fraction of all existing noises. Many of these have wave lengths or frequencies much too high or too low to set up corresponding vibrations in the human eardrum.

CAN WE REACH MARS?

"Nature has been kind to impose these limitations on our eyes and ears. Certainly, all would be chaos and confusion if we could see and hear everything. On the other hand, science would be seriously handicapped if it had not perfected instruments and apparatus to detect the invisible and inaudible.

"At different times certain people have interested themselves in the possibilities of communication with possible inhabitants of Mars.

If anything of this sort is ever to be accomplished, it will probably have to be done by means of ultra-short radio waves."

This, of course, is far removed from the theory that micro-waves stop at the horizon, but Mr. Mouromtseff admits he bases his idea on theory just as atoms and electrons were created by theory to explain certain phenomena.

"We are certain that not only heat and light waves can penetrate something like the Heaviside layer, but that all radio or 'dark light' waves, less than seven meters long, will penetrate that layer and leave the earth," explained Mr. Mouromtseff. "It is conceivable that the power we have succeeded in getting into our 42-centimeter beam is sufficient to pierce the Heaviside layer and travel 35,000,000 miles to Mars. It is possible that such small power may carry to such great distances, because of the fact that practically all of the intervening space is really a high vacuum and does not, therefore, absorb the waves, once they get through the earth's atmosphere."

In a searchlight, the rays originate at one point, reflect from a parabolic surface and pass out in a narrow beam. With the Mouromtseff apparatus the radio waves reverse this process by striking the parabolic mirror, where they are reflected to a short antenna and detector tube located at the focal point corresponding to the source of light in a searchlight.

Suppose the tiny waves were projected like a great searchlight across the intervening space to Mars and actually reached its surface. Then new riddles are involved. What code would the Martian understand and, vice versa, how could the earthly residents interpret dots and dashes of strange tongues from the emptiness of space?

The Martians might, if they had machines to receive the messages, interpret the earthly clicks as a new kind of static and blame the disturbance on the sunspots or magnetism. A powerful radiophone might bombard Mars with words and music, but how would they understand?

Television might be the answer. Pictures would be proof. Illustrations would help the inhabitants of Mars to understand the earthly chatter. Scenes would give them many clues, and what an exchange of ideas might ensue, especially if the Martians were further advanced than the earth. They might learn much from the earth and the earth might learn much from them.

The tiny waves may be a sky-way of approach. What will flow over them, however, only time can tell.

HORIZON IS NOT THE END

Rightly one may sense some disagreement among the experts. One group ponders over interplanetary communication with ultra-short waves. The other asserts such waves are useful only over "eye" distances. Analysis of the two ideas, however, reveals that the reasoning of both may be correct.

The fact that the ultra-short waves are picked up only across comparatively short distances on the face of the earth does not mean that they end their flight at the horizon. It is only the jumping off place. Indeed, there is evidence that they travel in a straight line jumping away from the earth at a tangent at the horizon like sparks from a grinding wheel. The sparks do not return to the wheel but fly off into the air. So it may be with ultra-short waves. If they are to be "bent" around the globe it is necessary that relay stations pluck them from space before they get out of reach of the earth and "boost" them along from city to city. In fact, two such relay stations might be needed for New York skyscraper signals to reach Philadelphia.

Apparently ultra-short waves have little affinity for the earth. Therefore, they are not earth-bound, and might very well continue indefinitely in the direction they are propagated, unless absorbed in space. Ultra-short waves in their relation to the earth are like a steel bar resting on top of a basketball; they touch only a small area. The rod, however, may reach out and contact another ball several feet away. In the same manner the very short radio waves might poke out through space and touch another planet.

When radio waves are made short enough they are really "optical" rather than quasi-optical. They can be directed against a flat metal surface to be reflected exactly as light from a mirror. If the wave is projected at a definite angle against a skyscraper or metal object, the rebounding wave leaves the "mirror" surface at the same angle. That is in accordance with the law of optics.

These ultra-short waves and micro-waves are more "delicate" than the medium and long waves. The extremely high frequencies are generated by precision apparatus and it is no simple task to inject high power into the tiny waves and prevent them from wandering off a specific channel.

The various problems are called acute. The length and bend in every little wire in the sending and receiving circuits are of marked significance. The technicians hope that they will discover a way to entice these waves to handle more than a few watts of power. How to make a 6-meter wave carry ten kilowatts is a puzzle. To gain the most efficiency from the waves, wire-reflectors are employed to concentrate the energy and project it in directional beams. The disadvantage, of course, is that the broadcast does not cover a given radius with equal intensity.

The ultra-short waves are the prima donnas of the Hertzian wave family. Every care must be taken to prevent the receiving antenna from being "shielded." If some object, even a tree, blocks the path of the waves, reception can be improved by moving the antenna a few feet to obtain a "clear view." One ultra-short wave experimenter tells how he tried to receive signals in his kitchen, but all in vain for the stove was a "shield" or "absorber." He moved the receiver into the dining room and picked up the signals, but when he moved the set near a steam radiator in the room the elusive waves vanished again.

As long as the service area of an ultra-short wave transmitter is limited, obviously, quite a few stations can operate on the same frequency without interfering if each station is just over the horizon from the others. Under such circumstances, New York, Providence, Boston, Philadelphia and Washington could all operate 3-meter television or facsimile stations without the broadcasts overlapping. There is no telling whether or not this theory will hold, for already between New England hill-tops communication has been established on the 2½ meter wave across a 100-mile span.

Fascinated by the micro-waves, technicians who revel in scientific exploration are moving toward greater triumphs in photo-radio or facsimile broadcasts now heralded as "the gateway to television."

The medicinal properties of the ultra-short waves are also under thorough investigation, for if a micro-wave can affect the white of an egg without disturbing the yolk, as is true, what may be the influence of various waves on human membranes, tissues, organs and malignant growths? Already general fevers have been kindled by the tiny waves, and experimenters believe that even the average human body has a natural wave length of about 3 meters, that is, currents pulsate in the body at a frequency equivalent to 3 meters.

RADIO THERAPY

Medicinal radio is referred to as "radiothermy." The apparatus is called "electrotherapeutic" and the treatment "electronic" or ultra-short wave therapy. By no means, do even its most ardent sponsors herald it as a universal cure. Experiments, however, reveal interesting possibilities. Some of the results have been highly promising, in fact, encourage profound research.

In this science of ultra-short wave therapy, heat is produced by the action of a condenser field upon an insulating substance such as the human body. No metal contacts the tissues. It has been observed that the only substance in a condenser field which does not become heated even under the influence of the shortest waves is the air. Non-conductors such as glass can become very hot when subjected to this electric field; human tissues, which have a certain electric conductivity warm faster than insulators.

Research experts in this realm have formulated a rule that, "the smaller the electrodes and the further their distance from the body, the shorter must be the radio waves for a definite effect." Choice of the proper size electrodes is dependent upon whether deep-seated heat is desired, or skin effects. Designers of the apparatus caution that ultra-short wave treatment should produce a moderate, agreeable warmth, never a burning sensation or pain. Oddly enough, overheating through ultra-short wave applications does not necessarily cause a sensation of heat but of pain. That is a signal to shut-off the machine, and when the pain disappears, treatment is resumed at diminished electrical output.

