MEN AGAINST DISTANCE

THE STORY OF COMMUNICATIONS

BY JOHN J. FLOHERTY

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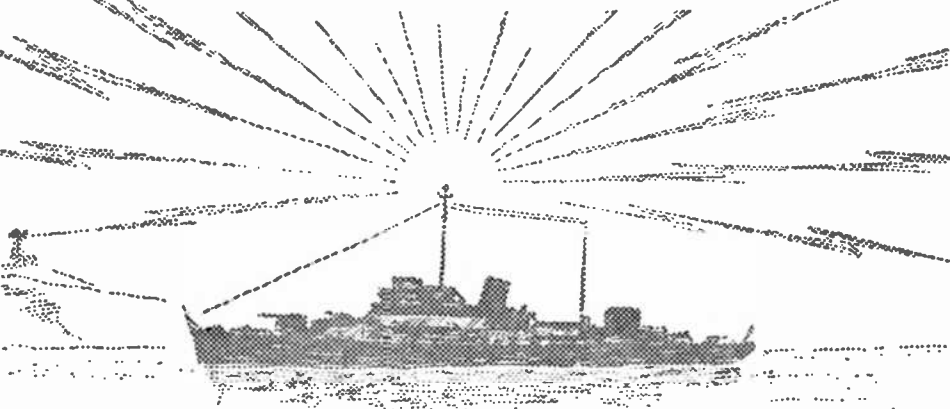

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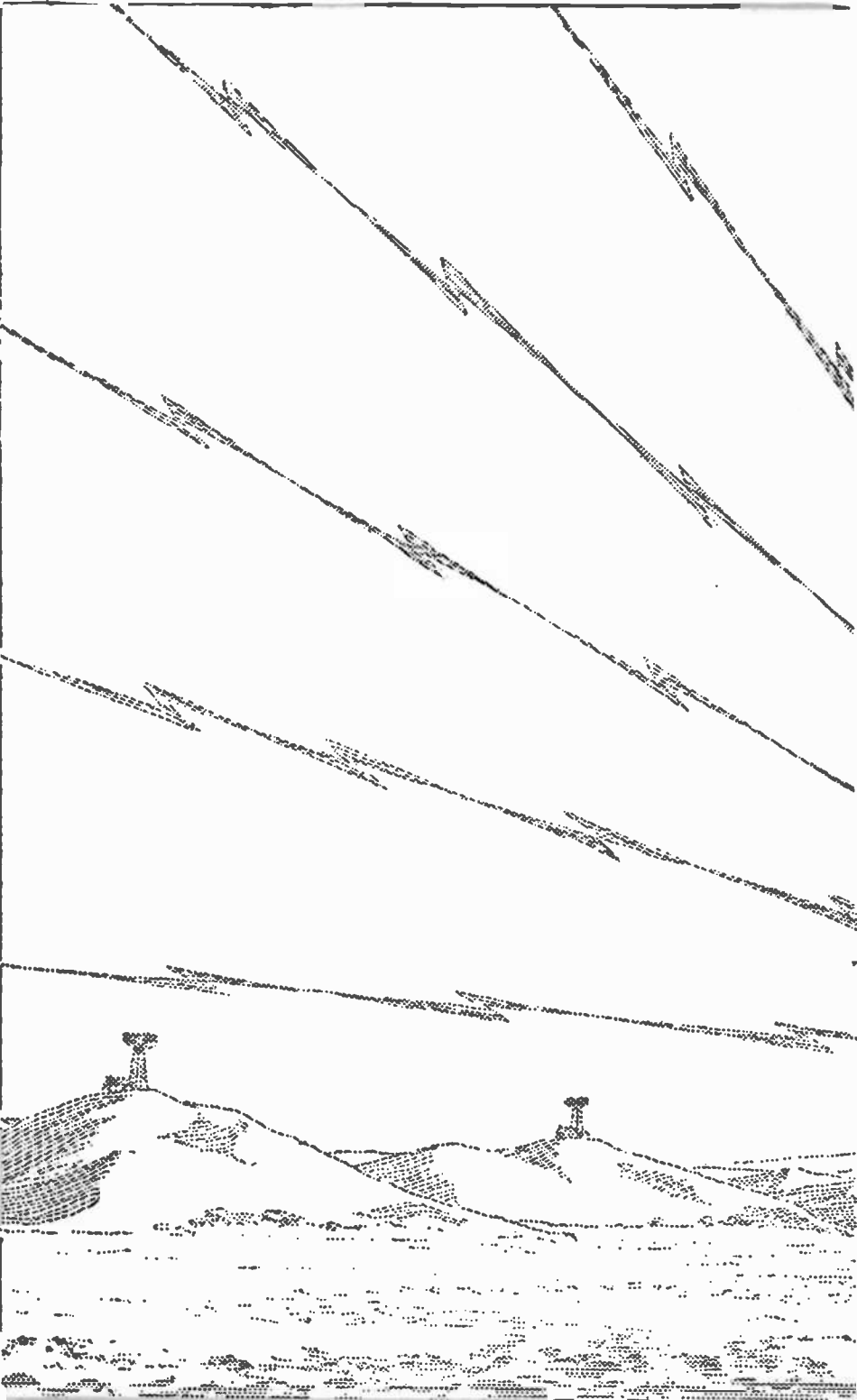


FROM THE AUTHOR

IN MY ROLE of reporter my incessant quest for material has taken me into strange and unfamiliar surroundings, there to hobnob with sandhogs, miners, deep-water sailors, test pilots and a score of other trades and professions in which the man on the job is supreme.

My most thrilling experiences, however, have been in the mysterious realm of communications, where a million workers labor day and night weaving and maintaining a worldwide network, part visible, part invisible, so that neighbor can speak with neighbor, city with city, and country with distant country.

During my expeditions into this strange world I was often reminded of Morse's immortal message over the first telegraph wire between Washington and Baltimore, "What hath God wrought!"

The mysteries of the telegraph, telephone, radio, television, radar, loran, shoran and the inexplicable behavior of the electron that makes them all possible, still leave me bewildered.

In the fields of operation, however, where those various miracles are installed, operated and maintained by tens of thousands of everyday hard-working people, many of whom never finished high school, I felt more at home. Here were stories of fortitude and loyalty in which men and women defied storm, flood and fire to "keep the lines

open" and so insure the safety and welfare of the communities served by their many companies.

To those heroes and heroines my utmost admiration and to all the dreamers, the scientists and the technicians who made it all possible, my undying respect!

To the following I am indebted for their kindly guidance during my months of exploration in their mysterious and mighty domain: Bell Telephone Laboratories, American Telephone and Telegraph Company, New York Telephone Company, Radio Corporation of America, National Broadcasting Company, and the men and women of all ranks in the field of communications who lent a helping hand to enable me to tell the story of *Men Against Distance.*

J. J. F.

CONTENTS

Men Against Distance

1

TOMTOMS TO TELEGRAPH

THE MORNING OF JUNE 2, 1953, WILL BE RE-corded in history as the occasion of the world's most elaborate display of pomp and pageantry. It marked Great Britain's coronation in the ancient Abbey of Westminster of a well-bred English girl as its fifty-fifth monarch and eighth reigning queen, Elizabeth II.

Three thousand six hundred miles from the scene of the ceremonies, my family and I sat at breakfast under the maples that top our terrace a hundred feet above Manhasset Bay and Long Island Sound. From the haze in the distance the towers and minarets of New York City rose in misty silhouette against the summer sky.

Beside me on the table lay a shiny black box, small enough to put in one's coat pocket. It was a portable radio receiver. As I raised the lid, a man's voice, resonant and clear, came from its silvery grid. The accent was British; the source, a commentator of the British Broadcasting System, describing in detail the coronation of the lovely young queen.

Now and then he interrupted his running story to catch the solemn voice of the Archbishop of Canterbury administering pledges and the oath of high office to the new monarch and her softly spoken response: "All this I promise to do." An exultant chorus, "God save Queen Elizabeth Second," rose from assembled nobles and echoed through the cathedral. The cheering of the multitude lining the streets as the Queen rode by in the royal coach, the clopping of horses' hoofs and the tromp-tromp of military boots came clearly through the 3,600 miles between London and our little black box.

As the British announcer signed off, I closed the lid. The ensuing silence was broken only by the twitterings of the birds which frequent our trees.

I sat in wonder at this miracle of modern science. Then I remembered Samuel B. Morse's historic phrase, "What hath God wrought," the first words transmitted by telegraph, the first instantaneous communication between men separated by great distances.

Morse had gained considerable repute as an artist when he turned his talents to science. On graduating from Yale in 1810 he went to England to study art. While there, he attended a lecture on the electro-magnet and immediately developed a keen interest in electrical phenomena. Several years later, while returning to the United States on the packet ship *Sully,* he conceived the idea of the telegraph. Scarcely had he set foot in New York when he be-

gan to develop an instrument that would tick off messages over long distances. At the same time he devised a code of dots and dashes representing the letters of the alphabet. It is known to this day as the Morse Code.

In 1837 he gave a demonstration of his electro-magnetic telegraph at New York University. His audience appeared to be only mildly interested. Undaunted, he continued his research and experimentation. In 1838 he petitioned Congress to construct an experimental line from Baltimore to Washington. His request met with skepticism and ridicule. Bitterly disappointed, he returned to Europe, hoping to get some foreign government to back him. He met with refusal on all sides.

Crushed and almost penniless, he struggled for several years to convince investors that his invention would prove to be a source of untold wealth. His pleas went unheeded. With total failure confronting him, he went to bed one night in his shabby lodgings. Denied even the blessing of sleep, he arose next morning weary and heartsick. Meanwhile a packet ship had arrived carrying mail from the United States. He was handed a letter postmarked "Washington." His hand trembled as he opened it. Now so accustomed to disappointment, he could scarcely believe what he read. At the midnight hour of the expiring session, Congress had appropriated $30,000 for his experimental wire line between Washington and Baltimore.

The work of stringing a wire between the two cities was completed in less than a year. The triumphant inventor demonstrated to the world the unqualified success of the electro-magnetic telegraph. The first message was sent over the sixty-mile wire from the United States Supreme Court room in the Capitol at Washington to Baltimore on May 24, 1844. Since that day telegraph wires have spanned the world, knitting countries and peoples more closely

through the medium of instantaneous communication. The letter Morse received was twenty-five days in transit. The same message a few years later could be transmitted in twenty-five seconds.

Marvellous as Morse's invention was, it was only a step toward the ultimate in long-distance communication. Ever since man discovered he had a voice and vocal equipment for speech, he has expressed himself through words. At first they were merely monosyllables that imitated sounds of things animate and inanimate. As the centuries passed, words were grouped into sentences and language came into being. Men could express their thoughts, their emotions, their desires. But the human voice, no matter how powerful, could be heard only for a few hundred yards under ordinary conditions.

Then one day primitive man discovered that a shout through cupped hands held at the mouth projected the voice to a greater distance. It was the first megaphone, that later was developed into a variety of trumpets made from the horns of animals, spiral seashells, conches and tall reeds.

As ages passed, these primitive trumpets were fashioned from metal and became a means of mass communication. In the turmoil of the early wars the trumpet was the voice of command. Its clear call carried far beyond the voices of the commanding generals. Massed fighting men obeyed the trumpet blasts that meant as clearly as words, *Forward!, Charge!, Cease fire!, Retreat!* and other commands.

Those were the prototypes of many sound-signaling devices in use today. Steam and motor-driven vessels have a system of whistle signals through which they communicate over considerable distances. For instance, a two-whistle blast from one vessel approaching another means, "I will pass you to starboard (on the right)." A single

blast indicates the vessel will pass on the left. Ocean-going tugs have a standard code of thirty-two whistle signals, consisting of various combinations of short and long blasts.

Day or night, when fog hides the lighthouse and its beacon, mariners are warned of danger by distinguishing blasts from its giant foghorn. The shrouded light can be identified by the number of seconds of silence between blasts and the duration of a single blast.

As this is being written, I can hear the doleful moaning of the foghorn on Execution Rock Lighthouse nearly three miles distant. After each three-second blast is a silent period of seventeen seconds. Consulting the LIGHTLIST of the ATLANTIC COAST, the navigator can identify the light by the time lengths of its blasts and of its silent periods.

Execution Rock sends out also every three minutes a "distance signal" of a short and a long blast with a simultaneous radio signal. Since radio travels with the speed of light (180,000 miles a second), its signal reaches a vessel, say two miles away, almost immediately. The sound signal, traveling at only 1000 feet a second, takes about 10 seconds to reach the same vessel. The number of seconds between receipt of radio and sound signals, when divided by five, gives the approximate distance from the light; in this case about two miles.

Among less advanced peoples the drum in various forms has served the same purpose. The tomtom is perhaps the best-known primitive means of communication. Once while in Haiti, I was permitted to attend at midnight a native rite far up in the hills. It was during the full of the first moon of the year. As the donkeys we rode plodded unerringly along the black trails, tomtoms sounded for miles around. Some were close by in the dense undergrowth; others came from varying distances among the

faraway hills. All had a common cadence that increased in tempo with passing minutes until the pulsing chorus attained a wild ecstasy. Then as if a signal had been flashed for miles around, the babel of drumbeats subsided into a silence, broken only by a belated ruffle or two of bony fingers on a goatskin drumhead.

During the throbbing cyclone of sound, I became conscious of the fact that my body swayed on the donkey's back in the precise tempo of the tomtoms. Catching myself being carried away by the mystic rhythm, I fought it. But it was like trying to dance in waltz time regardless of the beat of a top-flight swing orchestra.

The following morning while breakfasting with my host, Major X, I learned that the tomtom, although frowned upon by the Haitian Government because of its stimulus to primitive excitement, remains in fact as much a part of the life of the Haitian masses as is the telephone or the juke-box to people in our own country. Furthermore it is a time-honored means of communication when social, political or pseudo-religious gatherings require that the natives be summoned.

I asked the Major if he could explain the psychological impact of the tomtom on mass emotions.

"It is said," he replied, "that the expert 'tommer' keeps time with his heartbeats. As he works himself into an ecstatic frenzy, the heart action grows more and more rapid and so his drumbeats take on an increasingly faster tempo. His state of rapture soon becomes contagious, not only among his fellow tommers but among his audience as well. During the craze for dance music of jungle origin that swept the United States, a similar thing happened. The musicians who composed the dance orchestras, often whipped themselves into a wild musical fury that soon transmitted itself to the dancing audience. No orchestra

was complete without an array of drums that beat out the unrestrained tempo of jungle tomtoms."

Bells, gongs, cymbals, hollowed logs and even smoke signals have been used to disseminate good news and bad. Reflecting the sun's rays from a mirror in short and long flashes was for many years a much used method of military communication. The transmitting instrument was known as the heliograph.

In their transcontinental surveys the Coast and Geodetic Survey field crews encounter mountain ranges over which imaginary but precise lines must be established. "Sights" are taken from one mountain peak to another that may be fifty or more miles apart. During daylight hours those widely separated points are often hidden from each other by clouds or haze or smoke from forest fires. Heat rising from the intervening valley causes refraction fatal to accurate calculation. In such cases the surveyors work after midnight, when a tiny pip of light, sighted through the telescope of the surveying instrument, is clearly visible from one mountain top to the other. Then a code of light-pips makes accurate communication possible. The light source is essentially a simple flashlight powered by a couple of ordinary dry-cell batteries.

In contrast is the light newly installed by U.S. Coast Guard on Ambrose Lightship at the entrance to the port of New York. Its 5,600,000 candle-power beam is visible in New York City thirty miles distant. It is by all odds the world's most powerful sea navigational light and a vital source of information to thousands of vessels as they approach the greatest and busiest port in the world. When darkness or fog blankets the sea, its flashing heartens the navigator and points the way to Ambrose Channel and safe harbor. Acting as a traffic officer on a congested road

intersection, it directs incoming, outgoing and coastwise ships on their appointed courses. Without this light, entering New York Harbor would be hazardous almost to the point of disaster.

During the early days of the Far West, when it was known as "wild and woolly," there was no means of rapid communication between California and the East. The transcontinental railroad was not yet completed. The telegraph, still a seven-day wonder, was confined to the Eastern States. A fast growing population and business expansion made it imperative that some means of more rapid communication with the outside world be established.

Stage-coaches were operated by Wells, Fargo and the Adams Express Company. While transportation of passengers and gold was their chief concern, they also carried mail. Rough trails, hostile Indians and "road agents" skilled in armed robbery made coach travel extremely hazardous. Heavy goods: food, clothing, building materials, agricultural implements, etc. were transported mostly on ox-drawn wagons.

The largest firm in this overland freight business, Russell, Major and Waddell, employed nearly 6000 men, 40,000 oxen, 1000 mules and 4000 wagons for hauling sixteen million pounds of supplies to Western Army Posts. Then, realizing the pressing need for a speedy system of communication, this firm secretly organized the Pony Express. They scoured the country for its hardest riders and fleetest horses; they built relay stations ten to fifteen miles apart. Each was a fortress, a precaution against Indian raids. There riders and horses were bedded and fed, while fresh men and ponies sped with the precious mail to the next relay station.