High power does not seem to be essential. For example, 10-watts is considerable power if comparatively small electrodes concentrate the radiations over a small surface. Furthermore, it is found that 10-meter waves may pro-

A RADIO "SEARCHLIGHT"

Ultra-short waves have properties similar to those of light. The beams can be focused by a reflector like a searchlight for point to point communication. I. E. Mouromtseff is shown with the reflector at his Pittsburgh laboratory.

ject energy into depths not reached effectively by 20 to 30-meter waves. It is believed that the energy of the longer waves is absorbed by the subcutaneous tissues.

As the waves are shortened, the size of the electrodes can be reduced, and, therefore, more energy is "beamed" on a small area. If the wave is short enough, small electrodes can be far enough away from the body, and yet project enough energy to create heat at depths. It seems to be a general opinion that the energy which can be utilized for concentrated heating effects depends upon the shortness of the wave.

"Electronic doctors," as they might be called, explain that electrodes close to, but not touching the skin produce a concentrated heating effect of the skin but little depth warmth. Electrodes equally spaced about one inch from the skin heat uniformly. General fever work, it is believed, can be done equally as well with waves 20 to 30 meters long as with a 10-meter wave. The effect of waves below 5-meters is still an open question, according to experimenters. Some are inclined to believe that the shorter the wave the higher is the therapeutic efficiency and more uniform the penetration.

Metallic fragments, bullets, etc., lodged in the tissues may hinder successful ultra-short wave treatments because of overheating. Teeth fillings (metallic) are not generally obstacles, nevertheless the patient should be divested of all metallic substances such as keys, coins, watch and chain. The treatment chair or couch should not contain metal parts; they might cause irregular distribution of heat or cause burns, should sparks jump from the body to the metal. It is a good general rule that no metal should touch the patient, nor should the patient be placed on a semi-conductor even if covered with a blanket. Furthermore, the air-gap between the electrode and the skin is important, otherwise overheating of the skin and possible burns may result.

Those who have designed these ultra-short wave appliances suggest this rule when maximum depth effects, such as heating the abdomen or chest, are desired: "Ultra-short wave apparatus is adjusted to maximum output and the electrodes are placed a distance from the skin where the patient feels an agreeable warmth. Then refinement in the adjustment can be made by slight reduction in the machine's output." It is pointed out that the higher the output of an ultra-short wave instrument the less heating of the electrode itself, and, therefore, a better depth effect is obtained. Experts in the field warn that a shorter wave will only be efficient if it is combined with sufficient output, therefore, it is always necessary to produce a normal feeling of heat at the surface.

Trained experts under medical supervision should, of course, operate the instruments. Radiothermy is no hit-and-miss method or a job for the amateur. Great precaution should be exercised under any circumstances, especially when the brain or heart are in the treatment field. Some patients become dizzy, develop headaches or nervousness, when the ultra-short wave is applied to the head. The pulse should always be controlled.

Results of more than five years of practical study in this field of therapy indicate that where a strong perspiration is the aim, the treatments should not be given through the clothing. A thin layer of absorbent material is usually placed between the electrode and the skin to keep the skin dry, otherwise, the wet surface might cause overheating and burning sensations. Possibilities of burns exist mainly where bones are close to the surface, for example, at the elbow, knee and ankle. An increase in the air-gap between the electrode and the skin minimizes this possibility.

Electronic-medicine had an accidental beginning. It was observed that experimenters working in the General Electric laboratory at Schenectady developed "friendly" fevers, and became very warm, despite the fact that they were in good health and the room was not overheated. Investigation revealed that the short waves with which they were experimenting were causing artificial fevers. A new field of research was opened, and, today, radio-fever can be created and controlled exactly to the point where it helps the body fight a particular ailment. Attention is called to the fact that where a heart might not be able to withstand a certain drug that could produce an artificial fever to war against a disease, the radio-fever might have no ill-effects and yet accomplish the desired result, without danger to the stricken person.

Investigations of radio treatments have been conducted in numerous medical laboratories and in leading hospitals, especially in the war against paresis, arthritis and other maladies. The operator, probably a nurse or a doctor snaps a switch, turns a dial and the patient rolled in blankets begins to warm up; the thermometer reveals that the ultra-short waves are at work on the blood stream. All patients, of course, do not show equal response; much depends upon the nature of the affliction.

No physician terms radio a sure cure for arthritis; some may be cured; others merely relieved. But they do say the tiny waves are a powerful weapon in fighting paresis. As a remedy for asthma and a defense against infection, radio-fever shows great promise when it "boils the blood."

Medical men are keenly interested in the new science. They are learning more and more each year about radio-thermy that reinforces the ramparts of the human system when attacked by the enemy—disease! Here is a real field for exploration!

CHAPTER X

PICTURES BY RADIO

"I have heard of thee by the hearing ear,
But now mine eye seeth thee."
Job xlii. 5

FACSIMILE or photo-radio is the process of broadcasting pictures, drawings, maps, printed matter and other graphic material. The reproduction at the receiver is called a picturegram. Telephoto is a similar process for sending such items over wire lines.

Since the public eye was focused on this new art in 1925 when photo-radios were flashed from New York to Honolulu, progress has been rapid. Short waves and improvements in vacuum tubes have done much to speed the development. From the research laboratories three main photo-radio systems have evolved.

The graphic method features an electric pen which sketches the facsimile. The optical process utilizes a sharp pencil-like beam of light which plays through lenses upon a sensitized paper to "paint" the picture or reproduce the print. The third, and more speedy method is television by means of which the complete picture or message is cameraed and flashed instantaneously. The other two methods are slower because they transmit and assemble the broadcast line by line as the pen or light beam moves to and fro across the negative and paper, sketching 100 lines to an inch.

The general principle of the pen-and-ink method is clearly portrayed by this simple illustration: Place a piece of paper over a five-cent piece and move a pencil across it in closely spaced parallel lines; the Indian's head of the coin then appears in black and white on the paper.

A PEN DOES THE TRICK

Now watch a little pen motivated by an electric magnet do the trick for radio as it feverishly traces back and forth across an unwinding reel of paper three or more inches in width. It writes what the radio waves are saying, and if they are vibrant with cartoons or pictures, the pen sketches them too. The little pen, moving like an excited finger, streaks across the paper with a motion that seems anxious to go some place—beyond the confines of the tape. John V. L. Hogan, research expert, is sure it will write radio history.

This facsimile instrument is a compact box about a foot square and it can be built for the price of a loudspeaker. The engineers foresee the day when such a unit will be incorporated in the home receiving set. They envision on the cabinet top a glass window through which the user watches the pen scribe its message or draw a picture. It prints from thirty to sixty words a minute.

The engineers confess that entertainment value is lacking in such an instrument, but they see many ways in which it can supplement sound broadcasting. Possibly the machine might work in the night, producing a long reel of stuff to be read at breakfast time. It is not entertaining to continually watch the pen perform its work, any more than a person would install a stock or news ticker in the home for entertainment. Therefore, night-time operation is suggested.

In a demonstration to give some idea of what the instrument can do, while a voice was describing the beauty of a motor trip up the Hudson to West Point the pen alongside the receiving set was drawing the road map of the entire route. Then the outlines of an elephant and several comic characters were broadcast, so that children might rip the completed sketch off the machine as the paper tape rolled along. The voice on the sound wave furnished instructions on how to make a paint book and color the figures that came through the air.

To indicate the clarity of the machine's work, sheet music was broadcast and the three strips pasted alongside at the receiving end gave the operator a copy of a popular song.

Then a skeptic smilingly asked what would happen to the melody if a static storm bombarded it.

Well, there might be a few strange or discordant notes; faces might be freckled in a radio picture and words in a message might be blotted out when static wildly splashed the ink.

STEPS TOWARD PERFECTION

John V. L. Hogan is an old hand at radio invention. He is the man who patented the practical method of single-dial tuning by arranging all the tuning condensers on a single shaft controlled by a lone knob. That simplified the broadcast receiver. Now he reveals the logical steps necessary to make facsimile radio practical for the home:

1. The design must be sufficiently simple to permit sale of the receivers at prices about the same as those of broadcast receivers.

2. Operation of the receivers must be so simple that they can be successfully handled by unskilled users, and the receivers must be capable of running for considerable periods of time with little or no attention.

3. The recorded pictures and text must be produced on plain paper, so as to avoid the nuisance, delay and expense involved in

any chemical or photographic processing.

4. Operation of the receiving recorder must be fully visible, so that the user may see each mark as it is being made. This lends interest to the use of the system, but, more important, shows at a glance whether or not receiving conditions are correct.

5. Recorders must have a continuous paper feed, so that it is not necessary to reload the machine for each picture.

6. The received record should be made in ink, so as to provide a permanent, easily handled, non-smudging and dry copy.

7. Speed of operation should be relatively high, so that the user will not have to wait unduly long for each finished picture.

8. Reproduction should be sufficiently clear and sharply defined.

No photographic work is required at the sending or receiving terminals of this pen-and-ink system. At the transmitter a positive picture or the print is fed flat into the machine instead of feeding it from a revolving drum. The advantage, of course, is that the operators at the transmitter can see the material, whereas when a drum revolves the picture or print cannot be discerned. A light beam shines on the paper strip and that illumination reflected in accordance with the lights and shadows of the picture to a photo-electric cell starts a corresponding current through the wires to the radio transmitter.

While technicians continue to perfect pen-and-ink and pencil-beam instruments, leaders in the industry who look into the future, can see ultra-short wave television as the utopia for facsimile broadcasting. It was David Sarnoff, President of the Radio Corporation of America who declared, "My faith in the future of radio science is geared to facsimile; facsimile is the gateway to television."

Smoking his pipe and looking into space high above the rooftops of New York from his office on the 53rd floor of a skyscraper in Radio City, Mr. Sarnoff, squinting a bit, seemed to be peering into the future. He reminisced to portray the future against the background of the past.

"Since Morse invented the telegraph there has been no radical improvement in telegraphy," recalled Mr. Sarnoff. "Morse, a poet as well as an inventor, created the Morse code of dots and dashes. His alphabet has been in international use ever since, but now we are on the threshold of the first great advance in the art of telegraphy. We are sending pictures and printed matter through the air and have found the key to speed the traffic. No longer must the message be broken down into hundreds of dots and dashes. It is reproduced by light 'brushes' that 'paint' it line for line. The next step is to flash the complete picture. That is a great step forward.

"The first logical step, of course, is to transmit still pictures and print. That is facsimile radio. The next step will be to send moving pictures. That is television."

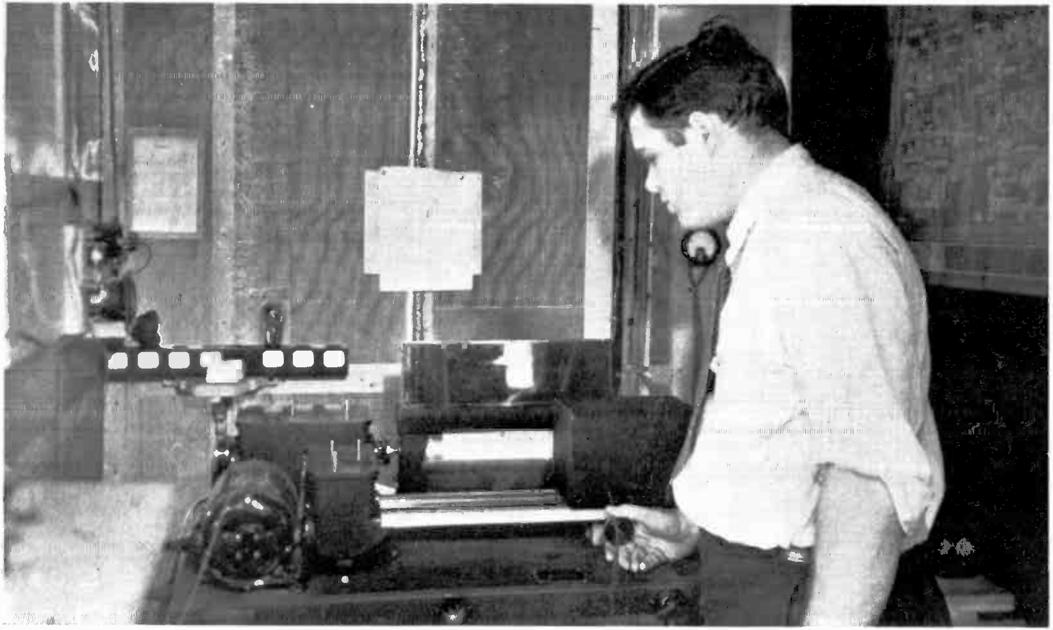
A LIGHT BEAM "PAINTS"

The domestic and over-the-ocean facsimile service on the normal short wave channels, that is, between 15 and 100 meters, is utilizing novel instruments designed to greatly improve the texture of the illustration. A pin-point beam of light is made to play through lenses on a photograph or printed matter wrapped around a slowly revolving cylinder. The light beam strikes the paper like a tiny star, each twinkle of which assists in "painting" the picture being flashed from some distant city. A photo-electric cell closely adjacent to the light beam is instantly affected by the gradations of light from pure white through grays to inky black reflected from the revolving picture. As the "star" moves across the face of the picture being transmitted, the variations of light intensity picked up by the photo-electric cell are greatly strengthened by an amplifier and made to modulate the transmitting aerial. That puts the picture on the air.

At the receiving end the process is practically reversed. A small flickering pin-point beam of light plays across another slowly revolving drum upon which is wrapped either a piece of photographic bromide paper or a photographic film. As rapidly as the picture is completed it is passed through a hole in the wall of the operating room into a dark room for development by standard photographic methods. It is then ready for delivery by messenger.

While this operation is being completed in the darkened radio room, the operators in the main room keep an eye on a monitor device that also "paints" the picture, no matter whether it is arriving directly from London, Berlin, Buenos Aires or San Francisco. This novel monitor functions in daylight. In place of a light beam a midget nozzle sprays ink on a revolving piece of ordinary glossy paper, while a tiny shutter operating across the mouth of the nozzle deflects the spray in accordance with the in-coming radio impulses that comprise the picture.

Facsimile pictures 6¼ x 9 inches can be sent across the Atlantic or from California to New York in twenty minutes, but if the cylinders are revolved slower, requiring forty minutes to complete the picture, the detail is generally clearer. The speed of the cylinders on which



ELECTRIFYING PRINTED WORDS

Miniature copy of the Schenectady Union-Star wrapped on the cylinder for a short-wave flight to a ship at sea by means of facsimile radio.

the pictures are wrapped for transmission and reception, can be regulated.