With war between the states imminent, President Lin-

coln's first inaugural address had momentous meaning. Ordinarily it would take several weeks to bear the Presidential words of warning from Washington to California. The message was rushed by special train to St. Joseph, Missouri, the end of the line. The Pony Express sprang into action. Seventy-five riders were at their appointed relay stations. Each was a link in a clattering chain of speeding hoof-beats. The Presidential message was borne 2000 miles over god-forsaken country in seven days and seventeen hours.

Many of the riders were Indian fighters noted for their skill in carrying out dangerous missions,—among them was one whose nickname was Buffalo Bill. A number of those horsemen had specialized in carrying communications despite difficulties or dangers to far distant points. Their fee for such an errand was often as much as $2,500. The regular postal rate for mail carried by Pony Express was $5.00 for each half-ounce. With the encroachment of the railroad and the telegraph, it was reduced to $1.00 a half-ounce.

Some two thousand years ago the Chinese had a well established long-distance communications service. Geese were employed as carriers of written messages from one potentate to another. Their unerring flight at fifty miles an hour through all kinds of weather was valued so highly by Celestial officialdom that the image of a flying goose is carried to this day on the Chinese government's Postal flag.

Winged messengers are still used by the United States Army Signal Corps. Several establishments for the breeding and training of carrier pigeons are maintained for military communication in the field. Although the dove is a

symbol of peace, a number of those bird heroes have been decorated for valor in battle.

There was one I remember. Bearing an urgent request for re-enforcements, the pigeon was attacked by preying hawks. Battered, bleeding and unable to fly, the gallant bird crawled and fluttered along the ground for five miles till it reached the cote where it was to deliver the message attached to its injured leg.

And so from the earliest ages man has devised many means of communication through sound, sight and the swift movement of men and animals. All were based, however, on symbols, aural or visual, that expressed words, and all were substitutes for the human voice that unfortunately had a distance range of only a few hundred yards. Yet it was the burning desire of all men to project their living voices and their spoken words beyond the horizon and to the far reaches of the earth to those they loved or hated or to those they dealt with socially, politically, economically or militarily.

It was not until 1876 that the gag was removed from the mouths of men who yearned to talk in defiance of distance.

2

SPEECH TAKES WINGS

ONE DAY—IT WAS MARCH 10, 1876—A PHLEGmatic world was startled by the announcement that a young man, almost unknown in scientific inner circles, had projected his voice and his words over a wire loosely strung in a shabby building at 109 Court Street, Boston. At the other end of the wire in a distant room his awed assistant, hearing his master's voice, became the first human being to receive a coherent telephone message clearly. It was a moment that will go down in history as a turning point in the progress of mankind.

The young inventor was Alexander Graham Bell, born in Edinburgh, Scotland, March 1847. He was the son of

Alexander Melville Bell, a prominent teacher and author of textbooks on correct speech. His mother, Eliza Grace Symonds, daughter of a surgeon in the Royal Navy, was an accomplished musician who lost her hearing when Graham, as he was called, was a boy of twelve. It was from her he inherited his great love of music. The boy's grandfather, Alexander Bell, also a specialist in the art of good speech, had built a wide practice in the correction of stammering, lisping and other speech defects.

Even before he had entered his teens, young Bell showed a great interest in invention. He was never so happy as when tinkering with discarded household odds and ends. His choicest possession was an old broken-down clock which he loved to take apart and put together again. When he was about fourteen, he visited a flour mill in Edinburgh. The owner, knowing his young visitor was of an inventive turn of mind, asked half jokingly if he could suggest a way to remove husks from wheat before grinding. Graham, taking the question seriously, became silent, thoughtful for a few moments. Then he spoke with all the confidence of a seasoned engineer. "If you will run the wheat between stiff rotary brushes, you will find the husks removed." The miller, quick to utilize a good idea, used the rotary-brush method of husk removal successfully for many years.

When scarcely fifteen years old, young Bell became fascinated by the mechanics of speech. He and his brother had made a model skull and fitted it with a reproduction of human vocal apparatus that was worked with a bellows. With it they gave lifelike imitations of a baby's efforts at speech. Its pitiful wails of "Ma—ma! Ma—ma!" were so real that neighbors hurried to the assistance of what they thought to be a lost child. At this period also the embryo scientist trained his pet terrier to howl steadily while he

manipulated the dog's mouth and vocal chords so that they formed a fair semblance of words. Friends gasped when they heard the dog with Graham's aid say, "Ow—ah—oo—Gamma?" (How are you, Grandma?)

Because he was considered something of a prodigy, he was welcomed as a student-teacher at a boy's school in Edinburgh. There he taught music and elocution in exchange for instruction in other subjects. Although teaching and study left him little time for science, young Bell carried on a series of experiments to determine how different vowel sounds are formed by varying positions of the tongue and mouth cavity. A London scientist who had read a report on those experiments, suggested to Graham that he read a book, *Sensations of Tone* by Von Helmholtz, who had combined notes of electrically vibrated tuning forks into synthetic vowel sounds.

The book became the turning point in Bell's life. When he had read it, he became obsessed with the possibility of telegraphing speech, although he had no idea of how to go about it. He knew, however, of the success of Morse's electric telegraph, then a rapidly growing enterprise. Without electrical experience he brooded over his pet project.

A year or so later he was appointed to the teaching staff of Somersetshire College, where he met a fellow teacher who had dabbled extensively in electricity. In a short time he, too, acquired a considerable knowledge of it. To further his studies, he installed a telegraph line from his room to that of his friend. Soon both young men were proficient in the Morse Code. When they were not engaged in their teaching duties, they "pounded the key" for hours on end, sending messages back and forth.

One evening while the two pseudo-telegraphers were tapping out their nightly confidences, they drifted into

what was apparently innocent gossip. A certain professor was the subject. The weather was warm; the windows were open and the clicketty-click of the instruments carried plainly to a nearby room. By a streak of ill luck the occupant was the professor himself, once a telegraph operator. Adept in Morse Code, he heard his initials tapped out. They were followed by a cryptic reference to the professor's association with an unpopular character in the community.

Knowing where the wires led from Bell's room to that of his friend, the infuriated professor ripped them out. Then, confronting Bell who was still at his telegraph key, he said loftily, "My dear Bell, when discussing another person's private affairs, it might be healthier to use a secret code!"

Embarrassed and a little resentful, Graham Bell later resigned from the teaching staff and went to London, where he took charge of the professional affairs of his father, who was then on a lecture tour in America. As an extra-curricular activity, he lectured on the anatomy of the voice apparatus at University College, London. Overwork brought on declining health. Two of his brothers had already died of tuberculosis. Physicians gave warning that he, too, was threatened with the disease.

Meanwhile the elder Bell, always a man of action, decided to leave the damp atmosphere of Britain and take his family to Ontario, Canada, although it meant a serious financial loss. .

Some time later Graham Bell, who had remained in England, then deeply engrossed in devising an instrument that would transmit several telegraph messages simultaneously over a single wire, decided to follow the family to the New World. For months he had worked far into the night with his two sets of tuning forks, sending several

tones at the same time from one set, then separating the tones at the receiving set. He called it his "harmonic telegraph." His efforts, however, had met with little enthusiasm either in scientific or financial circles. Disappointed but not discouraged, he went on working day and night with his tuning forks.

One morning he received a letter from his father. It informed him that the principal of a school for the totally deaf in Boston wanted to hold a series of lectures on "Visible Speech," for his teachers. Unable to go to Boston, the father suggested that Graham take his place. Before he had finished reading the letter, Graham had made up his mind; he would sail for Boston at once. It was the opportunity he had dreamed of, the chance of a lifetime to follow the trail to success blazed by Samuel Morse, for whom his admiration was unbounded.

A week later he stepped aboard a sailing vessel at Glasgow. All his worldly belongings were carried in a leather portmanteau—the suitcase of those days. Glasgow was a bustling industrial city with a population larger than most American towns. Situated on the River Clyde, its waterfront was lined with shipyards, tanneries, factories and warehouses. As his ship was towed down the tortuous channel into the open water of the Firth of Clyde, the young emigrant, leaning on the vessel's rail, wondered with sinking heart if, after all, he were embarked on a wild goose chase.

With deep water under her keel and ample sea-room around her, the three-masted ship cast off the lines to the tow-boat. A bellowing mate sent men swarming aloft to shake out sails loosely festooned on the yards. On deck the scene was one of orderly confusion as sweating sailors pulled and hauled on braces and halyards and slings. Hoarse voices mingled in a bedlam of commands and mut-

tered curses. Over all rose the lusty rhythm of a sea chantey spurring men to heave in unison on rope or capstan.

Sails were set and sheeted home with geometric precision until the bark was transformed into a tall tower of snowy canvas billowing under the press of a freshening wind. Now under her own power, the vessel quivered with life as she sped away on her long journey. Feathery wisps of spray, leaping playfully over the bow, sent many of the passengers running to cover. Bell kept his post at the ship's rail. The salty tang of the sea, the transparent blue of the sky, the wheeling gulls eyeing the ship's wake for tidbits from the galley, kindled in him new hope, new courage.

A middle-aged man wearing a long navy cape approached young Graham. "My name is Mackintosh," he said affably. "The steward tells me we are roommates. I understand your name is Bell. I once knew a Doctor Alexander Bell. Nice chap. Fine fellow. He had something to do with speech and that sort of thing. Was he a relative by any chance?"

"He was my grandfather."

The older man gasped a little. "Why, my dear fellow, you and I will get along famously."

During the weeks that followed, incessant bad weather confined the two men for long hours to their stateroom. Observing the custom of the sailing ships in times of stress, all passengers were "battened below."

One evening while the ship was fighting a violent northeaster, Bell asked his roommate, "And what do *you* do, sir?"

The older man answered, "Personally, very little. I happen to be president of a large ship-building company on Clyde side. This ship was built in one of our yards. With

masts of teakwood, timbers of white oak and planking of yellow pine she is as staunch and seaworthy as the hands and minds of men could make her. Besides, she has every convenience and safety appliances that money could buy."

At that moment a murderous sea caught the ship broadside and flung her almost on her beam-ends. Everything that was not fastened down was thrown to the deck. Screams of women and shouts of men came from nearby staterooms; from outside, the thunder of tumbling waters and the howl of the gale through the rigging. It was the same bedlam they had experienced many times before.

When the ship and her terrified passengers had regained their balance, the shipbuilder said proudly, "See what I mean? A less seaworthy vessel might well have foundered."

Bell did not seem to be impressed. Deep in thought, he scarcely heard what his companion had just said. After a moment or two of silence he spoke. "I've been thinking of the long roster of noble ships that have been lost without trace and of the thousands of souls who have gone to the bottom without even the faintest hope of rescue. Suppose on some dark or foggy night we had piled up on one of those icebergs we've sighted, or ripped open our bows on a submerged derelict. Suppose a fire on board got beyond control, what could we do but await certain death? And the irony of it is that a rescue vessel a few leagues distant would be unaware of our plight because we had no means of communicating with her. On land Mr. Morse's electric telegraph carries messages hundreds of miles in a twinkling."

The older man broke in impatiently, "But Morse has wires from point to point. You would not expect telegraph poles on the sea."

The studious Bell retorted warmly. "Mark my words, sir! The day is not far off when neither wires nor other

solid connecting media will be necessary for long-distance communication. New electrical phenomena are discovered almost daily. The age of electricity is just around the corner. If a lightning bolt can leap through the atmosphere from a heavily charged cloud to a church spire or other high structure, isn't it conceivable that science may send a lesser bolt over a greater distance?"

Again a violent lurch of the ship made her shudder from bowsprit to rudder-post.

Fully clothed and weary to exhaustion, the two friends threw themselves on their berths, hoping to escape in sleep some of the discomforts and anxieties that bedeviled them. Mackintosh, born to the sea and ships, was soon snoring like a wheezy bellows. Bell, less fortunate, lay awake staring into the semi-darkness. What would his future be in the new land? Success or failure, poverty or riches, happiness or misery, respect or rejection?

Morning came with sunshine and a calming sea. The wind had flattened out to a gentle breeze. Land had been sighted from aloft; the end of an adventurous voyage was near.

Bell and his friend the ship-builder sat on adjoining deck chairs, their eyes fixed on the distant shoreline. The captain, making his rounds, paused to greet them. "Nice day for entering port," he said affably. "If this breeze holds out, we shall be tied up at the pier by tea time. Sorry I could not give you better weather."

As he left to continue his round, Mackintosh turned to Bell, "I say," he said, "where are you stopping in Boston?"

"I'm blest if I know," was the answer. "This is my first visit. Perhaps you can recommend some place that will not be expensive."

"Better come with me. I usually stop at a small hotel downtown. It is clean, comfortable and reasonable."

"That will suit me admirably. You see, my funds are quite limited. I must make a little go a long way."

"Spoken like a true Scotsman! But never let your dreams cool off, for success is but dreams come true and wealth is merely a symbol of work done. If your work is as good as but a fraction of your dreams, my purse is at your disposal for say, fifty or perhaps a hundred pounds sterling."

That night in Boston the two men enjoyed the luxury of large and comfortable feather beds. Bell, however, unaccustomed to the sea, still felt the incessant roll of the ship. His sleep was disturbed by nightmares of boarding seas.

Up and about early next morning, he strolled along Boylston and Tremont Streets and through the well-kept Boston Common. The leisurely pace of the people and indefinable atmosphere of culture reminded him of his native Edinburgh. He prowled the less frequented streets, hoping to find some inexpensive place where he could carry on his inventive work.

"Could you tell me of a place where I could do a little tinkering?" Bell asked a brawny man in uniform.

In those days the police were called "watchmen"; it was their duty to know intimately the entire area in and around their posts.

"And that I can," replied the officer. "Down the street a bit there's an ould building that's all but empty—rats, you know. You can rent all the room you want there for a song."

The building at 109 Court Street was an antiquated structure, shabby and neglected. In an attic on the top floor Bell discovered two adjoining rooms that were within his means. Young, strong and filled with visions of success, he reveled in the hard labor of cleaning out the clut-

tered rubbish and readying the place for a haven where he could dream and study and work.

Nor had he forgotten the School for the Deaf that had made him decide to come to America. He went to its classrooms where he was to lecture and was cordially received by the principal and teachers. As time went by his lectures became notably successful. He was able to teach the use of more than four hundred English syllables, many of which his pupils had been unable to learn in two or three years under other methods of instruction.

Meanwhile by chance he had met a young man named Thomas A. Watson who had something of a reputation as a mechanical genius. The two men became fast friends. Each, confiding in the other, told of his aims and ambitions and of his problems—which at that moment were mostly financial.

Although his funds were running low, Bell managed to buy sufficient electrical equipment to set up a rudimentary telegraph line in his garret workroom. A galvanic battery, a homemade sending instrument commonly called "the key" and a receiving instrument known to telegraphers as "the bug," several hundred feet of copper wire, a few tools and a collection of unrelated metal odds and ends made up his working apparatus. A large kitchen table as a workbench, a couple of rickety chairs and a few technical books were the furnishings of his makeshift laboratory.

Bell and Watson spent many evenings in collaboration. Their discussions invariably turned to telegraphy and the vast field of development that lay ahead.

It was during one of those night sessions that Bell described a project which he had been working on for some time. Although weary and haggard, he picked up a pencil and on a piece of paper drew a complex electrical hook-up and a strange mechanical device that he hoped would

transmit several Morse messages simultaneously over the same wire circuit. He called it the "harmonic telegraph." Actually, though he did not know it, he had conceived the basic principle of the telephone.

Watson stood fascinated. Quick to recognize genius, he realized that Bell was no mere putterer, that a great future was in store for the young Scotsman. "Tell you what I'll do, Bell," he said earnestly. "If you will tell me exactly how you want this contraption made, I'll make it."

"Thanks, Watson!" There was a tremor of deep satisfaction in Bell's voice. The two men shook hands, and so began a lifelong friendship and partnership.

Bell outlined the principle of his new device. He said to his new assistant, "If I get a mechanism that will cause a current of electricity to vary in intensity as the surrounding air varies in density while a sound is passing through it, I can telegraph any sound, even the sound of speech."

Although he had a clear conception of the problem, Bell did not know then how to solve it in actual practice. It took almost a year of patience and hard work on the part of both men before they succeeded in developing a number of instruments composed of wooden and metallic odds and ends. They were in essence a commonplace electric buzzer in which slender steel reeds from an old parlor organ were substituted for the conventional metal vibrators. When electrically vibrated, the reeds should give off a mellow musical tone.

The crude transmitters were set up in the room that served as Watson's workshop. An equally crude receiver was installed on Bell's worktable in the adjoining room. At the appointed instant Watson pressed a switch to set one part of the apparatus in operation. Nothing happened. He tried again and again without getting so much as a click from the instrument. A careful check showed

that the contact point was screwed too tightly against the reed, so Watson plucked it with his fingernail to start it vibrating. Bell in his own room heard the unusual sound over the wire. He even recognized the characteristic pitch and quality in the twang of the vibrating reed. Something of a Stoic, he gave no evidence of excitement, but his heart beat faster. He was hearing for the first time in human history the tones and overtones of a sound transmitted by electricity. That moment marked the birth of the harmonic telegraph which played so important a role in the development of the telephone.