PHOTO-RADIO AND TELEPHOTO

The general principles of photo-radio and telephoto (pictures sent over wires) are quite similar, except, of course, the medium in the one case is "the ether," and in the other it is a wire. This calls for slightly different technique.

The radio process is either on or off. It is a keyed signal printing a pattern comprised of lines of various sizes. For example, dots "paint" the light areas of the pictures, while dashes "paint" the dark areas. In this system as long as there is a signal above a certain low level, with strength enough to operate a local vacuum tube relay, the instruments perform.

The intensity of the recorded areas of a telephoto, however, depend upon the strength of the incoming signal, therefore, the light and shade of the picture govern the intensity of the current. Radio employs the "on-off" process to combat fading. If the telephoto method were applied to radio instead of to a wire, fading would affect the intensity of the current and mar the true reproduction of the picture.

Nevertheless, in both instances the picture is broken into elemental areas. The light and shade of each area is transmitted in succession, while at the receiving end of the wire or radio, the areas are reassembled on a sensitized paper or on a photographic film.

This is the telephoto process as developed by the Bell Telephone Laboratories: A photographic print, written or printed copy, is fastened to a rotating cylinder. A tiny beam of light slowly moves along the cylinder, so that the pin-point of light traverses successively every section of the picture. The intensity of the light reflected from every spot on the paper varies with the brightness or darkness of the picture. Much of this reflected light is concentrated by a reflector into a photo-electric cell. That causes a current to flow in an external circuit. This current is proportional to the illumination of the cell, and its response to changes in illumination is practically instantaneous. As the cylinder and picture rotate under the advancing spot of light, the illumination of the cell, and consequently the current from it, registers in succession the brightness of each elementary area of the picture.

The current carrying the picture elements is then directed over the wires to desired destinations, but, of course, at the receiving terminal there must be an instrument to reassemble the picture. The electric current must be translated into lights and shadows. A light-valve does the trick. It consists essentially of a narrow ribbon-like conductor lying in a magnetic field in such a position when at rest as to cover entirely a small aperture. The incoming current passes through this ribbon, which is in consequence deflected to one side by the interaction of the current with the magnetic field, thus exposing the aperture beneath. Light passing through this aperture is thus varied in intensity. If it then falls upon a photographic sensitive film bent into cylindrical form, and rotating in exact synchronism with the film at the sending end, the film will be exposed by amounts corresponding in proportion to the lights and shades of the original picture.

In this process of picture transmission the photo-electric cell, which treats lights and shadows as the microphone does sound, gives rise to a direct current the intensity of which varies: rapidly when the spot of light passes over an area of alternate black and white; not at all when the area is uniformly light or dark. In electrical parlance, the "alternate black and white" condition results in a combination of direct and alternating currents; the "uniform" condition in a steady direct current. Commercial telephone circuits, however, do not transmit direct current or slowly alternating currents as readily as they transmit rapidly alternating currents. To speed up the alternations, an ingenious scheme is employed.

Instead of scanning the picture by a spot of steady light, the beam is passed through a light valve opening and closing 2,400 times a second. What is reflected into the photo-electric cell is then a flicker of varying intensity, and the cell output has as one component a 2,400-cycles-

THEY IRON OUT ELECTRICAL RIPPLES

A line-up of mercury vapor rectifier tubes used in WOR's 50,000-watt transmitter which made its first official appearance on the air March 4, 1935.

per-second current. This current, modulated according to the lights and shades of the picture at the transmitting end, traverses the lines and amplifiers of the wire network. At the receiving end the alternating current is converted into a fluctuating current which vibrates the ribbon of the receiving light valve.

In order that the light and shade traced on the receiving cylinder shall produce a true copy of the original picture, obviously the two cylinders must rotate at the same uniform rate. Should one cylinder rotate a trifle faster than the other, the successive trips of the light spot across one cylinder would begin a little sooner each time on that cylinder, and the received picture would appear askew. Therefore, all cylinders are driven by motors the speed of which is synchronized or held identical by tuning forks.

Mechanically, the sending and receiving telephoto machines are essentially alike. Each includes a cylinder about 17 inches long and 12 inches in circumference, which is mounted in lathetype supports at each end so it is free to rotate. A constant-speed motor drives the cylinder through a magnetically operated clutch.

The sending and receiving cylinders both have a spring-held clamping strip running the length of the cylinder under which one edge of the closely wrapped print or film is slipped. In the sending machine, since no sensitive film is utilized, the loading is done under ordinary lighting conditions, but the receiving cylinder is loaded in a dark room, although the same loading fixture is used for each.

The optical system of the sending machine consists of a small electric lamp of high brilliancy which projects a ray through the light valve to an inclined mirror. This mirror reflects it onto the picture where it covers approximately one ten-thousandth of a square inch. The light reflected from the picture is collected by mirrors and reflected back into the photo-electric cell in the body of the carriage.

The receiving optical system includes a similar light source, a light valve, and lenses which focus the ray of light onto the film.

Since the machine is operated in daylight, and the film must receive only the light from the optical system, an arrangement of slides and curtains is provided between the cylinder and the optical system to allow only the actuating ray to strike the cylinder.

The optical systems on both machines are mounted on carriages which are moved parallel to the axis of the picture cylinder by a long closely threaded screw. The cylinder is rotated 100 revolutions a minute, and the carriage moves one inch a minute, so that a full-size picture requires seventeen minutes for transmission. Each receiving cylinder is taken into an adjoining dark room, and the film is developed into a negative, from which photographic prints are made in the usual manner.

CAMERAGRAMS ARE TELEVISED

Greater speed is the goal of the engineers, and that is why they pin great hope on television. With speed as the incentive, research experts are experimenting with facsimile on 3-meter waves, and in so doing they approach the technique of television and gain high speeds in transmission.

The principles of facsimile and television are very much the same. The trick is to broadcast a complete picture or letter that is scanned by what might be called a radio "eye" or camera. Communication men foresee the day when in place of the telegraph and wireless keys communication offices will be equipped with moving belts on which will be clipped the pictures and messages written by typewriter or in the handwriting of the sender. As they move along the belt they will be cameraed by an electrical optic linked with an ultra-short wave transmitter. The complete picture will be flashed and received in the twinkle of an eye.

The fear that the ultra-short waves would be inoperative in cities because of the absorbing effect of steel structures has been dispelled to some extent by experiments. The station can be located in the heart of a metropolitan center as long as there is a lofty pinnacle from which the tiny waves can hop-off. To operate such a system between New York and Philadelphia, two automatic relay outposts are believed necessary, one at New Brunswick and the other near Trenton, N. J. They will boost the strength of the images and quickly toss them along to their destination.

From this experiment the engineers expect to learn many valuable lessons; and upon their success over the 90-mile New York to Philadelphia circuit will depend extension of the ultra-short wave system that some day might evolve into a television network for the home-entertainment. In any case it seems that sky-scrapers and mountain peaks will be high-speed facsimile and television take-off sites.

CHAPTER XI

AMERICAN VERSUS EUROPEAN RADIO

There is one glory of the sun,
  And another glory of the moon,
And another glory of the stars;
  For one star differeth from another star in glory.
I Corinthians 15. 40

CONTROVERSY probably always will be rampant relative to the merits of the American system of broadcasting compared to European methods, especially Uncle Sam's technique versus John Bull's. Schools throughout the breadth of the land have debated the subject; so have economists, financiers and statesmen. The topic contains much food for thought, and for interesting argument.

Broadcasting in the United States is private enterprise founded upon "public interest, convenience and necessity." That is the guiding principle of the law.

The Royal Charter under which the British Broadcasting Corporation is granted a monopoly in broadcasting specifies that the service should be conducted "by a public corporation acting as trustees of the national interest." The charter refers to the "great value of the service as a means of education and entertainment." In administration the corporation is autonomous.

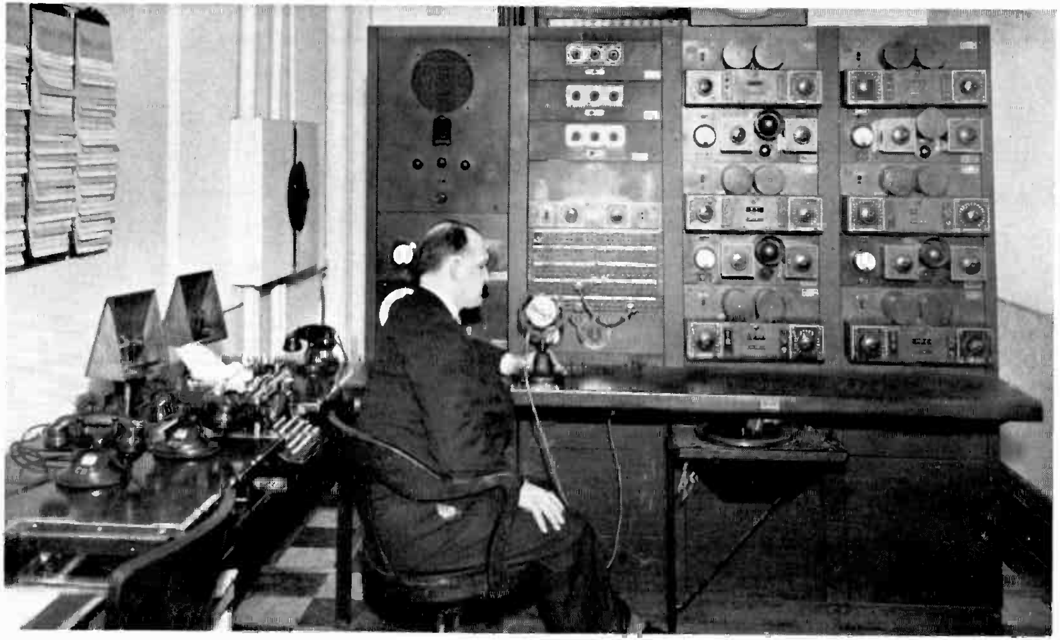
While "public interest" is upheld as paramount in broadcasting on both sides of the sea, the great difference in the two systems is found in the fact that American radio is commercialized by the sale of time on the air and rental of the electrical facilities. England's air is noncommercial. American broadcasters argue that competition stimulates efforts in showmanship and greatly improves the programs. On the contrary, the Englishman asserts, "the very fact of monopoly is often a stimulus."

The average American, when he is bored and tired of the commercial ballyhoo, often longs for the British system, but when he studies the English broadcasts, he usually tosses the programs aside as "too highbrow"; "too much education." The average American listener agrees with the broadcast showman's contention that "the public wants to be entertained, not educated." The British broadcasters contend they are experts in their art, well equipped to judge what is best on the air, so they argue, "we give the public what we think it should hear, rather than what the listener thinks he wants."

In the United States the listener eavesdrops gratis; the owner of each receiver in the British Isles pays an annual license fee of $2.50 to ensure adequate finances for broadcasting service. Therein lies another vast difference in the two systems.

AN AMERICAN CONCLUSION

Confession is made at the outset of the argument by the National Association of Broadcasters that it is improbable that Uncle Sam's system of broadcasting could be established successfully *in toto* in Britain or that the essential features of John Bull's system could be



THE "ELLIS ISLAND" OF BROADCASTING

A radio gateway to and from foreign lands: through this control panel at the RCA headquarters on Broad Street, New York, European programs are fed to the networks for broadcasting. The operator at the microphone notifies the foreign broadcasters to "go ahead."

made to fit American ways and means. The psychology of the peoples differs.

Conclusions, that in most instances American public interest can be served better by privately owned and competitively operated broadcasting stations and networks rather than by a government monopoly, are based on these facts compiled by the National Association of Broadcasters:

1. Conditions in Great Britain and the United States are not analogous. The broadcasting problems in this country are of a complexity with which it would be practically impossible for a system of government ownership and operation to cope successfully.

The technical and financial requirements of a government broadcasting system in this country are much greater than in the United Kingdom. The social and political problems involved in the establishment of such a system are vastly more complicated. Though it is conceivable that such a system might be established, it probably could be done only at great cost to the taxpayer, and without benefits, if any, corresponding to the price paid.

2. The record of operation of the British broadcasting system has revealed it to contain inherent weaknesses which would tend to make it inacceptable to the American people.

The system of taxation is open to abuses which seriously impair the potential efficiency of government-owned broadcasting, and reduce the service which the listener receives from the dollar, shilling, mark or lire which he pays in radio taxes. It is a system which, especially in this country, with its wide diffusion of receiving set ownership among all classes, would be onerous to the low income set owner. For these reasons any attempt to adopt a system similar to that of Great Britain in this country would be certain to meet with grave difficulties.

Likewise the British or any other government-owned and operated radio broadcasting system involves a theory of program management and control utterly out of keeping with American viewpoint on this question. In the bureaucratic and paternalistic regulation of programs, there exists an impediment to the construction of a democratically conceived program structure which will give the listening public the type of entertainment and information which it desires. Such a system with its resulting programs, would be highly inacceptable to the American people.

Finally, the system of government-owned and operated broadcasting, even in liberal England, has shown itself to involve a theory of program censorship which is entirely incompatible with American principles and which constitutes a most serious threat to freedom of speech.

3. The American system of broadcasting has rendered service to the listeners of this country, which, in spite of minor defects, has been generally satisfactory. The service rendered by private broadcasting in this country, moreover, is on the whole, equal, and at times superior to that rendered by the British Broadcasting Corporation—at least from the American standpoint. Though neither system is considered perfect by the respective listeners in the two nations, the response of American listeners to broad-

casting from this country indicates a general state of satisfaction with the major aspects of American broadcasting.

Can a system of government-owned and operated broadcasting produce service, eighteen hours a day, and seven days a week, which the American people would enjoy more than they do the service rendered under the existing system? Would the service under government ownership be sufficiently superior to that of the present to warrant the cost which it would entail to the taxpayer?

These are pertinent questions the American broadcasters ask when the economics of broadcasting are discussed.

AN ENGLISHMAN'S IMPRESSION

The Englishman who visits America gains the impression that radio is "quick come, quick go." The precision, split-second programs amaze him; the choppy fifteen-minute broadcasts studded with commercial announcements astound him; in fact, he is shocked. In England the second hand on the clock is not the guiding factor, but in America it is the fretful red finger of Time that tells the performer when to begin and exactly when to stop.

"Radio in the United States runs a breathless pace," observed Roger H. Eckersley, director of entertainment for the British Broadcasting Corporation. "We often broadcast a symphony concert for two hours, a Shakespearean play for an hour or more, although we feel that sixty minutes is enough for the average drama on the air. We do not rush from one program to another. Gaps between broadcasts are frequently intentional for the sake of transition; to avoid the shock of passing from, let us say, a religious program to a dance band.