During the hours that followed Bell paced his attic floor deep in thought. Occasionally he bent over his worktable to make notes or rough sketches of an instrument he had in mind. Having successfully transmitted a complex sound over a wire, he believed he could make the sound capture the characteristics of the human voice. It was a task more difficult than he had imagined.

Later Bell entered Watson's workshop and laid a rough sketch on the bench. "I think this will work," he said. Then he went on to describe in minute detail the various parts of the device and how they were to be assembled. Like the harmonic telegraph instruments, it consisted of a reed mounted over a magnet but with the free end of the reed fastened to the membrane of a drum resembling a tambourine.

When the membrane was made to vibrate by a human voice, it caused the reed to vibrate over the pole of the magnet and thus set up in the electric circuit a wavy current that resembled the air waves set up by the voice. The receiving instrument was made in the same general pattern.

Days later sending and receiving instruments were installed in their respective rooms. Watson at the transmit-

ter, speaking with a strong voice, counted "One!—two! —three!—four—" etc., and then repeated the letters of the alphabet. Bell sat listening at the receiver, a shadow of disappointment on his face. While the tones and quality of Watson's voice came in clearly, his words were not distinguishable.

The experiment, however, marked another milestone on the difficult road that lay before them. A human voice had come in over the wire; some day the voice would come in the form of intelligible words and then—success!

Buoyed by that hope, Bell stuck doggedly to his experiments through months of privation, sleepless nights and days of heartbreaking labor.

One day, as on many others, the young inventor was testing one of his experimental transmitters without much success. Suddenly as if it were a bolt of lightning an idea flashed through his mind. He called Watson.

"I want one end of a two-inch piece of copper wire attached to the center of the membrane diaphragm. Under the other end I want placed a tiny receptacle holding half a thimbleful of diluted sulphuric acid, so that the vibrations of the membrane will cause the wire to touch the acid ever so slightly!"

That very evening Bell sat down before a crude transmitter that Watson had built according to instructions. At the other end of the line Watson was listening eagerly. Everything was in readiness for the test.

At the last moment Bell, always orderly in his habits, decided to straighten the clutter of scientific paraphernalia on his worktable. It may have been Fate or it may have been clumsiness that upset a tall stand tube containing sulphuric acid and spilled it over the inventor's trousers. Feeling the stinging bite of the vitriol on his flesh, he shouted, "Watson! Come here! I want you!"

A moment later Watson burst into the room, shouting excitedly, "Doctor Bell, I heard every word you said distinctly!"

Bell scarcely felt the pain of his burns. The dream of years had come true. The silence barrier that had kept peoples apart, had been broken. Unmindful of his acid-soaked clothing, he shook the hand of his faithful assistant. "Well done, Watson!" he said. "Without you I would have been lost. From now on we are partners, come what may!"

It was a partnership of poverty; a five-dollar bill in Bell's wallet represented his total capital.

The apparatus Bell had used in transmitting his first message was indeed a crude and cumbersome affair. It was evident that his next project must be the development of a practical telephone transmitter and receiver that would be compact and portable and that would comply with the requirements of the United States Patent Office.

Because of his excellent reputation as a teacher and lecturer on vocal physiology, Bell succeeded in getting a number of engagements during the ensuing weeks. His fees, though meager, were sufficient to keep body and soul together and to provide Watson with a few good materials for the finished model of the telephone.

One evening while he was glancing through a Boston newspaper, an item caught Bell's attention. It recorded the arrival of the steamer *City of Paris.* Among the notables on board was "a Mister Mackintosh, a Clydeside shipbuilder."

Early next morning the weary and worried inventor called on Mackintosh at the very place where both had boarded nearly two years before. Cordial greetings finished, the shipbuilder asked Bell how he was getting along

and what progress he had made in the improvement of "Mister Morse's telegraph."

Bell gave his old friend a detailed report of his latest invention in sending human speech over a strand of wire.

"Do you mean you can actually speak to someone miles away?" There was a mild note of disbelief in the older man's voice.

"I mean just that!" Bell replied quickly and with such sincerity that the canny Scotsman believed him, at least in part.

"And what do you propose to do with it?"

"Nothing for the present," Bell stammered. "You see, I've run out of money. The fact is, I'm broke. Perhaps you remember you once said you might help me financially if ever I needed it. You know of course that making a finished model takes money and patent attorneys are expensive these days."

"Quite so! How much do you think you'll need?"

"I should say about three hundred dollars."

Mackintosh stroked his mustache thoughtfully. "Tell you what I'll do," he said. "Meet me tomorrow at ten at the offices of Saunders and Hubbard. I think I can prevail on them to advance sufficient funds to see you through."

The next day the firm of Saunders and Hubbard agreed to supply funds for the completion of Bell's telephone model and for the necessary legal expenses for patenting it, in return for a share of whatever patent rights might result from any or all of Bell's experimentation.

A few weeks later on March 7, 1876, Bell was notified that his first patent had been granted. His invention, however, brought no financial return. As if to make matters worse, his backers informed him they could make no further cash advances.

Again short on money to carry on his experiments, he turned to teaching, lecturing and giving public demonstrations of the newly invented telephone. The latter were well attended and covered by the press, but still the money trickled in slowly.

Then one evening while he and Watson were discussing their future outlook, Bell lapsed into silence. With eyes closed he slumped in his chair deep in thought. Suddenly he sat upright. The modest, almost shy genius brought his fist down on the cluttered worktable with a resounding thump. "I've got it!" he shouted. "What we need is countrywide publicity! Just that and nothing more!"

In the days that ensued, the rejuvenated Bell, setting aside his laboratory work, spent his time with the news editors of various papers, extolling *verbal* long-distance communications as the most modern means of newsgathering. He spent hours with the executives of the then existing telegraph company in an effort to secure the use of a wire from Boston to Salem some fifteen miles distant.

Fearing an intrusion on their field of communications, the officials refused to co-operate. A few days later, however, they had changed their minds. They reasoned that Bell's proposal would give them an opportunity to prove that his newfangled talking device would not operate over such a long distance. After much discussion the telegraph officials agreed to place a wire from Boston to Salem at Bell's disposal.

Despite his inherent modesty Bell proved a good publicity agent. The press of Boston and surrounding communities played up the story of the coming demonstration of human speech transmitted over a fifteen-mile wire.

On the evening of the great event news reporters and men of science flocked to Bell's Boston laboratory where a receiver was set up on the inventor's workbench. Simul-

taneously in a lecture hall at Salem a large and skeptical audience was assembled. In the center of the stage a pedestal supported a transmitter. It was a black box resembling an oversized box-camera of those days. Two slender wires led from it to an open window. Upstage a blackboard rested on an easel. Bell in evening dress explained in simple terms the principle of the telephone, illustrating his remarks on the blackboard.

Back in Boston hard-boiled newsmen and dubious scientists sat and listened with varying emotions as Bell's words came clearly over the wire.

The following morning and for weeks to come newspapers carried stories on the demonstration of the miracle of long-distance speech. Forward-looking people began to realize the usefulness of the telephone and its possibilities in the business world. Fourteen months after Bell had been awarded a patent on his invention, the telephone was put into commercial use.

At first telephones were leased in pairs from the Bell Telephone Company. The person leasing the service put up his own poles and wires to connect him with the phone of a relative or friend, or he ran a line between his home and his place of business. There was no way, however, by which he could talk by telephone with others in the community who had leased instruments.

Soon the eastern part of the country was buzzing over the new miracle of science. There were many who believed it to be another hoax. Those who were privileged to talk over a friend's telephone to a distant acquaintance were so awed or startled by the fearsome instrument, they either lost their voices or shouted at the top of their lungs. In those days the word "phone" was pronounced "fome" by many, particularly in New England.

New Haven, Connecticut, was the first city in the world

to have a commercial telephone exchange. A switchboard, interconnecting eight lines and twenty-one subscribers was put in service there in January, 1878. In those early days and for a number of years thereafter teen-age boys were employed as telephone operators.

The fame of the telephone spread rapidly throughout the eastern states. It became the subject of conversation in clubs and homes, on the farms and in the market-places. Soon the demand for installations was greater than the possible source of supply. The informal business arrangement between Bell and his backers, Saunders and Hubbard, took the form of a trusteeship. Bell, true to his promise, insisted that the faithful Watson be admitted as one of the patent owners.

And so was formed a partnership that was the ancestor of the world's largest empire of communications. Second in the genealogical line was the American Bell Telephone Company, owner of the Bell patents. It licensed local companies to *rent* Bell telephones to their subscribers. These companies grew and prospered beyond their wildest dreams. The larger they grew, however, the more chaotic became their financial fabric because of their fabulously expanding operations. As a result there was waste, confusion and only mediocre service to the public.

At this period the American Telephone and Telegraph Company was organized as a controlling and co-ordinating factor under which its participating companies worked in harmony. Broadly known as the "Bell System," it contains today:

(1) The largest industrial laboratory in the world. The Bell Telephone Laboratories are devoted to research, development and design in the communications field.

(2) A group of telephone companies, each serving its particular territory.

(3) A supply organization, the Western Electric Company, which manufactures or purchases equipment and supplies for the entire system.

(4) A headquarters organization which co-ordinates the entire enterprise. The A. T. and T. owns most of the stock of most of the operating companies. Functioning as a general staff to assist the operating companies, it also furnishes long-distance telephone service over its Long Lines department.

Today's nationwide system of voice highways links together more than forty-five million telephones, most of them serviced by the Bell System. The rest are operated by some 5,500 telephone companies and by smaller units such as rural lines which number more than 60,000. All however, have facilities through which they can be connected with the Bell System, so that a remote farmer in Iowa has at his disposal forty-four million phones through which he can say "Hello" to a friend or conduct a business transaction.

3

MEN AGAINST DISTANCE

WHILE ALEXANDER GRAHAM BELL HIMSELF never carried the invention beyond its elementary stage, he foresaw in detail the possibilities of universal communication when his discovery would reach its ultimate development. While addressing a group of London capitalists in March 1878, he said, "It is conceivable that cables of telephone wires could be laid underground or suspended, communicating by branch wires with private dwellings, country houses, shops, manufactories, etc., uniting them through the main cable with a central office where the wire could be connected as desired, thus establishing direct communication between any two places in the city."

Contrary to the popular conception of Bell's effort to create a device that would carry the human voice over a wire, the greater portion of his inventive genius was centered, not on the telephone but on his harmonic telegraph. That was in large part due to the attitude of his financial backers, Saunders and Hubbard, who looked on the telephone as merely an inventor's dream and a mighty poor risk for invested capital. The electric telegraph was then a well-established business hampered only by the limitations of the telegraph wire that could carry only a single message at a time. It did not take much business acumen to sense that a device that would send several messages simultaneously over a single wire would be welcomed by the telegraph companies.

So unimportant did the telephone appear to Bell's partners, it was not mentioned in the agreement on patent rights which covered only the harmonic telegraph. It was merely through Bell's code of fair dealing that it was included later when the three partners formed a company registered as the Bell Patent Association.

At that time the telephone was a crude affair with many inherent defects. It was considered more a curiosity than a commercial enterprise. Bell, seeing in it the nucleus of a great industry, insisted that development of it be carried on at least on a modest basis. The partners, Saunders and Hubbard, agreed grudgingly to associate with them "a practical mechanician of sufficient skill and ability under Mr. Bell to make the invention financially successful."

A contract was made with Thomas A. Watson, Bell's laboratory assistant. It provided that Watson should give at first half his time and later all his time to working on the debatable invention. In return Mr. Watson was to receive $3.00 a day as wages and a one-tenth interest in the patents. That agreement marked the birth of the Bell

Laboratories of today, the world's largest integrated organization devoted to science and employing some 7000 scientists and technicians. From these laboratories have come the miracles of development that have converted Bell's primitive little telephone into a worldwide necessity. Without it civilization would slip backward a hundred years.

Although Bell's first telephone patent was issued in 1876, it took several years to introduce it to the daily life of the American people. As late as 1880 there was not a single switchboard in general use. One was installed in Boston. It was a tiny affair set up in the brokerage office of E. T. Holmes. It interconnected four banks and a large manufacturing concern by utilizing in the daytime the wires employed at night in a telegraphic burglar alarm system.

The next four years brought a great development in telephone facilities. In 1881 the world gasped in surprise when a line from Boston to Providence, Rhode Island, was built and opened for service. Three years later a person in New York could talk to a friend in Boston 235 miles away. Soon Boston and New York were talking to Chicago, Milwaukee, Pittsburgh and Washington, D. C. By 1892 nearly half the people of the United States had been put within talking distance of each other.

Meanwhile independent telephone companies were springing up all over the country. Many of them were small affairs serving a prescribed locality and without any long-distance facilities.

With growth came mergers in which two or more companies pooled their interests. Eventually the telephone industry had become so snarled it was like a skein of yarn a kitten had played with.

In those days there was no national telephone service.

An important step toward it was the organization of the American Telephone and Telegraph Company in 1885. The company was formed to build and operate long-distance lines to interconnect the regional companies and so put them within reach of telephone users anywhere in the United States.

Then began one of man's most ambitious projects: building an empire of communications. Long lines were extended farther and farther. Vast sums were spent on investigations and surveys. Experiment and development of apparatus, equipment and methods were carried on day and night. Administrative functions were centralized so the public would get effective and economical service.

There were those who shook their heads dolefully over the millions of dollars that were being poured into such a gigantic enterprise; many considered it a hazardous gamble. A few newspaper reporters who had listened in Bell's garret laboratory to the spoken words of the inventor while he was fifteen miles away could not comprehend the grip the telephone had taken on the populace, although more than one of them had scored scoops by phoning hot stories to their city desks. There were even a few editorial writers who took a glum view of the telephone as a universal means of communication. They considered it a fad that sooner or later would lose its novelty and advised would-be investors to use extreme caution.

The advice was not entirely without reason, for in those days using a telephone was something of an ordeal, particularly for timid people with a fear of electricity. The type of instrument used was known as a "wall phone." It was a box-like affair attached to a wall in some remote quiet corner. The ritual of making a phone call was described to me by a very old lady who during her girlhood

had witnessed many a telephone call made by her father, a prominent New York physician.

The first phase of the operation was to turn violently a crank on the side of the instrument and to wait for an answer from "Central." If none came, the cranking was repeated again and again and was accompanied by a series of increasingly angry bellows—"Hello, Central! Hello, Central!!" Eventually a crackling and sputtering came from the instrument and was succeeded by a vibrant humming over which came the cracked voice of a teen-aged boy operator, "Numbah, plee-aze?"

The number given, the perspiring caller waited, shifting from one foot to the other, and muttering an occasional "Hello." Finally over the buzzing and strumming of the instrument a faint "Hello" came from the other end of the line. The conversation that followed was interrupted occasionally by a shouted request, "Speak a little louder! I can't hear you!" And so the call went on for several exciting minutes. When it had ended with a twirl on the crank, the sweating caller wore a smile of victory.

Later when "long lines" were established, long distance calls were something of an adventure. Despite constant improvement, the telephone was still infected with annoyances. When the usual ritual of calling "Central" had been observed and the caller had given the name, address and number of the person he wished to speak to, he was told to "hang up" which meant to return the receiver to its hook. Furthermore he was informed that there would be a delay of fifteen or twenty minutes before "the other party would be on the wire." Only those of strong voice and good diction could make themselves clearly understood when the distance was greater than a hundred miles.

Only last week in Port Washington, New York, I picked up the phone on my desk and casually called my daughter

in California. Quite as casually the operator took the number. There was silence for a few moments and then came the welcome voice as clear and as softly resonant as if we were together in the same room.

While we were chatting, memory played one of its strange tricks. I harked back to the days when I was a cub news reporter and stumbled on a story in Paterson, New Jersey. The treasurer of a textile concern had absconded with a large sum of money. It was a sordid story of an otherwise good citizen ruined by his obsession of betting on horse races.

I hurried to a public phone in a nearby cigar store. For reasons of privacy I spoke to the city desk in a well guarded voice. The phone buzzed and hummed and crackled, and to make matters worse, the rewrite man to whom I gave the story was not only tired but extremely nervous because it was but minutes to closing time when the paper "went to bed."

When I arrived at the office the following morning, I picked up a copy of the edition that carried my story. I expected to see it on page one under a three-column head. Instead I found it smothered by the ads on page eleven. I scarcely recognized it. Dates, proper names, the sum embezzled and other pertinent data were either incorrect or incorrectly spelled. "Poor phone connection" was the excuse.

Some years ago a friend of ours shared a "party line" combining four telephones. On occasional evenings about eight o'clock the entire line went dead and remained so for an hour or two. Frequent inspection by the telephone company failed to detect anything wrong. For months the best service men in the telephone company were baffled by the breakdown that always occurred at the same hour.