"We, of course, do not sell time on the air so we need not be on the exact tick of the clock. But I presume the American system of broadcasting is good for America, where things move quickly. More leisurely broadcasting, however, pleases English listeners.

"I will say that American broadcasting is well oiled; it moves smoothly. I admire the topical interest of the broadcasters, that is, they keep pace with current events. I suppose for that reason the programs are more sensational and more strictly entertaining.

"I think the American program sponsors underestimate the intelligence of the masses," said Mr. Eckersley. "We began by giving the audience the more serious things and they have learned to enjoy it. We are not averse to jazz bands. After all, jazz meets the desire of youth; there is no reason why they shouldn't have it. But as a whole I should say that American broadcasting is more personal, more sentimental than in England."

WHAT SIR JOHN OBSERVED

Sir John Reith, director of the British Broadcasting Corporation, who has been called, "the Mussolini of the Microphone," in discussing the evolution of broadcasting, once took a quick glimpse across the Atlantic for the sake of comparing American radio with the non-commercialized English ether:

"The many American stations humorously called 'Ego Stations'—that were created for the purpose of publicizing the particular opinions or wares of their proprietors find themselves less and less able to do so since the criterion by which they are judged under the Radio Act is whether they serve 'public interest, convenience and necessity.' "

Occasionally, Sir John's curiosity is aroused and he travels across the Atlantic to see and to hear first hand if America is really stepping ahead of England in the art and science of broadcasting. Once on Manhattan Island, 3,000 miles from his own radio throne, he confesses geography plays an important role in the likes and dislikes of broadcasting. Logically, one might suppose that inasmuch as radio is international, the music and jokes from one land might delight another no matter how far away. But that does not hold true. What pleases those assembled around the 18,000,000 receiving sets in the United States does not necessarily win the plaudits of the 7,000,000 radio-equipped homes in the British Isles. For example, the English find it difficult to understand the dialect of Amos 'n' Andy.

Nevertheless, American and English program directors have much in common. That is why the American is likely to find solace in this British comment:

"However honestly a program builder searches for the answer to the questions which underlie his work, he cannot find a solution to his problem which will satisfy 25,000,000 listeners. It must always rest with the individual listener who tends to use broadcasting intelligently to build his plan of listening for himself. . . . One thing only is certain, and that is that it is quite impossible to please all listeners all the time. It would be a help if listeners would pick their programs, instead of turning on at random, expecting to get what they want."

OPERA IDEAS DIFFER TOO

Even in opera with its international appeal the broadcasters do not always agree in the manner of presentation. Should the productions be complete from the stage of an auditorium or should they be tabloid or "capsule" operas specially condensed and adapted for broadcasting?

Americans have tested both methods; direct from the stage of the Metropolitan Opera, and hour tabloid versions sung in English by noted artists. Both broadcasts are believed to attract a large audience. England also wonders which style of presentation is most meritorious. A London critic once remarked:

"Even in countries where opera is supposed to be part of the national life, in something the way that cricket is in England, to broadcast it has always been a problem. Several solutions have been tried. The easiest, and, as some authorities think, the most nearly successful is to install the microphone in the most suitable position in the opera house and let it bring home to listeners the audible part of whatever is being played to an audience there—the voices, in song or spoken words, the orchestra, the applause, cheers or laughter from in front. Even that apparent simple disposal of the question has its own difficulties.

". . . How are we to present, by means of sound alone, something which will be even a possible substitute for what the eye must miss? One method has been tried whereby a narrator describes the action to listeners. . . . Few, indeed, are the speaking voices of such quality as can interrupt the sound of music without grating harshly on the ear; and to have a passionate love duet broken in upon by the bald announcement 'He kisses her,' is to set the whole fabric tottering on the verge of bathos."

DANGER OF PROPAGANDA

In Europe, radio from so many different countries overspreading frontiers has caused perplexing situations not encountered in the United States. For instance, an Englishman observes:

". . . It is conceivable that broadcast political propaganda might become so extreme as to become equivalent to 'an unfriendly act' and so tantamount to a declaration of war. . . . The only way in which an offense against the comity of nations can be prevented is by the recognition of the peculiar need for international good manners in broadcasting. It is not for nothing that the British Broadcasting Corporation has carved in its entrance hall the words, 'Nation Shall Speak Peace Unto Nation.' "

SOME OF ENGLAND'S PROBLEMS

England's radio problems, however, are not all technical, or artistic. There are economic puzzles and usually the riddle is linked in some way with geography. The fact that the British Isles are entirely surrounded by water does not isolate the kingdom from the broadcasts of other nations. So easily do broadcasts jump the international fences that undoubtedly at times it must irritate those striving to keep the English air free of commercialism. John Bull must wonder at odd moments if he should capitalize his own "ether" as long as some foreign station can reach across the water and bespeak advertising in the air he has fought to keep "pure."

"There is the 150-kilowatt station in Luxemburg—the most powerful transmitter in Europe—hurling programs with commercial announcements couched in three languages, English, French and German," said Cesar Saerchinger, the Columbia Broadcasting System's European representative. "These broadcasts are easily intercepted in England and violate the Englishman's idea of an air clear of advertising—but what can be done about it?

"Radio recognizes no frontiers. Some of the English listeners find an advantage in this, however, because on Sundays no jazz or dance music is sanctioned from British aerial wires. But Luxemburg accommodates and flashes the dance tunes across the Channel. Also, Athlone, near Dublin, Ireland, handles commercial programs that serenade the western coast of England as Luxemburg and 'Radio Normandy' on the French coast do from the east. So England is bombarded commercially from both directions. This has caused some to wonder," said Mr. Saerchinger, "if eventually John Bull will throw up his hands and commercialize his own ether. However, such a move seems doubtful; I do not believe England will Americanize its broadcasting."

The British Broadcasting Corporation has an annual income of approximately $15,000,000 from license fees collected from radio set owners, and the amount increases as the audience grows. Of this fund the government takes about $8,000,000 for "giving the broadcasters the air." And during the depression, while England was striving to balance the budget, the broadcasting organization made several substantial contributions to the governmental treasure chest.

"There are many more talks in the English air than in America," continued Mr. Saerchinger. "I think this is explained by the fact that the broadcasters, being more subject to the government in foreign countries, feel that they must perform a real public service and can best accomplish it through talks than through entertainment. People definitely want information, especially in outlying regions."

IS AMERICAN PLAN IDEAL?

Shall the United States adopt the British system of radio operation and control?

The affirmative contend the present broadcasting in the United States is ideal; the negative argue against the American formula and tell why they favor the British principles.

The main argument, of course, revolves around the question whether a radio plan suitable to the comparatively small area of the British Isles could serve the wide territory of the United States with equal utility.

Geography, of course, is a factor of no little consequence in the debate; also the population and psychology of the people. There seems to be no end of arguments pro and con for both formulas, but before attempting to answer the question whether Uncle Sam should adopt the essential features of the English system of operation and control of radio, the proposition must be defined.

THE BRITISH SYSTEM

The American broadcasters make it clear that they understand "the essential features" of the British plan as follows:

1. The creation of a public, non-profit corporation under the Federal Government for the purpose of owning and operating the broadcasting facilities of this country.