Then one evening our friend saw a grandmotherly old

lady who lived next door seated near an open window. She was busily engaged in darning the family socks and stockings. Suddenly the mystery of the silent phones was cleared up. The dear old soul, who also had a phone on the party line, was innocently using the telephone receiver as a "darning egg." She was ignorant of the fact that when one phone receiver on a party line was lifted from its hook, the other phones were cut off from the central station.

It is difficult to comprehend the fabulous changes and developments that have occurred in the telephone industry within the memory of thousands who are living and active today. Back in 1904 "Jum" Smith, now dockmaster, was a drug clerk in Bayles' Pharmacy, Port Washington, less than twenty miles from New York City. At that time the village boasted a population of less than 2000.

Although only a country druggist, "Doc" Bayles was a wide-awake merchant. He carried a profitable line of boots and shoes in conjunction with his drug business. As an added attraction to his store, a favorite meeting place for the villagers, he decided to have a telephone installed; there was not another for miles around and very few nearer than New York City.

Natives flocked to see the newfangled "talking box" that carried the voice over a long distance. Some screwed up courage to use it by calling up friends and relatives in the big city. On those occasions the other customers in the store gathered round the caller in open-mouthed wonder, listening to every word and sometimes shaking their heads in doubt or disbelief.

Soon the city folks began to call the drugstore, leaving messages to be delivered to their friends in Port Washington. It was the drug clerk Smith's duty to write down the message, harness his waiting horse and drive to the home of the recipient.

That often meant a journey of five or ten miles. In summer it was a pleasant relief from the drudgery of the store. In winter it was often a trying ordeal. With temperatures hovering around zero and blizzards blanketing the countryside, it was frequently a struggle of man and beast against the elements.

One bitter night his buggy overturned in a snowdrift and the panicky horse ran away. Smith was left stranded in the snow and darkness several miles from home. The horse, repentant, returned to the scene and Smith rode bareback to deliver the telephone message. He found the house with some difficulty and knocked on the door. A woman appeared in dressing gown and boudoir cap. "What do you want?" she asked sharply. The half-frozen clerk handed her the message, expecting the usual "thank you" and perhaps a modest reward. The woman read the penciled communication twice and then thrust it at the messenger. "Take it back!" she ordered. "I don't want it!"

Dockmaster Smith went on to tell of the growth and development of the telephone. The local physician had one installed for easy communication with the drugstore. One of his patients had a phone put in as a quicker means of calling the doctor. A wealthy woman, a friend of the patient, followed with a phone that was used largely for gossip and small talk. A member of Congress, a noted orator who lived two miles from the drugstore, came there frequently to dictate letters and speeches to his secretary in his New York office—and eventually had a phone installed in his home. Within a year the village boasted of thirteen telephones with no means of intercommunication.

A switchboard was set up in the drugstore. It was a simple affair not much larger than a bread box and equipped with thirteen "keys" or switches. Smith the

drug clerk became the first telephone operator in that area.

Soon the telephone lost much of its mystery. Its convenience and many advantages became a favorite topic. Orders for installations poured into the telephone company. The drugstore switchboard was enlarged again and again until it was no longer possible for the drug clerk to handle the traffic. A central office was set up in the second floor of a house on Main Street and two girl operators were employed. Today there are about 10,000 telephones in the general area that was once served by a switchboard with thirteen subscribers.

The multiple switchboard in use today is a marvel of modern inventiveness. Each subscriber line terminates at the board. There it is duplicated or multiplied at intervals as many as twenty times, thus placing 200,000 points of connection at the disposal of the operators and thus enabling them to give almost instantaneous service to the person making the call.

The multiple switchboard of the larger type is composed of tens of thousands of individual parts that compare in workmanship with the parts of a fine watch. It may contain as many as two million soldered connections, each no bigger than a pinhead. Its electrical signal lights number 15,000 and the wire used in it measures about 4000 miles—more than enough to span the United States.

Among the great advances in telephone communications is the introduction of the dial phone. It not only speeds the service to the user but makes it more accurate since it practically eliminates human error. It performs in a split second a complex operation that formerly depended on the deftness and not infrequently on the mental and physical condition of the operator.

Even where dial service is furnished, the girl with the smiling voice is always on the job to handle toll and long-

distance calls, to provide telephone numbers not yet listed in the directory and to give any other help the caller may desire, including such emergencies as Fire and Police.

The number of telephone calls during an average day rises and falls like the tides. In a typical city the highest point of the traffic curve is reached between 9 and 11 o'clock in the morning. Lunch hour brings another peak that soon subsides only to rise again between 3 and 5 o'clock when shoppers and housewives take over. During those periods of peak load the dial telephone system pulses with life. So complex is its operation, it is beyond the grasp of the lay mind.

For instance, when a person dials a telephone number in a large city, some 2000 switching connections are made in the giant apparatus at the central office. The dial telephone set used in the home or the office appears to be a comparatively simple affair, yet inside its plain exterior are 433 separate parts, some of them so small a magnifying glass is used in their assembly. Wherever one turns in the astounding empire of telephony, one is confronted with miracles and mysteries that would baffle Bell himself were he alive today.

It has been but a few years since it was discovered that two wires gave better telephonic results than the single wire of earlier days. At this moment a single cable no bigger around than a boy's wrist contains more than 2000 wires, over which as many telephone conversations can be carried on simultaneously.

Prior to the introduction of the multi-wire cable, city streets had become forests of poles topped with thousands of cross-arms, supporting hundreds of wires.

In lower New York City the congestion of overhead wires was so great, busy streets looked as if an invading army of giant spiders had spun a tangled web over the

entire area. Aside from being unsightly, the suspended wires were a constant menace. Sleet, snow and high winds played havoc with them. Traffic was tied up when storms strewed sagging or broken wires across the streets, and all business depending on the telephone came to a virtual standstill.

Eventually municipalities passed ordinances prohibiting overhead-wire installations. Luckily the multi-wire cable had reached the practicable stage. Hundreds of miles of underground conduits were constructed; cables were installed in them and so began another era in the development of the telephone.

No sooner had it been established as a practical and rapid means of local communication than widely separated cities began to clamor for a service that would connect them with other large centers of trade and population.

Unlike the telegraph, that could send the dot-dash signal unimpaired to faraway places, the telephone was restricted by distance. A conversation transmitted by wire for more than a hundred miles, became progressively fuzzy and faint until at last it was totally unintelligible. This was a challenge not only to the telephone industry but to science. Lights burned far into the night in the Bell Laboratories where scientists, assistants and technicians labored to link together widely separated communities with speaking wires. A dramatic evidence of their success came in 1886 when New York City's first long-distance line to Philadelphia, ninety miles away, was established. It was the first faltering step toward worldwide telephonic communication and the coming of age of the Long Lines department of A. T. and T.

Soon it was possible to talk over a distance equal to that between Boston and Buffalo. Three years later occurred

the first "thousand-mile talk" between New York City and Chicago.

Many advances in telephone science were necessary before service could be extended beyond the Middle West. It was 1911 before New York could talk to Denver. Then in 1915 came the historic day when the first transcontinental route was opened.

Alexander Graham Bell, now world famous, participated in the inauguration of this coast-to-coast line. From a telephone in New York City he talked with his former laboratory assistant, Thomas A. Watson, who was then in San Francisco.

This first transcontinental line was 3,390 miles long, required 130,000 telephone poles and passed through thirteen States. Six million pounds of copper wire were strung from coast to coast. It was a gargantuan task of engineering and construction. Material and equipment had to be manufactured; legal rights-of-way had to be obtained; skilled crews fought their way step by step over plains, mountains, rivers and deserts. Hardship, privation and even death marked the progress of that period's most daring project.

As early as 1912 Bell System engineers had begun the adaptation and development of the DeForest radio vacuum tube as a long-distance amplifier. Despite the many scientific advances in the art of telephony, distance still remained a barrier to good transmission. Not until it was discovered that the little magic tube could defy distance, was perfect service over Long Lines assured. When introduced at critical intervals along the telephone circuits, these radio tubes gave strength and clarity to the message. In a matter of months after the completion of the transcontinental line, the first successful demonstration of radio telephony took place. Speech was transmitted from Mon-

tauk Point, Long Island, to Wilmington, Delaware. In the same eventful year transoceanic telephony by radio was first achieved. Messages were exchanged between Washington, D. C., and Paris.

In 1927 the first commercial overseas service was established on a single circuit between New York and London. Today a person in the United States can speak over the telephone to another person in any of ninety-eight foreign countries and territories as well as to numerous ships at sea. In fact, 144 of these circuits are now permanently established.

The infant Long Lines has grown in a comparatively few years into a young giant who has not yet attained his full stature. Long distance traffic now totals about 313 million calls a year. A million messages in one day is a common occurrence.

To keep pace with the demands on its long-distance facilities, the Bell System has probed as never before into the remotest nooks and crannies of science.

Formerly a call, let us say between New York and San Francisco, was completed over one of many possible routes. If one route was busy, the operator tried another and another until she found an open voiceway to the Pacific coast; only then was the call completed. During periods of heavy traffic the process was slow. After years of concentrated effort along came scientists with what they called the "Translator," a mechano-electronic brain that performs in seconds a task far beyond the capacity of human operators.

The Translator is the newest electronic link in the program for nationwide dialing. It is a bewildering maze of lenses, photo-transistors, mirrors, penetrating light beams and perforated metal cards. Its function: to select the most direct and fastest route. If the circuit is busy,

it will pick out automatically an alternate route in the twinkling of an eye. The only change involved in the mechanics of dialing is the addition of a three-digit code. The United States and Canada are divided—for purposes of long-distance calls—into ninety areas, each of which has a three-digit code number.

When dialing, the code number precedes the local telephone number. Even before the dial has come to a dead stop, many things begin to happen: one of the metal cards with a conforming pattern of perforations drops into a beam of light. All light except that passing through the pattern of holes is blocked out. The needle-like light-shafts strike photo-transistors that react by sending electronic impulses through a complex system of wire and switch relays. Those relays search simultaneously through the vast assembly of apparatus for the best and most direct routes. A few seconds after the operator has dialed the coded number to the Translator, the telephone bell is ringing at the destination of the call.

The relays, built in vertical banks from floor to ceiling, contain some of the most intricate and costly specialized equipment ever installed in a commercial enterprise. The overall cost of the project totaled fifteen million dollars, a sum that does not seem exorbitant when we consider that the Translator took four years to build, that it occupies three entire floors, that 22,000 miles of copper wire were used in its construction, that it contains 130,000 switches in which more than 50 million connections were soldered individually by hand.

The Translator, gigantic though it be, is but an index of the vast amount of effort and money expended by the telephone industry in establishing and maintaining the world's greatest communications service so that the aver-

age person can, at the flick of a dial, talk to another over a distance of three blocks or three thousand miles.

None but someone close to the industry can visualize the magnitude of the task that confronts those charged with keeping this worldwide web of wires and electronic waves under a twenty-four-hour-day control. Flood, fire and hurricane are communications' most pernicious enemies; ice and snow are close seconds. Three times within a few years the most disastrous storms in telephone history ravaged wide areas. All three disasters put tens of thousands of phones out of order, isolated many central offices, impaired toll and long-distance services and caused extensive damage to plant equipment.

Two of the storms were of tropical origin. They roared in from the south, driving before them huge tidal waves, floods, wind and rain of hurricane force. Fires broke out in many places. They battered the metropolitan coastal and northern areas of New York State and left a part of New England prostrate. Hundreds of lives were lost. Property damage reached the half billion mark. In one New England area three million trees were destroyed. The third of these memorable storms struck unexpectedly one December day. It was an ice- and snowstorm that weighted down wires and poles with such a heavy crystal coating they collapsed by thousands, many of them entangled in fallen trees.

In these crises linemen and technicians were sped by truck and rail and plane to the scenes of disaster. They came from as far west as Nebraska and Arkansas and as far south as Virginia—thousands of them.

During a severe ice storm in 1942 I had an opportunity of observing a battle of men against the elements. A fine drizzle and a barely freezing temperature enshrouded everything under a heavy coating of ice. Tree branches

drooped to the breaking point; shrubs and plants were flattened; slender wires became crystal ropes; and cables were coated to the thickness of a man's arm. Telephone and power lines broke under the overwhelming weight. Flashes from the power lines, writhing and crackling, on the highways, lit up the night sky. Stout poles were askew or prostrate. In some places ice-laden trees had fallen, carrying down with them masses of wires in a hopeless tangle.

In the glare of floodlights a score of men went about their varied tasks without haste or excitement. It was evident they were selected men, trained in handling just such emergencies. Some were wearing black rubber coats and others leather windbreakers. They worked against a background of glittering crystal. Repair trucks stood along the roadside, great black silhouettes against the brilliant light. The *swoosh* of crosscut saws, the *chop-chop* of axes, the intermittent squeals of block-and-tackles used in heavy hoisting, the sharp orders of men perched high on teetering poles to their "ground men"—all created a dramatic scene in black and white.

Standing close to one of the trucks, a rubber-clad man surveyed the confusion around him. Occasionally he issued an order as impersonally as a general to his army in the stress of battle. He was the foreman, an old campaigner in the war against the elements. Catching him in an off moment, I ventured a question in the form of a statement.

"Rough going!" I said.

"I've seen worse," he replied without taking his eyes from the work at hand.

"How many telephones are out of service?" I asked.

"About a couple of thousand, I reckon. But they'll be okay by morning!" Somehow he reminded me of our old

family physician whose parting advice was frequently, "Take this! Have a good night's sleep! You'll be okay by morning."

It was midnight when I reached my home. Power failure had left our oil-heating plant cold as a gravestone. The comfort of the telephone to call for help was also missing. Before noon the following morning, however, a neighbor phoned me. During our conversation I learned he was unaware of the havoc created by the storm and of the heroic efforts of the men who fought all night long to restore his telephone service while he slept.

The annals of telephone companies, large and small, are filled with case histories of disasters in which men and women who displayed valor of the highest order, have been recipients of the Theodore N. Vail Medal of Merit. In the twenty-eight years since the Vail Memorial Fund was established, 1,360 awards have been given to telephone men and women. In times of flood girl operators have stuck to their switchboards while water swirled around their knees. In many cases this meant that difficult rescues were made of operators who, defying danger, remained at their posts until evacuated in boats or rafts or by other means.

Four telephone operators stayed at their switchboards while a hurricane of unusual violence toppled buildings all around them. A flood, caused by a high storm tide, and a downpour of rain invaded the room where they worked. Standing on chairs and benches, they maintained the service despite the tremors of the building under the force of wind and flood. They waded or swam to safety only when the switchboard was inundated.

When a gale-driven forest fire almost wiped out Bar Harbor, Maine, a number of employees of the New England Telephone and Telegraph Company refused to leave

their posts although surrounded by fire and choked by smoke. Providentially a shift in the wind saved the building in which they were trapped. The Telephone Company honored the group with a bronze plaque commemorating their loyalty and fortitude.

One January morning a few years ago the Albany-Schenectady area in New York State found itself imprisoned under a heavy sheet of ice; 35,000 telephones were put out of commission.

Then began a battle against odds, the like of which few utility companies had ever encountered. For almost a week 1300 telephone men fought hammer and claw against the ice. Linemen, spacers, repair men, accompanied by staff men to direct and report their activities, moved into the field in the familiar green automobiles and trucks equipped for emergencies. They cleared the lines of more than 900 trees and repaired 12,000 breaks in telephone lines. More than 2000 broken or damaged poles were repaired or replaced.

With a thaw and rain came falling ice and snapping branches that smashed the restored circuits again and again. Poles sagged in the quagmire ground or were sucked out of it by the pull of the wires. On one particular day the work achieved by all 1,300 men was twenty restored circuits. While 3,330 circuits had been repaired, 3,310 failed under the ice barrage.

Re-enforcements were hurried from east, west and south to join in the war against winter. Fleets of trailer vans were dispatched from Chicago and New York. Among other emergency items they brought in twenty-three miles of new cable and five hundred miles of wire. Trailers dropped new telephone poles along the roadside to replace those that were damaged. Work went on around the

clock for several days and nights before order came out of chaos and complete telephone service was restored.

A most important phase of the industry is carried on in forest areas. Lumberjacks provide the millions of poles that for generations have been the visible symbol of the telephone and telegraph service.

The poles are cut in remote regions of the south and west, according to the most advanced lumbering practices; they are floated down mountain streams or hauled out of the woods by truck and trailer to treating plants, where they are seasoned, trimmed and shaved, then processed with preservatives and individually inspected before being shipped to the telephone companies. The poles range in size from 16-foot "toothpicks" to 90-foot giants weighing as much as 5,000 pounds.

While chatting recently with an old hand in the pole business, I learned some curious facts about what is possibly the least known of our more important industries. Having advanced from a lumberjack's job to a supervisory position, he had facts and figures well memorized. "It's a strange thing," he said, "that while the number of telephones is constantly increasing, the number of poles is rapidly diminishing."

"Can you explain this?" I inquired.

"Easily," he said. "Take that section of New York City known as Manhattan Island. Not so many years ago it was a forest of poles supporting a web of single open wires. In all, Manhattan had but a few thousand phones. Today it has more than a million and a half telephones and you will find only sixty-six poles in the entire area. In the outlying districts of the great city, however, there are ninety thousand poles. They are used mainly to support overhead cables. Each of those cables contain many hun-

dreds of wires that formerly were strung separately on the poles.

"Then you must remember that in the old days all wires were overhead. Today more than two-thirds of them are carried in cables and conduits underground. Another reason for the disappearance of poles is the wide use of radio telephony in which neither wires nor poles are used. Although more than a million poles a year are now being installed by the telephone industry, it is my opinion that the day will come when poles and wires will disappear completely. Radio and electronics will take over, using the all-pervading ether, instead of wire, as the universal conductor.

"When that day comes, as come it will, countless millions of dollars and billions of tons of vital materials will be saved for other uses; to say nothing of untold man hours that will be liberated for other industries. Then storms and blizzards and floods and ice will be powerless to stem the flow of spoken words to the farthest corners of the world.

"Don't forget that a day never passes without some advance in the field of electronics, as applied to radio and its electronic sisters—television, radar, loran, shoran and a long list of undeveloped phenomena that will astound us in the years to come. I know, because I've been through the world's greatest source of knowledge concerning the techniques of communications, electronic and electrical. There I saw some seven thousand scientists, specialists, technicians, helpers and workers in general, all bent on giving the world better and still better systems of communication."

"Where was that?" I asked.

"The Bell Laboratories," he said as he knocked the heel from his pipe and took his leave.

4

CONTINENTS ARE LINKED

WHEN SAMUEL FINLEY MORSE IN 1844 DEMONstrated his electric telegraph to the Congress of the United States by sending a message from Washington to Baltimore, he had but a vague idea of the importance of his invention and of the developments and applications of it that would follow. Inventors sprang up like mushrooms, each with his own idea of how the telegraph could be improved or how it could be used for purposes other than the sending of messages. Indeed there were those who contested in the courts the validity of Morse's patent.

In the late eighteen-sixties, despite the confusion of war between the states, the telegraph had made a place

for itself in the country's economy. Busy cities were beginning to show a growing network of overhead wires. New York, like many other rapidly growing communities, became a hotbed of crime, particularly burglary, theft, robbery and arson. Police protection was rudimentary. Crime prevention was unknown. The best efforts of the city administrations were futile against the inroads of the lawless.

In 1871 a group of public-minded citizens, in order to preserve the good name of New York, formed a company whose sole purpose was the prevention and detection of crime and the establishment of public safety. At that time the telegraph wires were kept busy during the business day. At night, when crime was prevalent, they were as inactive as so many clotheslines.

The company, named the American District Telegraph Company, provided its subscribers with rapid police and fire protection. In the homes, offices and factories of its patrons, it installed call boxes connected with a central office that in turn was connected with police and fire departments and with other law enforcement agencies.

The call box, a simple affair, was actuated by a crank that, when turned, flashed a number on a board at the central station where the operator, consulting the list of subscribers, found the address at which the call box was installed. Then he dispatched a messenger to the police and fire departments and another carrying a fire extinguisher to the house that sent in the call.

In the light of today's system of municipal communications, the call-box system seems crude and inefficient, yet this alarm service was quickly installed in numerous other cities.

In 1901 the company added to its service protection against burglary. Soon protective agencies in other cities

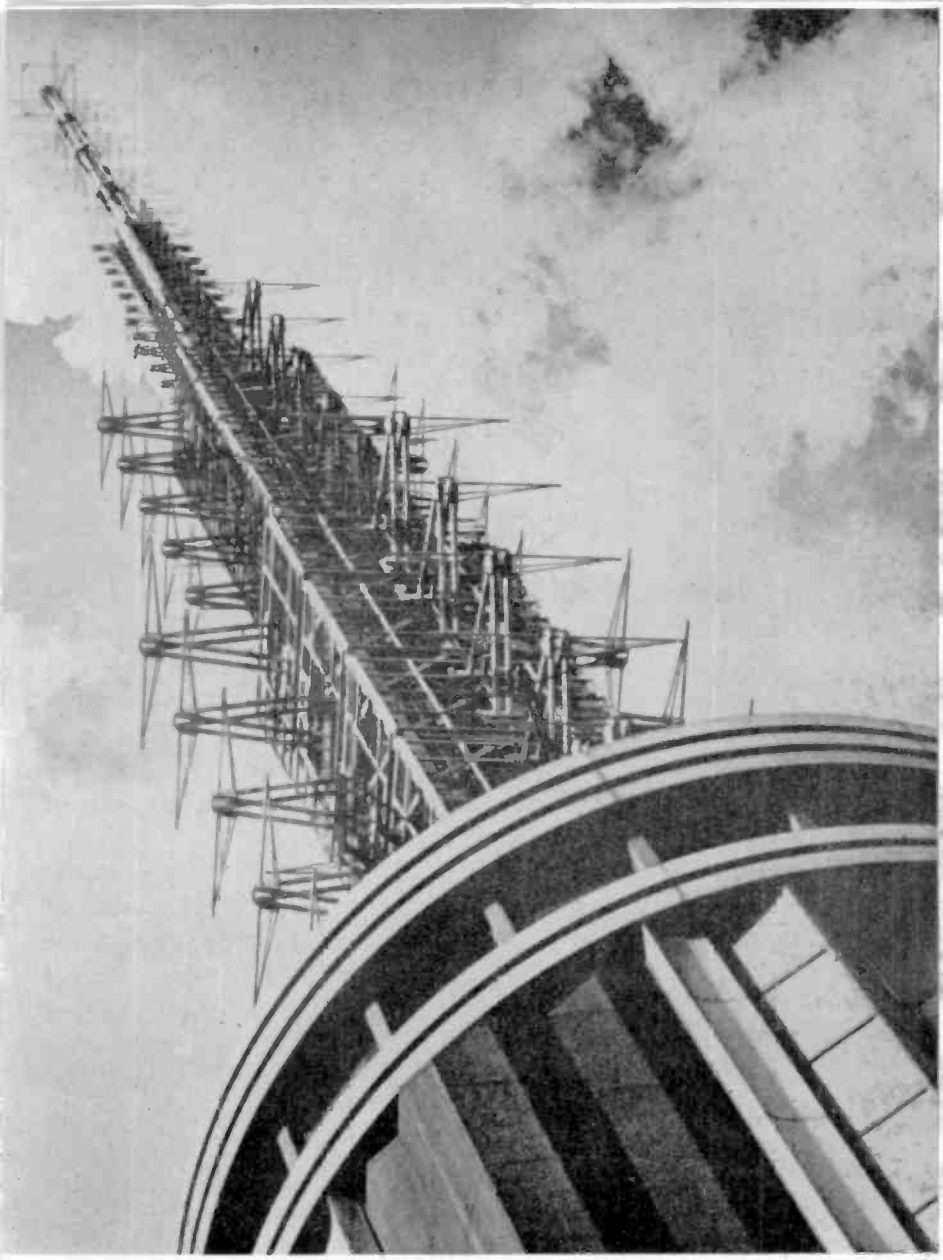
combined with the original company in a single national organization that became known as A.D.T. (American District Telegraph).

The greatly expanded company prospered far beyond its expectations. It enlarged its services to cover practically any business or industry that required watchfulness or constant supervision: banks, factories, commercial establishments, chemical plants, stores, museums, public buildings or indeed any place that would normally require the services of a watchman. A.D.T. established its own laboratory, and was soon up to its armpits in science and the development of all kinds of electric and electronic telltale devices.

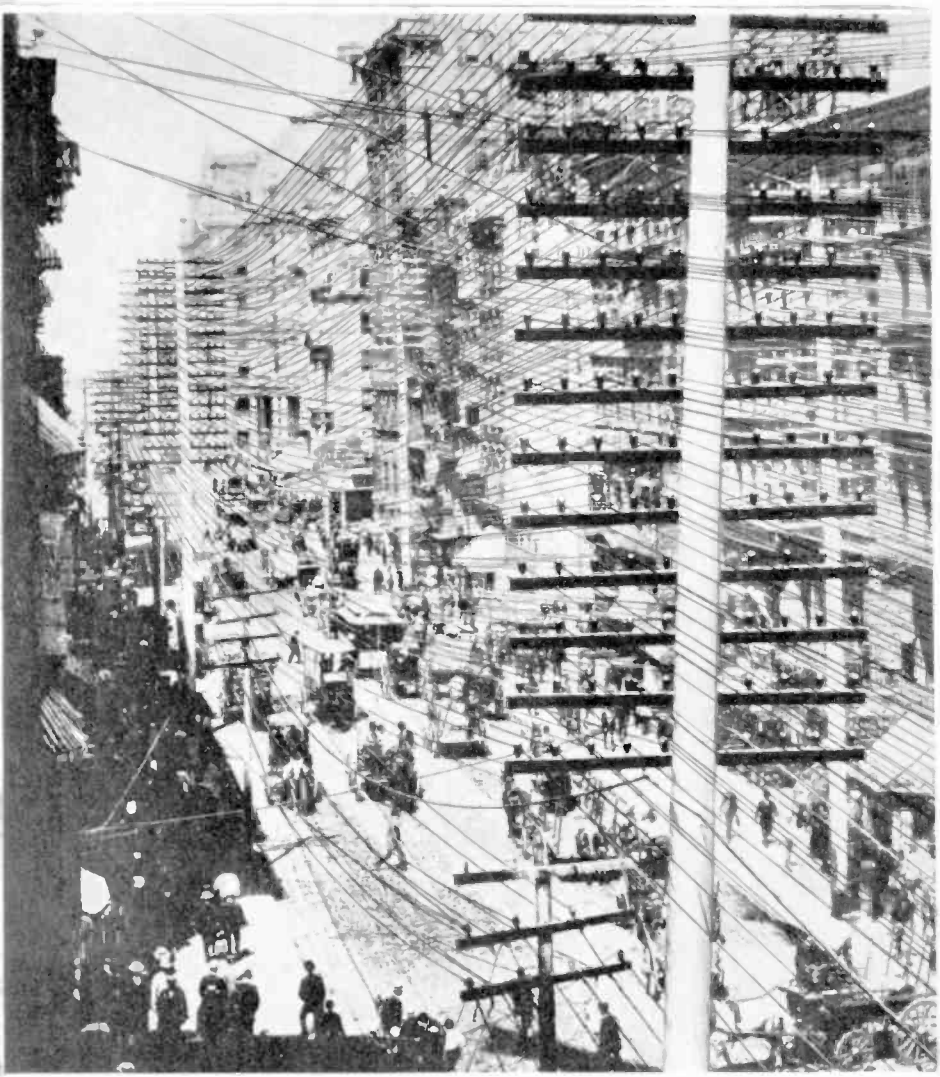
Its central stations are the hearts and brains of this, the most extensive private system of communications in the world. These stations are huge control boards on which hundreds of colored lights blink on and off like fireflies on a summer night. Telegraph keys set up a clatter, as they tap out on tapes reports from operatives, emergency calls and others that come in over A.D.T.'s network of wires.

Today the company has 4,300 employees engaged in the superhuman task of guarding 26 billion dollars' worth of property in five hundred cities. It owns or leases more than 57,000 miles of private wires. It operates several hundred radio-equipped patrol cars and has 25 million dollars invested in its signaling, laboratory and other equipment. Among its subscribers are many Federal Reserve Banks and their branches, the United States Treasury, the fabulous cache of gold in Fort Knox. It also renders its protective service in safeguarding our most vital possession—our priceless store of atomic secrets.

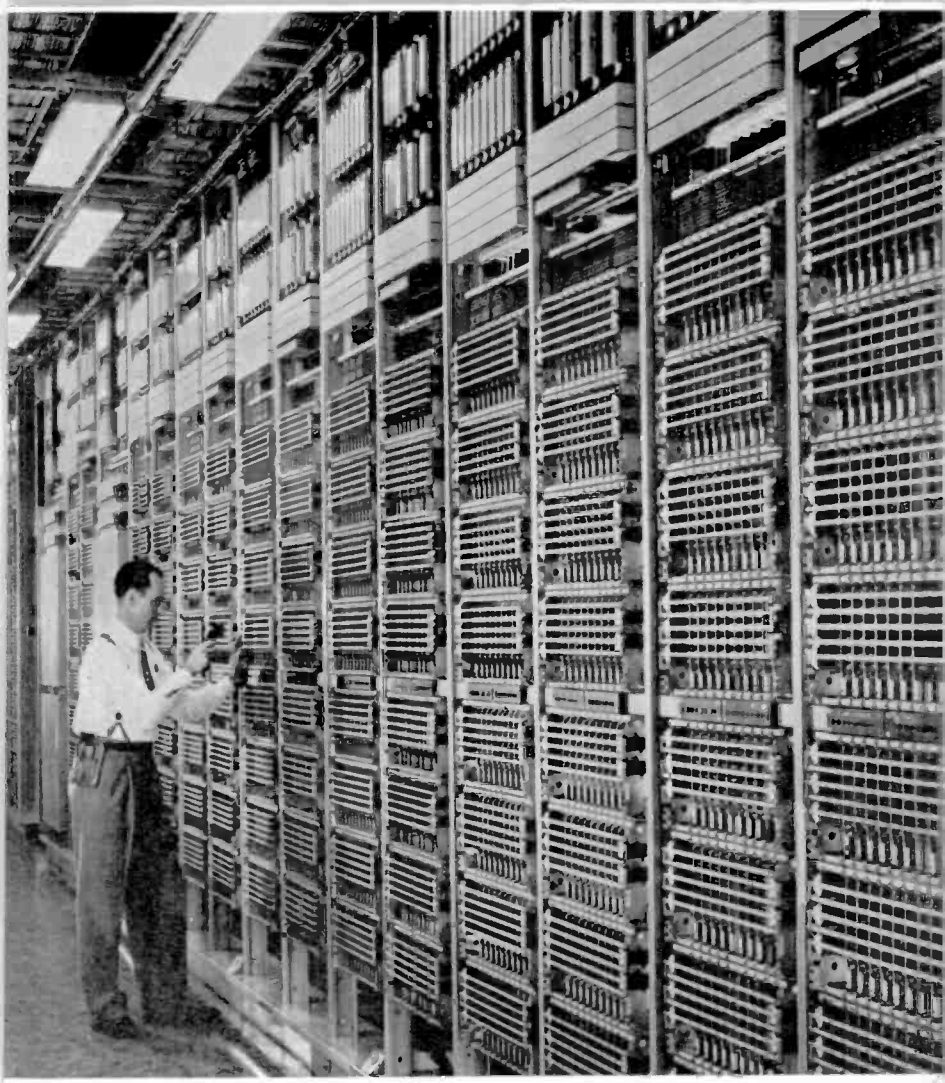
Among A.D.T.'s most efficient protective devices is "Telapproach," a new application of an annoying phenomenon



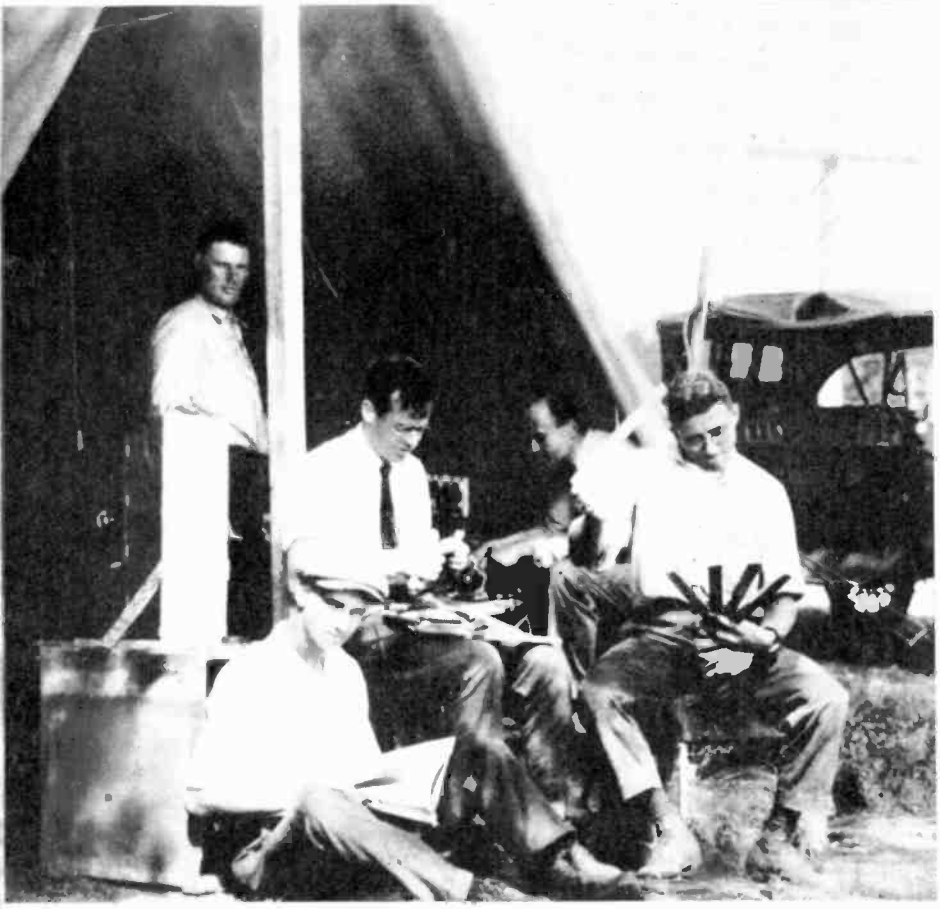
An eagle's-eye view of the multiple antennae built atop the Empire State Building, New York City. Towering 1200 feet above Fifth Avenue, it serves five television stations and three transmitters. All of them can broadcast simultaneously.