2. The close supervision of the system by a governmental department, even to the point of possessing the power of censorship over programs. In Great Britain this supervisory power is vested in the Postoffice.

3. The support of this system by means of taxes imposed upon radio-set owners.

The main characteristics of the present American system are outlined as follows:

1. A privately owned and competitively operated system of stations and networks.

2. The support of this system by means of the sale of broadcasting "time" for advertising purposes.

3. The safeguarding of the public interest under this system by means of a governmental agency, such as the Federal Communications Commission—which might be given increased authority if necessary—or a similarly constituted authority.

The debater who does not believe the British principles applicable on this side of the Atlantic quickly agrees, however, that both plans have merit but "conditions are not analogous."

It is contended that the inherent weakness of the British plan, as far as adoption in the United States is concerned, is the $2.50 tax each radio-set owner must pay annually to defray the expenses of broadcasting. Furthermore, those in favor of the American idea assert that under commercial sponsorship of programs there is more competition and therefore greater liveliness and diversity in the performance.

HOW THE PROBLEMS DIFFER

The British broadcasters with only twenty transmitters have the comparatively simple problem of serving an area of about 94,000 square miles, in which are located 44,000,000 people and more than 7,000,000 receiving sets.

John Bull by his receiving licenses can count the size of the audience, whereas in the United States it is more or less a guess, based upon the 1930 census, which included a tabulation of radio-set owners.

The American radiomen declare their problem is not so simple. The territory to be covered is immensely larger. The population is less concentrated; less homogeneous. A vast variety of local interests cannot be disregarded. American broadcasting overspreads an area of more than 3,000,000 square miles; more than thirty-two times that of the British Isles. And the broadcasters like to estimate that there are at least 18,000,000 receiving sets served by 600 stations, 397 of which are generally in simultaneous night-time operation.

Those in favor of a "new American plan," assert it is more important that the people be informed than entertained. They argue for more educational broadcasts, and add that at present "there is no broadcasting system in the United States."

They call attention to the fact that British radio is a planned affair, while in the United States it grew like Topsy. Broadcasting began in 1920, but the law to regulate it thoroughly was not passed until 1926. It was a natural growth, unhampered by restrictions, so the

American broadcasters declare, as they analyze their first decade. Nevertheless, those in favor of a "new plan" believe the United States should select and adopt "the essential features, the fundamental principles underlying the British system."

The ultimate test which the citizen must apply to a system of broadcasting is listed by the National Committee on Education by Radio: "Who decides what is to go on the air and how is that decision motivated?"

Calling attention to "the sound principles underlying the British system," the National Committee outlines the three fundamental principles of nation-wide broadcasting: First, it shall be organized under a single government authority; second, the programs shall be planned under the general direction of this authority; third, the services shall be financed directly by the people.

WHEN THE GRASS IS GREEN

Books could be written on both sides of the case. The American listener often complains of the announcer's ballyhoo as the great evil that lurks in "the ether." He wonders if the English system would be a relief. Then, there is the American who visits in London and while there eavesdrops on the broadcasts. Usually he returns thankful that the English idea, which he admits may be all right over there, is not in effect on this side of the sea. On the other hand, there is the English visitor in New York who listens in and wonders how the populace can endure so much commercialism.

Possibly the British system is ideal for England, and the American plan ideal for the United States; neither represents an international Utopia. What may be good for one may not be good for the other. Pages and pages of arguments condense to the old adage, "The grass always looks greener on the other side of the fence."

REVENUE FROM ADVERTISING

While there is no advertising on the air in England, unless it filters in from some other country, nevertheless, the broadcasters derive a revenue from advertising. They are in the publication business as well as the ethereal business; the American broadcasters have not combined printing with radio.

The Radio Times of England is a weekly magazine containing radio programs printed on Friday for a week in advance. The price is four cents a copy. The circulation surpasses 2,200,000. The net profit derived from the sale of the magazine and advertising on its pages in one year has totaled $1,300,000.

"We were forced into the publication business," explained W. Gladstone Murray, official of the British Broadcasting Corporation. "Once the press stopped printing radio programs. They wanted the British Broadcasting Corporation to pay for the space. Gordon Selfridge, a London merchant, had contracted for a page advertisement in a leading newspaper; he devoted the space to radio programs as a public service, instead of advertising his wares.

"Immediately the circulation of the paper jumped. The value of the programs as news was seen and all papers immediately restored the printed programs. They have published them ever since, despite the fact that we issue The Radio Times. The newspapers, of course, have an advantage on the side of accuracy, since they do not go to press as early as we do. The Radio Times is printed in three editions to speed distribution. One edition covers Southern England, one Northern England and the third goes to the North of Ireland and Scotland.

"Comparison of American with English broadcasting is a difficult task," smiled Mr. Murray. "Both countries have a variety of problems and geographical conditions are, of course, entirely different. I do believe, however, that the Americans have greater difficulties in that they have no definite fund such as we derive from the license fees."

A TAX WAS PROPOSED

When the American broadcasters realized back in 1922 that radio showmanship was a business and not a philanthropic endeavor, they began to seek a source of revenue. Numerous panaceas were proposed. There were suggestions that listeners be taxed. Some thought voluntary contributions might be depended upon to keep the show running. Those of a scientific turn of mind suggested a rental or pay-as-you-listen plan, fashioned on the same principle as the telephone or a nickel-in-the-slot receiver.

Finally, the demand for transmitting outfits became so intense that it was suggested by the American Telephone and Telegraph Company, then owners of WEAF, that certainly all could not find room in the already crowded ether, so why not rent the facilities of existing stations?

A realtor tried the idea on September 7, 1922. Others followed, although the leaders in the radio industry were not overanxious to see the idea spread. They called it contamination of the wave lengths. But the plan seemed to be a natural solution of the problem and many broadcasters stepped off on the same foot.

Other nations, including England, Italy, Canada, Germany and Japan, evolved different formulas. They taxed the audience. Several countries, Italy among them, also collect a tax on the retail price of receiving sets. The revenue for Russian broadcasting is derived exclusively from State subsidies.

Holland is trying voluntary contributions. There are more than 500,000 licensed listeners who register either voluntarily as the possessors of receiving sets or as subscribers to the various telephonic distribution systems called "radio-centrales." Each country seems to have let radio grow more or less naturally to fit in with the geographical features and to serve the population whether congested or scattered. It is apparent that a broadcasting system ideal for one country is not necessarily the basis of a listener's delight in some other land.

COMPETITION IS FAVORED

The Federal Radio Commission once declared that "the American system of broadcasting has produced the best form of entertainment that can be found in the world. It is a highly competitive system and is carried on by private enterprise. There is but one other system—the European. That system is governmental."

Nevertheless, from time to time Americans pause to wonder if the broadcasters are on the right track.

Leaders in the industry do not look with favor upon direct appeals to the radio audience and particularly do they frown upon pleas that have to do with their own presentations. One argument is heard, however, that such a step, if successful, would give the listeners more voice in program planning. If they tired of a program at the end of its run they might not renew their subscription and the broadcast would end.

THE LISTENER'S PSYCHOLOGY

The psychology of the invisible audience is established in the United States on such a basis that giving has no major part in the scheme of broadcasting. The set owners have been taught that when they pay the price of a radio receiver they have purchased a ticket for the ethereal theatre, and no further transfer of gold or silver is necessary. Listening-in is free. The "ether" belongs to the people.