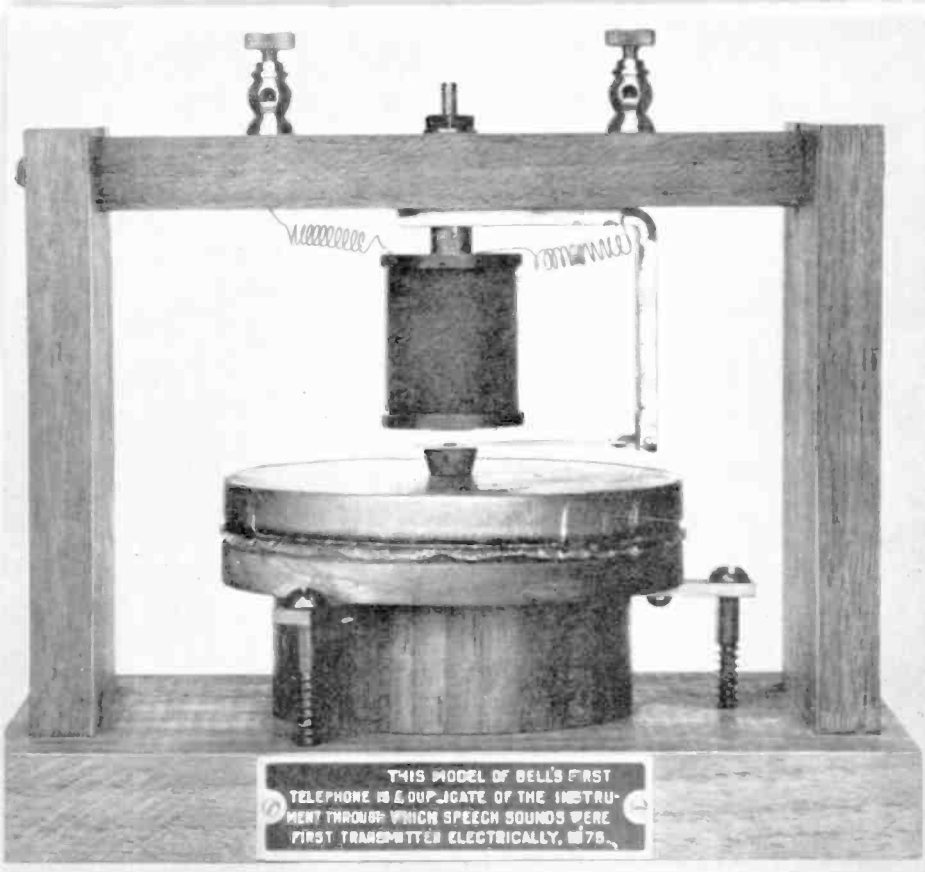
This is from an actual photograph of New York's busiest street, taken near the end of the last century. The canopy of wires and the palisade of poles were abolished when multiwire cables were placed in underground conduits.



Behind the scenes in a telephone central office. Here are the heart and the mechanical mind of the dial system. Legions of inanimate parts leap into action with every click of the customer's dial, and presto! two people a thousand miles apart can converse.



An old army tent, a few pieces of primitive wireless equipment, and four stalwart young men hungry for knowledge constituted the first RCA laboratory at Riverhead, Long Island, in 1919.



is gadget of wood and
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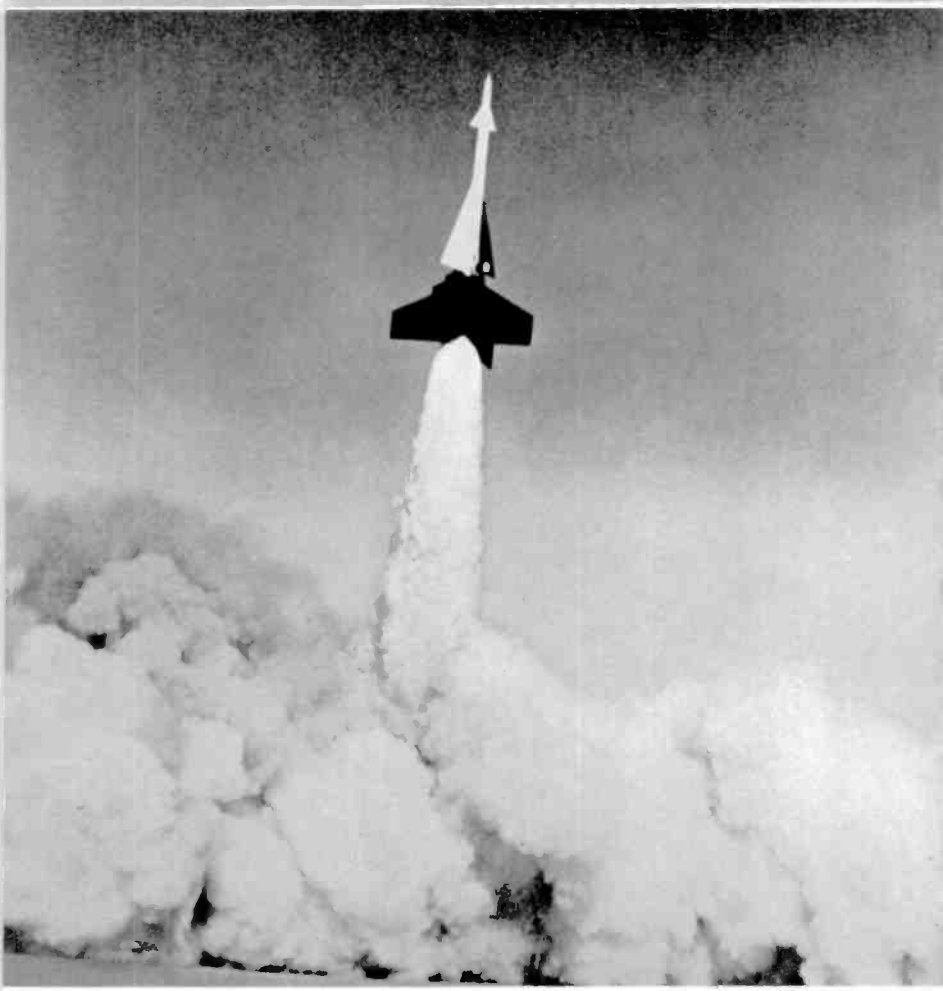
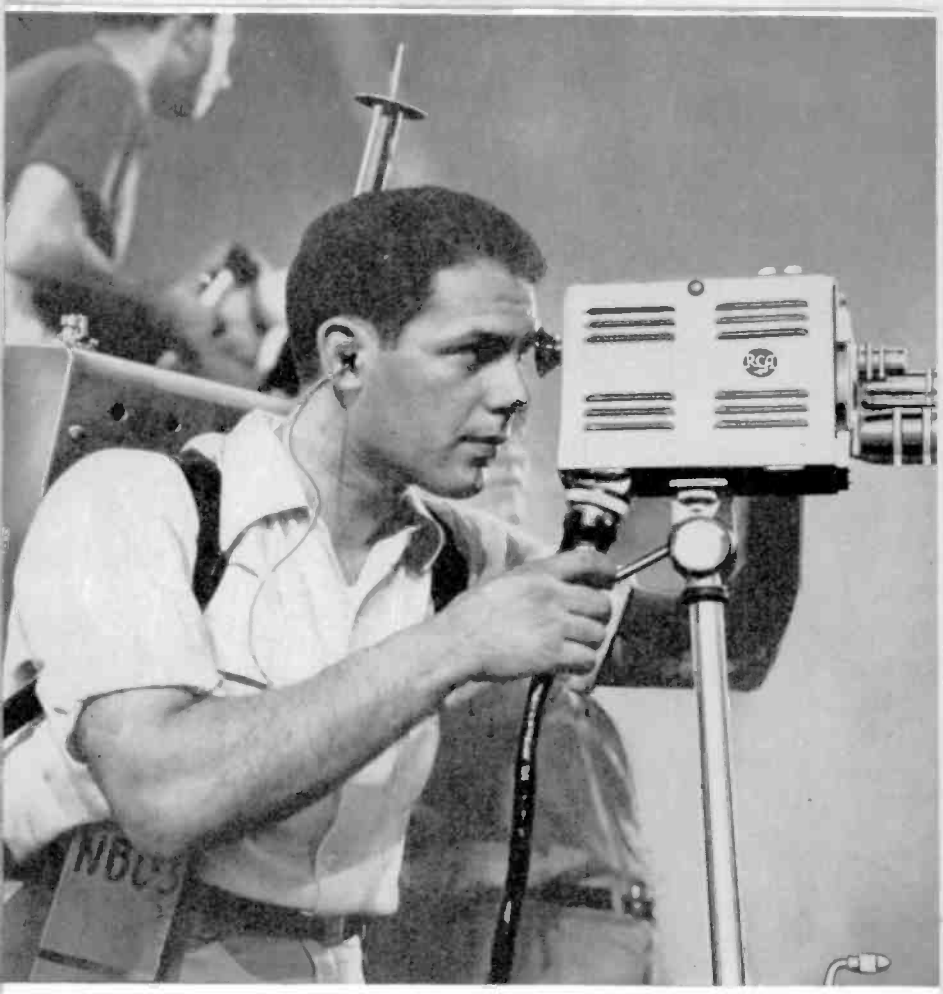
exander Graham Bell.
om a photograph taken
1876, the year in which
e telephone was pat-
ted.

Hurricanes, floods, ice and snow take heavy toll in our nation-wide system of communications. Even before the onslaughts of the elements cease, maintenance men hurry to the trouble spots to keep the lines open. Here is a typical winter scene in which one of an emergency crew carries on his lonely job while the temperature is ten degrees below zero.



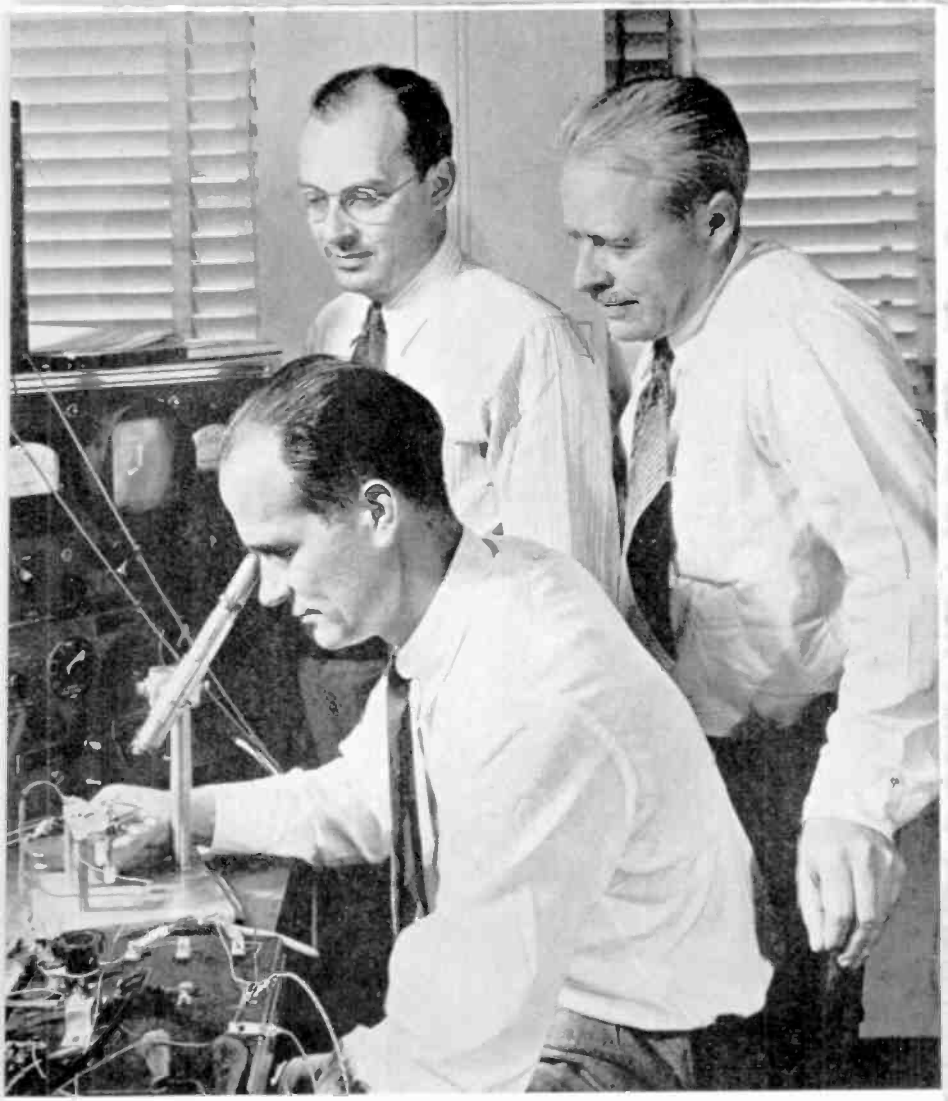
Within its metal shell the guided missile houses many devices related to the peaceful telephone. They were originated or developed by the scientists and engineers of the Bell Telephone Laboratories.



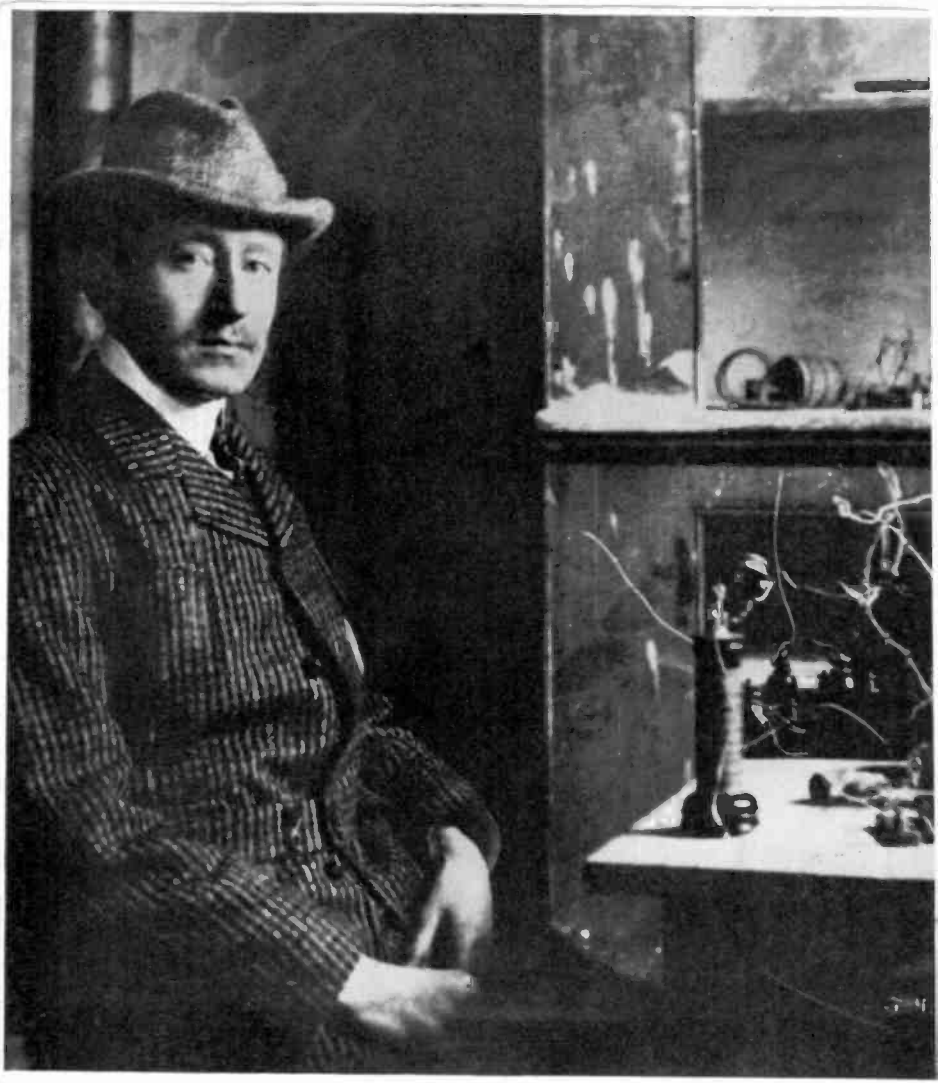
Here is the "walkie-lookie," a portable television camera and transmitter, used for the first time by NBC to cover the 1952 national political conventions in Chicago.

In 1946, television took to the air in co-operation with the U.S. Navy at Anacostia, D.C., and so made aerial reconnaissance instantly available to the High Command for the first time.

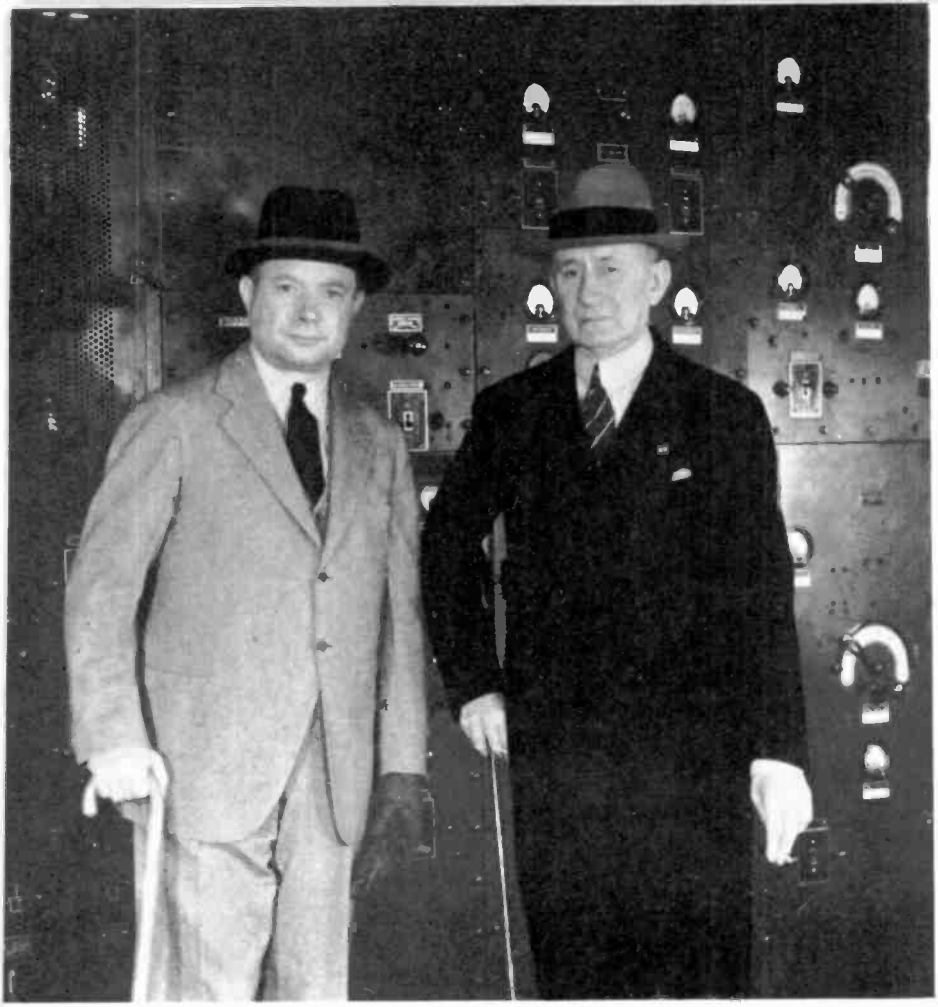
No bigger than a kernel of corn, the transistor is the mighty midget in the world of electronics. Consisting of a tiny germanium crystal embedded in plastic, it performs many of the functions of the vacuum tube.



Here the tiny transistor is under microscopic observation by Bell scientists. No man can tell how far-reaching its contributions may be in the future field of communications.

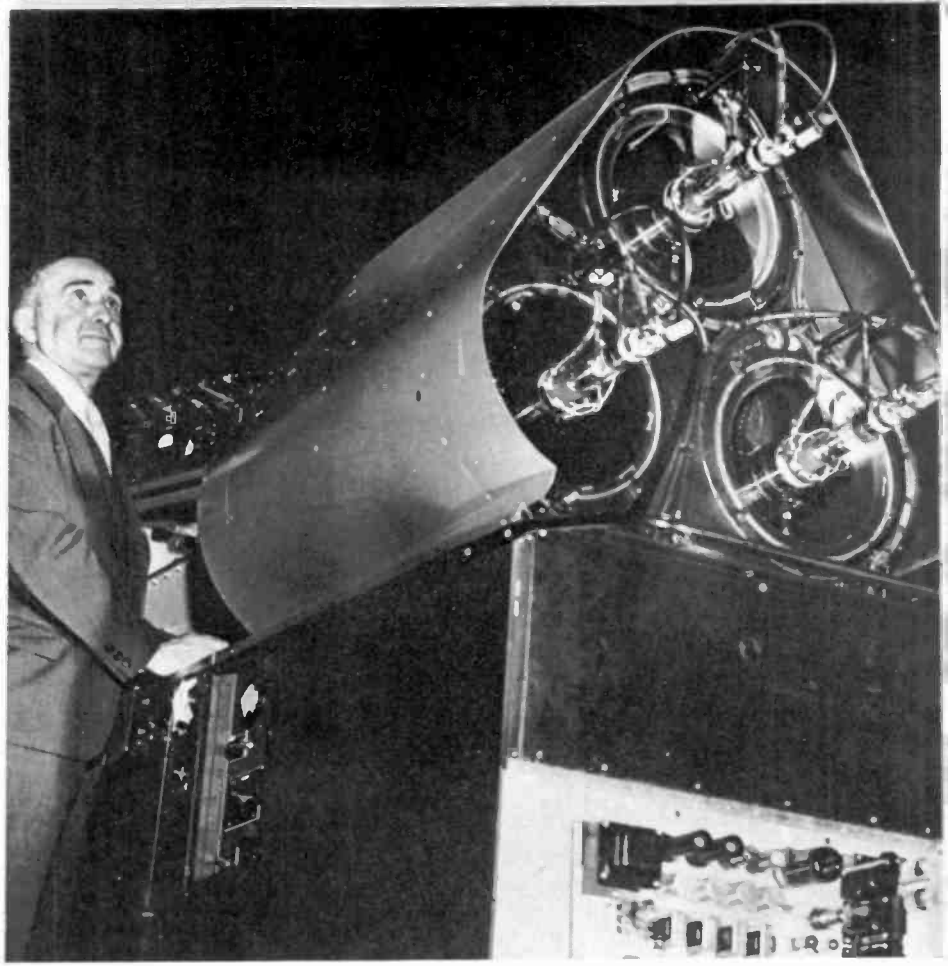


A rare photograph of Marconi and the receiving set at St. John's, Newfoundland, with which he received the first transatlantic wireless signal, December 12, 1901.

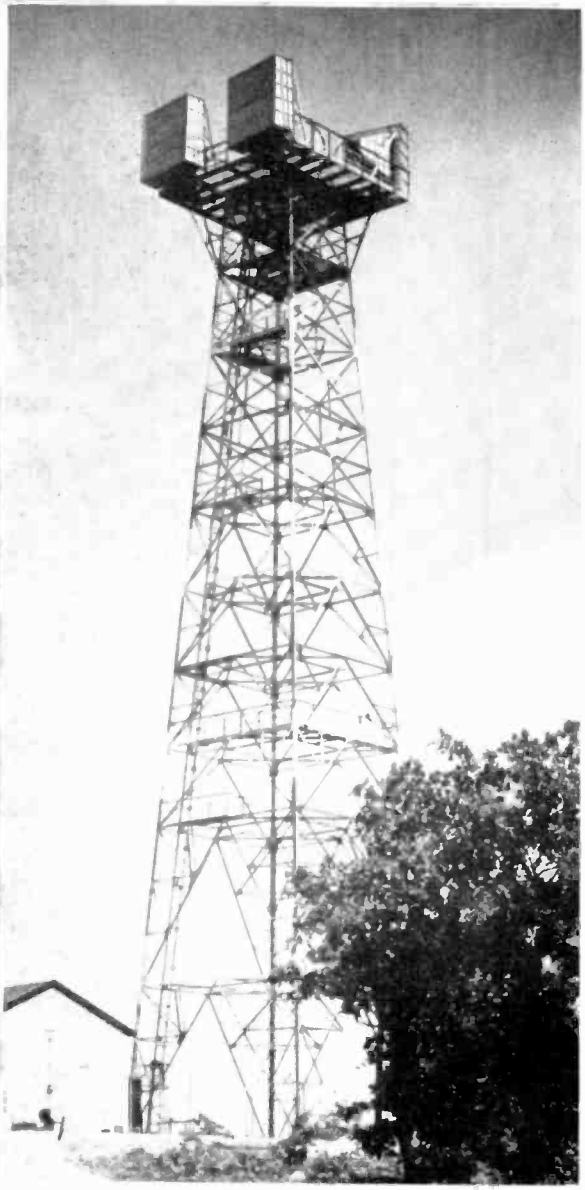


Guglielmo Marconi, father of radio, and David Sarnoff, father of television and godfather of many of radio's great achievements, meet at RCA's fabulous Communications Transmitting Center at Rocky Point, Long Island.

Brigadier General David Sarnoff, Chairman of the Board of Directors, Radio Corporation of America.



With the advent of color television comes this formidable-looking apparatus. It is an all electronic receiver and projector actually in use in a New York theatre. It is showing color television in theatre-screen size.



This lonely sentinel standing on a hilltop is typical of the microwave towers used on the transcontinental radio relay system opened for coast-to-coast telephone and television service.

characteristic of old-time radio receiving sets. Many remember the squeals and howls that came from the instrument as a person's hand approached the dial. Radio men called it "body capacity"—a type of static created by the body of the person close to the set. Years of work finally eliminated it.

A short time ago A.D.T. engineers resurrected the squeals and put them to work with a simple radio device that detects the presence of a person within a few feet of a safe, a filing cabinet or other repository for records or other valuables, and then transmits a signal to the A.D.T. central office. Many an attempted safe-cracking job has been foiled by the little squealer.

A.D.T. has been called the "Sleepless Watchman," because its ultra-scientific equipment stands watch twenty-four hours a day over some 40,000 buildings, ready to report in the blink of an eye, fire, burglary, hold-up, accident, the temperature and humidity of a subscriber's plant, the opening of a door or the raising or breaking of a window.

Great as are the achievements of A.D.T., they might never have seen the light of day had not Samuel Finley Morse, the struggling artist, laid aside his brush and palette to devote himself to the task of establishing widespread communication by wire.

Having conquered distance on land, Morse dreamed of vanquishing the great ocean wastes that lay between the continents. He envisaged telegraph cables laid on the ocean floor between land and land. His dream project, however, got little support either from friends or financiers. There were those who whispered that his success with his electric telegraph had gone to his head. With the indomitable spirit of the pioneer, Morse refused to be discouraged by the rebuffs he had received on every hand.

It was not until a friend, an engineer of prominence, had computed the prohibitive cost and the risks and perils of the undertaking that Morse abandoned his plans for a sub-ocean cable.

In the meantime, as if to prove that his proposed project was no mere fantasy, he succeeded in securing a commission to lay a submarine telegraph cable across the bottom of the harbor between New York and New Jersey.

Although met by innumerable difficulties and several failures, he succeeded in finishing the job. The cable was used by the telegraph company for many years.

About that time a young man, Cyrus Field by name, the son of a clergyman, learned of Morse's unfulfilled ambition and was carried away by the sheer daring of the project. He, too, began to dream of the glory and the gain that would be showered on the man who would be first to link together the western and eastern continents through a 2,400-mile strand of wire.

Field was employed in a paper mill where he showed rare acumen and hardheaded sense for one so young. Industry, intelligence and an inexhaustible supply of practical ideas assured his rapid rise in the councils of the concern that employed him. When scarcely out of his twenties, he was made vice-president and from there he rose to the presidency and eventually the ownership of the business that had given him his start.

All through the years of his activity in paper production, Cyrus Field had two impelling interests: one was his business, to which he religiously devoted his daytime hours; the other his dreams and plans for what was to be the great adventure of his life—laying a cable from Newfoundland to Ireland.

Even before reaching middle age, Field had amassed a tidy fortune. Having fulfilled all obligations to his pros-

perous business, he retired to devote the rest of his life to the achievement of what had become his consuming ambition.

Scarcely had his well-earned retirement begun when a British engineer, who had laid successfully a submarine cable from New Brunswick to Prince Edward Island, came to New York to meet Field, whose cable-laying aspirations had become generally known.

With plans and specifications laid before him, Field saw an opportunity to test on a smaller scale the feasibility of the gigantic operation on which his heart was set. Within an hour he had agreed to organize the New York, Newfoundland and London Telegraph Company and to furnish a goodly share of the capital. He employed an English firm of contractors to lay a cable under the Gulf of St. Lawrence to Prince Edward Island and from there to the mainland.

As luck would have it, the cable was laid without serious difficulty, barring a few minor mishaps to be expected in pioneering operations. Scarcely had the first message of greeting been tapped out from the mainland than Field began to plan his campaign to tie two continents together with a cable longer and stronger than had ever been conceived.

With hopes for a new and larger company Field hurried to England. The British capitalists were at first a bit timid about investing in what they considered an extravagant undertaking, but Field's persuasive salesmanship soon won them over. They subscribed more than three-quarters of the required capital. Field bought the remaining shares.

Since many of the shareholders ranked high in British Government circles, Field had little difficulty in prevailing on the British Admiralty to loan one of its warships

to the newly formed Atlantic Telegraph Company. The cruiser *H.M.S. Agamemnon* was assigned to act as cable layer. The United States also contributed a naval vessel, *Niagara,* to the project.

After months of preparation, the cable laying expedition was ready to begin the work during the spring of 1857. The plan of operation was simple and plausible, at least on paper. The decks and holds of the *Niagara* were loaded with several hundred miles of cable before she sailed from Valentia Island on the west coast of Ireland, where the eastern terminal of the cable was connected with a telegraph instrument and other electrical equipment.

As the *Niagara* sailed on her carefully computed course, she paid out the cable foot by foot, yard by yard and mile by mile. The weather was good, the sea calm and the job seemed simple as drawing a thread from a spool. The *Agamemnon* followed, her decks and holds also glutted with cable. The plan was that when the *Niagara* ran out of cable, the *Agamemnon* would overhaul her with a new load so that the work could be continued with a minimum of interruption. But plans are fragile things, always subject to some unforeseen whim of Fate.

When the *Niagara* was about three hundred miles out from the Irish coast, a northeast gale battered her mercilessly for nearly thirty hours. Now shackled to the bottom by the cable, she had no choice but to take the brunt of the storm. Mountainous seas, charging her decks, forced the cable crew to run for their lives or take to the rigging. Unable to maneuver, the ship was flung violently upward on the roaring wave crests only to be dashed into the deep troughs.

Her lifeboats were smashed to kindling, her forward superstructure was bent and buckled. The screaming of the eighty-mile wind through shrouds and stays, the roar

of mad water along her decks, all joined in an inferno of sound.

But all through the torment of battle the doughty old vessel held on with bulldog tenacity to the slender strand of cable that connected her with the distant island. During a momentary lull in the conflict a message in Morse was sent to the terminal at Valentia, "Gale hurricane force. Holding on cable."

Minutes later a giant sea caught the vessel under the counter and heaved her bodily skyward, her stern high as a four-story building, her bow wallowing, half submerged in the trough. It was a moment of terror climaxed in a shot-gun report as fifteen fathoms of cable writhed up from the sea. The cable had parted. Three hundred miles of precious wire lost forever!

During three days of calm after the storm the *Niagara* combed the bottom with grappling irons in an attempt to recover the lost cable but without success. Field received the bad news without turning a hair. "Let's try again!" he said. " 'Nothing venture, nothing gain.' "

A year passed before the second expedition was ready for sea. In the meantime a new and different plan of attack was formulated. The *Agamemnon* and *Niagara* met in mid-ocean where the ends of the twelve hundred miles of cable, carried on each of the vessels, were spliced together. When everything was in readiness, the ships sailed in opposite directions, one to the east, the other to the west, paying out the spliced cable as they proceeded gingerly.

Now that the ships were joined by wire, they were able to communicate with each other. As if regretting its former tantrums, the weather was kindly. With a placid sea, warm sunshine and moonlit nights, work went on around the clock. Hopes were higher with each passing hour.

Soon after dawn one fine morning a joyful cry came from the crow's nest on the *Agamemnon*. "Land ho! land ho!" A cheer went up from the crew and a long blast from the *Agamemnon's* whistle. A few hours later the *Niagara* reported by telegraph over the cable that it, too, was in sight of its destination which on this occasion was the Irish coast.

Before sunset that day both ends of the cable had been landed on shore and connected with their respective stations in Canada and Ireland. The 2,400 mile wire had been laid on the ocean floor from continent to continent. Transatlantic communication had been established.

For several weeks messages—hundreds of them—were flashed back and forth along the cable. Shareholders in the Atlantic Telegraph Company rubbed their hands in glee. Field was feted as a hero. There was general rejoicing on both sides of the ocean.