Furthermore, no one knows who listens. There is no forceful way of appealing to sense of duty or to embarrass a listener who does not contribute. He is hiding behind the microphone. No one can point to him as a slacker. No one can arouse his musical patriotism by mere use of a fleeting discourse on why listeners should help to pay for the melodies they intercept.

Even in countries where the government taxes set owners there is difficulty in collection of the fees, and penalties are levied. Despite the law that specifies the tax of a dollar or two, there are said to be thousands of illegal or so-called "bootleg" listeners.

Radio is a mystic force that brings some-

EXPERTS IN SOUND IN THE CONTROL ROOM

Behind the scenes in Radio City the artists are at the mercy of the electrical-musicians who manipulate the knobs that regulate the volume to the proper level.

thing to the listener, but when it attempts to draw a coin or two out of the pocketbook—well, that is a thing for which science did not equip radio. All radio can do is to carry the plea and the argument to the listener. Whether he acts or not depends upon the individual, in more ways than one.

When television comes and some prominent person can point a long finger through space into the faces of a host when he cries, "Don't be a slacker!" then a fund might be raised, but even then the audience will be in hiding and all contributions will be voluntary and not forced. That is the psychology of broadcasting, and so it will be with television.

Radio lacks the mass influence. In a crowd a silver-tongued orator may start a parade down the sawdust trail to cast coins on a drum. In radio there is no visible leader for the crowd to follow. A person can sit all evening and enjoy the broadcasting and fail to contribute, because there is no one sitting next to him to see whether he does or not.

A BIG RIDDLE

How to levy a fee on unseen millions is a riddle that has caused more than one economist hours of concentration during the past decade. Generally, they open the discussion by calling attention to the fact that automobiles are taxed for their right to use the highways and they display license plates as proof; the driver pays his license fee and pays a tax on gasoline and oil. The railroad is taxed for right of way across the countryside, and ships pay fees for entering ports. The long-distance telephone call is taxed.

So is the radio set in many foreign lands, but not under the Stars and Stripes. That is why twentieth-century physiocrats have caught the idea that broadcasting might some day contribute to government revenue. They explain that the work of the Federal Communications Commission, also the inspection service, is beneficial to the radio industry and, therefore, broadcasters and listeners should assist in meeting the expenses.

The economists point to the fact that a property rental is generally paid for billboards erected along the highways or signs painted on barns. Why, then, they ask, should not Uncle Sam collect an annual toll on each wave length? Another argument frequently expounded, is that circulars going through the mail add to the government's revenue by carrying a postage stamp, but an hour radio program is criss-crossed through space without the federal treasury deriving any revenue, although the government controls the channels. A ship passing through a canal usually pays a toll, but a broadcast flashes across the entire continent without paying "a continental."

NEW QUESTIONS ARISE

Those who have studied the problem contend that it requires no higher mathematics to determine a fair tax on wave lengths. The calculators wonder, however, if the station should pay an annual tax for a wave or whether each program should pay a license fee based on the length of time it is on the air. For example, should Amos 'n' Andy contribute as much for their fifteen minutes as a symphony orchestra in an hour concert?

The calculations become more complex as networks are involved and the number of stations increased. Therefore the simple plan, that calls for less bookkeeping, is for each station to pay for its right-of-way. That idea is believed to be more practical. The power output is another factor in the problem; also the number of hours the station utilizes the wave. A clear or exclusive channel would probably be taxed more than a shared wave.

To tax the radio set in the home is not so easy. The number of wave lengths is known, but receivers scattered across the country are more secluded; they can more easily defy those who might seek them.

One proposal is to tax the detector tube. Every radio receiver needs a detector; it is the heart of the machine. If there is no detector, the set is "dead."

To put a toll on this tube is believed to be a simpler matter than issuing licenses each year.

If there are 18,000,000 radio sets in use in the United States, it might be a difficult task to ferret out each one and grant a license. Radio sets, being less conspicuous than an automobile on the street without a license plate, make the problem more mystifying, but the experts believe they have a solution.

One plan, which sounds rather impractical, is to bring about some technical change in broadcasting so that every one with a receiver would be compelled to buy one new tube—possibly a detector. This tube would be controlled by the government and would bear a tax of $2, plus the retail price.

The tube could be designed to have a life of 1,000 hours, so that the person using his receiver the most would pay more into the United States coffers than the listener who tunes his set only an hour a day.

Of course, the broadcast showmen and electric light companies are not cheerful about such prospects, because the public might become more economical in the use of radio. Instead of turning on the set in the evening to let the loudspeaker be rampant until bedtime, listeners might be more discriminating in the selection of programs. Otherwise they would be shortening the life of the detector by listening to something they did not particularly enjoy.

But Uncle Sam is not selfish. From the millions he could collect from the $2 tax he might return half to the public, under the proposed plan, while the other half went to the general treasury. The advocates of this idea would have the government buy time and sponsor programs, so that there might be two or three hours a night entirely free of commercial sponsorship. The music and entertainment, education and information would be of a high calibre, planned to elevate the cultural plane of America. Uncle Sam as a showman would strive to be a ringmaster all others would be inspired to emulate. That is what the idealists suggest.

"ETHER" BELONGS TO PEOPLE

But suppose the inventors cannot discover a way to make this novel change in the life of broadcasting. Will broadcast listening continue free? Not necessarily, because, if no way can be found to force every one to buy a new detector, a law might be passed whereby every radio set owner would have to buy a $2 stamp and place it on the present detector. Then anyone caught eavesdropping without a stamp-taxed tube would be liable to a fine or confiscation of his radio set. In the future, as each owner required a new detector, he would buy the stamp or pay the tax at the store.

Uncle Sam recognizes the ethereal tracts as valuable rights—and more so—because they are comparatively scarce. He is quick to declare that the "ether" belongs to the people; that no one possesses a vested right in a wave length. Seniority and "public interest, convenience and necessity" comprise the formula to which radio stations must adhere in order to hold their waves.

THE PACE DEFIES FIGURES

The broadcasters call attention to the fact that they consume nothing but time and watts when they use a wave length. There is no maintenance, such as highway paving and upkeep; no dredging of channels as in harbors and rivers. But they do encounter rapid depreciation.

Uncle Sam, however, has only to point to the cost of maintaining order in "the ether" and upkeep cost is seen. Until the Radio Act was passed in 1927, and the Federal Radio Commission was brought into being to regulate the industry, chaos prevailed. The broadcasters were like motor cars traveling blindly on muddy roads, with no signposts to guide them. Congress untangled the snarl and made the unseen traffic move with precision. That may be one reason for the assertion that those benefiting should help defray expenses.

Although broadcasting in the United States is but fifteen years old it is deep rooted; it has grown naturally under the watchful eye of Uncle Sam. It is doubtful if economists can teach "the old dog" new tricks. Nevertheless, there may come a day when evils, if they exist, can be rectified—that day will be when tele-

A ZERO HOUR AT THE MICROPHONE

Waiting for the studio gong to strike the hour as the signal for an hour operetta broadcast to begin. Gladys Swarthout, soprano of the Metropolitan Opera awaits the cue while the director watches for a signal from the announcer at the controls.

vision arrives. If the images are not to be supported by commercial sponsorship, then television had better not start that way in the beginning.

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