Then with the suddenness of a lightning bolt, tragedy struck. The cable for no apparent reason went dead, completely dead. Despite their best efforts the engineers were unable to put even a tiny spark of life in it. After numerous conferences the experts decided that a flaw in the covering of the cable had permitted sea-water to reach the metal core and so disrupt the flow of electric current.

It soon became painfully obvious that to find a flaw that might be no bigger than a pin-hole in thousands of miles of cable was beyond all human possibility. The first transatlantic cable was abandoned. And so it lies today, a bond of corroded copper, a kind of silent handclasp between two hemispheres.

The Atlantic Telegraph Company at the moment of its triumph was tagged with a loss of more than a million and three-quarters dollars, leaving Field a loser to the tune of several hundred thousand dollars.

A man of lesser stature would have fought shy of any cable project after his bitter experience. But Field would not permit his dreams to be dashed so easily. He stuck to his determination to, some day, somehow, establish intercontinental communication by the submarine method. He had already laid a practical underwater cable between Newfoundland and Prince Edward Island; the completion of his greater project was only a matter of distance.

For several decades prior to Field's first attempt to span the Atlantic with a cable, Europe and the United States were kept in a constant ferment over the fortunes, good and bad, of the *Great Eastern,* a ship of such magnitude as to defy the imagination of the period. Compared to the ocean-going craft of her day, she was as the modern ship *Queen Elizabeth* to a Hudson River excursion boat.

Designed and built for the rapidly growing emigrant trade from Europe nearly a hundred years ago, the *Great Eastern* was the last word in luxury. Five times larger than the largest ship then afloat, her nearly 700 feet in length would in the opinion of the experts doom her to destruction in stormy seas. With possible accommodations for 4000 passengers, she promised—to the investors in the "Great Ship Company"—to be a sure-fire money-maker. With six masts carrying more than an acre of canvas and three powerful engines to drive her side-paddle wheels and a twenty-foot screw propeller at her stern, she seemed invincible.

When placed on exhibition at many ports, thousands of people flocked to see the modern miracle of ocean transport. Hawkers, peddlers and sideshows set up shop in the vicinity of the pier where she lay. Newspapers ran columns on the beauty and luxury of her appointments. But her passenger lists were slim. In all her career only a few voyages showed a profit. Her ownership changed many

times and with each change more capital was poured down the drain.

Throughout the checkered career of the hard-luck ship the name Gooch appeared constantly. Despite changes in ownership Gooch always managed to hold a substantial block of stock. When eventually the ship was put on the auction block, he bought her for 25,000 pounds. Some thought he had become mentally unbalanced; others declared him to be stark mad, since no one in his right senses would burden himself with such an enormous white elephant. Gooch, however, remained silent. He had made long-range plans that were known only to himself.

In the meantime Field hung tenaciously to his grand passion—the laying of a practical transatlantic cable that would bring him fame and fortune. Nearly six years had passed since he laid the cable that soon proved to be a fiasco. Through sheer grit and shrewd management he had held the Atlantic Telegraph Company intact in spite of many difficulties, not the least of which was financial.

One day he received word that an English company had developed a cable insulation that was tough as rawhide, impervious to water, salt or fresh, and of great tensile strength. It was like the sound of a bugle to an old warhorse. It reawakened within Cyrus Field all his cherished dreams and ambitions.

Within a week a representative of the English company called on Field. He carried a short length of cable which showed a new principle of construction. Around a core of heavy copper wire were wound six smaller insulated copper wires, the whole wrapped in several layers of waterproofing and insulation and armored with an outside winding of insulated wire. The resulting cable was about an inch and a quarter in diameter.

Field was fascinated. Had such a cable been available

six years previously—but why grieve over past failure? The future gleamed bright with promise. Also it transpired that his caller was none other than Gooch, a heavy stockholder in the English company, the owner of patent rights and manufacturer of the new cable.

Gooch, well aware of Field's obsession to lay a transatlantic cable, came to the point quickly. He proposed that Field's Atlantic Telegraph Company and his British organization, the Telegraph Construction and Maintenance Company, amalgamate and form a new company that would not only make the cable but lay it between Great Britain and the American continent. Furthermore Gooch would put up a goodly share of the necessary capital.

First a businessman, Field took a business attitude toward what seemed a sound proposition. "How are we to carry two thousand four hundred miles of such heavy cable?" he asked, adding, "It will take a fleet of vessels. Then there is the splicing, with the probability of future leakage and failure."

It was the question for which the canny Gooch had waited. "We will carry the entire cable on one vessel and in one piece," he replied. "There will be no need for splicing."

Field was skeptical. "How are you going to do it?" he inquired.

Gooch's smile was like the sly grin of a fox. "We'll use the *Great Eastern,*" he said. "We own her lock, stock and rudder. She could carry several cables and still have room to spare."

The deal was closed. The big ship was overhauled to comply with the requirements of a cable-laying vessel. Two boilers were ripped out, one of her five stacks dismantled, a mast and all its complete gear heaved over-

board. Staterooms, saloons and crews' quarters were ripped out to make way for huge "tubs" that were to contain thousands of miles of cable.

Several months were spent in preparation for the great adventure. Twenty-four hundred miles of cable were coiled as neatly as thread on a spool in three iron tanks, each as large as a four-story building. An array of electrical instruments and controls were housed in a special structure on the hurricane deck abaft the bridge. Powerful winches and launching drums were installed in the fan-tail of the vessel. Special crews were trained in the delicate task of paying out the cable at a speed exactly equal to that of the ship.

One day when preparations had been completed, members of the royal family, accompanied by several of the British nobility, visited the ship. While on board they witnessed a strange rite—the first message to go out over the cable, both ends of which had been hooked up to a pair of telegraph instruments set inches apart on a table. Between them were thousands of miles of cable. At a signal from Gooch, a telegrapher tapped out the test message. It was "God save the Queen." Almost instantly the message was repeated on the receiving instrument. There was a round of applause; the test proved the cable to be in perfect condition.

The next day the *Great Eastern* left her mooring at Sheerness and headed for Valentia Island, the European terminal of the cable. The water off the island proved to be too shallow for the big ship. The cable-end was passed to a small vessel to be taken inshore. Successfully landed, the cable was connected with the electrical equipment installed in the newly built terminal station.

Escorted by two vessels of the Royal Navy, the *Great Eastern* laid her course for Newfoundland. Moving at a

speed of six knots, she paid out the cable for all the world like a giant spider spinning its web. The weather was fair, the sea calm and all went well until the second night out when the galvanometer indicated trouble on the line. The periodic reports received over the cable from Valentia suddenly stopped. The galvanometer not only reported trouble but it was supposed to indicate where the trouble lay.

A bevy of engineers, using the data given by the instrument, worked feverishly computing the distance between the ship and the obstruction in the cable. No two of them agreed on their figures. There was a difference of fifty miles between the lowest and highest. During a conference among Field, Gooch and the ship's captain, it was decided that the ship must retrace its course, raising the cable at the various distances as indicated by the engineers.

It was a heart-breaking job. The cable could not be reeled back over the stern, so the ship could not be driven backwards. Drastic measures were necessary. The cable must be cut and shackled to a floating buoy so that it could be found later. After proceeding ten miles, the fault was found. A short piece of wire was discovered, penetrating the cable to its core. To all observers it looked as if some *saboteur* had been almost successful in scuttling the whole cable project.

Watches were placed in the gloomy cable tanks. Both Field and Gooch took turns in protecting the cable from the unknown vandals. Despite their watchfulness the wire went dead at intervals. Even Field, the philosopher, the optimist, became disturbed. Each interruption lessened the chances of success.

When the vessel was about at the halfway mark, some twelve hundred miles from land, the galvanometer indicated still another failure. The dreary task of reeling the

cable back on board had only begun when there was a sharp report as the cable parted. The broken end snaked through the guides and into the sea. Those on deck stood as if stunned, for here was stark tragedy. The ocean floor at that point was nearly two miles down. To attempt to recover the cable by grappling would be sheer folly. That was the general opinion.

There was one who demurred, however. He was an engineer representing the company that manufactured the cable. Visualizing a huge loss to his company, he insisted that grappling be started at once. In spite of a freshening wind and a rising sea it was decided to begin the all-but-hopeless task. A heavy grappling iron and mile on mile of wire rope were made ready. The captain laid a course about fifteen miles to the eastward and about ten miles north of where the cable lay. His plan was to drift down at a right angle to the lost strand. Grappling gear was lowered away over the stern and the wire paid out as fast as it could sizzle through the chocks.

Nudged along by a twelve-knot breeze, the big ship drifted slowly and silently on her quest, four miles of wire trailing astern of her. With evening came heavy clouds and a fitful rain that turned into a steady downpour by midnight. Anxious eyes were glued on the curving wire for the first sign of a strain showing the grapnel had gripped something.

Soon after daybreak the wire became taut as a bar of steel. Excitement ran high as the order "Haul in!" was given. The winch whirred and whizzed as it swiftly spooled in the flying fathoms of wire. Even after the grappling iron had left the bottom, the strain held undiminished. There was now little doubt that it held the lost cable in its grip.

Just as victory seemed assured, the supporting wire

snapped and slid back into the sea. A black gloom settled over the ship's crew. It was as if some evil spirit of the deep had taken over. A group came on the bridge to petition the captain to abandon the unlucky cable and return to England before some greater disaster overtook them. The captain refused. Field, who happened to be on the bridge, approached the disgruntled men and said quietly, "We are all engaged in this undertaking, not so much for our personal profit as to render a service to our respective countries. When we took on this job, we knew it would be difficult but none of us believed it to be impossible. Events have indeed proved it difficult but no man can make me believe it is impossible. Remember the old adage, 'If at first you don't succeed, try, try again.'" One by one the men nodded their assent and left for their quarters.

New grappling gear was rigged but several days of foul weather interfered with the search. Then one morning the sun rose into a clear sky. A gentle zephyr gave the sea a surface of corded silk. Spirits rose, the men went about their work with a will. The last fathom of wire on board was put in use. Grappling was resumed over the same old course and continued late into the night. One of the Royal Navy escort vessels signaled, "Better luck this time!" A lantern on the bridge of the *Great Eastern* flashed back a hearty "Thank you!"

Shortly after six bells had sounded, the grappling iron snagged something on the bottom. Hour after hour the boring routine of hauling in went on with the cadence of a ticking clock. Just before dawn the tension on the wire slackened suddenly. The captive object, whatever it was, escaped the grapnel. Although disappointment and disgust were on every face, the wire crew made another attempt at recapture.

Scarcely had contact been made with the bottom when the wire became taut as a fiddle string. Readings of the dynamometer indicated that the cable had been hooked again. With the vessel hove to, reeling in was begun. This time, however, the wire was coaxed rather than forcefully hauled on board, for every man knew that a break would mean the total loss of some 1,200 miles of cable to say nothing of several million dollars. With the last fathom of wire in use, this was their last chance, their last hope of success.

Things went well for hours as the wire came on board slowly, stealthily, foot by foot. The dynamometer was showing a constantly increasing strain on the wire. It was now almost certain they had a firm grip on the cable. Each fathom raised from the bottom added its dead weight to the load on the wire.

Nerves were tense, courage high, but the men were wary. They kept a respectful distance between them and the straining wire. The coolest men on board were Gooch and Field. Although they had most to lose, they seemed the least concerned as they watched the delicate task of reeling in. The ship's bell tolled eight harsh strokes; it was noon. Before the bell's vibrations had died out, a ripping crackle came from the sea. The broken wire leaped high in the air and came coiling, whipping, flailing back on deck to the windlass that held it prisoner. Several of the crew were struck down; two were severely injured.

A grim silence followed the mad onslaught of the wire. The cable was now irretrievably lost since there was no more wire available for grappling. Gooch and Field after a short discussion decided to abandon the cable and return to England.

While on the return course, the *Great Eastern* was badly battered by a gale of hurricane force. A terrific sea crashed

down on the starboard wheel box, crushing it beyond repair and crippling the paddle wheel it housed.

For two weeks the cable terminal station on Valentia Island had received no word from the jinxed ship. Rumors that the *Great Eastern* had foundered in a gale, carrying all hands down with her, had spread like wildfire. Some said that the cable they called "Field's Folly" was accursed because it defied Nature.

Great was the rejoicing some days later when the gallant old ship, battered but still seaworthy, entered the harbor of Crookhaven with every man on board accounted for. The Great White Elephant of the high seas was accorded a hero's welcome.

For months on end the indomitable Field and the shrewd Gooch spent most of their waking hours in forming a new company—the Anglo-American Telegraph Company and in securing new capital to the tune of three million dollars. Their purpose: to lay a new cable on a different course from continent to continent. In the meantime a new and improved cable was being spun by Gooch's manufacturing concern.

The *Great Eastern* was groomed for the new venture. With some 2,500 miles of new cable coiled snugly in her iron tanks and with a tried-and-trusted crew on board, the fine old ship breasted the broad Atlantic, trailing behind her the late perfected cable; its east end was expertly connected with the sending and receiving instruments at the Valentia terminal station.

Never did ship sail on a smoother sea or with fairer weather. As day followed day the cable spooled out league after league and settled snugly into the timeless ooze on the ocean floor. Everything on board worked smoothly as a fine watch. Telegraphic communication with Valentia was uninterrupted. Once a large school of whales

caused anxious moments; the flip of a tail by one of the huge creatures might well bring disaster to the cable.

On the sixth day a stiff gale kicked up a heavy sea. The rolling of the ship put dangerous strains on the cable. A skilled hand on the brakes, however, eased the recurring tensions. No damage was done.

Fine weather followed. The vessel's speed was increased to ten knots. But for the rumble of the cable as it uncoiled from the tanks and the incessant clatter of the machinery paying it out, those on board might well have imagined themselves on a pleasure cruise. Not a single incident had marred the smooth and easy laying of the cable. Constant communication between the ship and the terminal station in Ireland had been maintained.

On the morning of the fourteenth day of the voyage, land was sighted. In a matter of hours the big ship dropped anchor and came to well-earned rest off the fishing village of Heart's Content, Newfoundland.

From bridge to glory-hole there was celebration. In the battle of men against distance, they had been victorious!

The next morning saw further rejoicing. The western end of the cable was ferried to the shore by fishing craft, then carried to a nearby relay station where it was connected with the submarine cable laid by Field some years previously, and so became linked with the mainland.

The news of the new Transatlantic Cable was heralded throughout Europe and the United States. Market quotations from the American and European financial centers flashed from continent to continent. Field and Gooch were deluged with cabled congratulations. During its first afternoon in business the cable earned more than five thousand dollars in tolls.

All the acclaim showered on Field had but little effect

on him. The successful laying of the new cable was, to him, merely another job completed. Although few knew it, he had never quite recovered from the loss of the earlier cable through lack of grappling wire. He spent long hours poring over a scrap of paper handed him by the watch officer. It contained the exact latitude and longitude of the spot where the end of the lost cable lay and where a red buoy had been placed on the surface of the sea.

One evening while being feted by a group of admiring engineers, he seemed listless as if his thoughts were far away from the festivities. Rising abruptly, he said, "You will excuse me, gentlemen! I have pressing affairs that I must attend to at once. Goodnight!" As he left, one of his hosts remarked, "I'll wager there's something big in the wind!"

And so there was. Early next morning Field chartered the *Great Eastern* for a search expedition to track down the lost cable. Three weeks later the big ship was back on her old job, combing hundreds of square miles of ocean bottom in the slim hope of snagging it. Hunting a needle in a hayloft seemed simple when compared with scratching the bed of the broad Atlantic for a slender strand scarcely more than an inch thick.

After some forty trys and hundreds of miles of hunting the grapnel gripped something. What it might be, nobody knew. After hours of reeling in, a seaweed- and barnacle-encrusted mass broke the surface. Field, leaning over the ship's rail, said quietly, "That's the cable. Handle it gently."

Cleared of the sea debris adhering to it, the missing cable was found in good condition. After it had been spliced to the cable supply on board ship, it was lowered to its permanent resting place on the bottom. With paddle wheels turning cautiously the big vessel began the second

stage of its journey toward Newfoundland a thousand miles away.

Again fortune favored Field. Day followed day with clear skies and a calm sea. The outgoing cable slipped under the surface with scarcely a ripple. On the sixth night a lookout reported, "Lights ahead!" A cheer went up from the cable crew; it was journey's end. The lights shone brightly from Heart's Content, hidden on the dark horizon.

At daybreak the ship dropped anchor in deep water. By noon the western end of the cable was completely installed at the relay station on shore. Two cables now linked the eastern and western world.

As soon as contact with the terminal station in Ireland had been made over the cable, Field sent a message inquiring if the new cable was functioning satisfactorily. Back came the reply: "Both cables OK. Signals strong and clear." When the operator handed him the answer to his message on a slip of paper, Field read it in silence. His hand shook a little. There was a quaver in his voice as he said almost in a whisper, "Thank God our job is done!"

No story of the laying of the first two transatlantic cables would be complete without a word about the fate of the *Great Eastern,* the jinx-ship that made success possible because of her great size and carrying capacity. Her fame as a cable-layer had been linked all over the world with that of Cyrus Field.

About the time of her heyday as a cable-ship a young newspaper correspondent was making an outstanding success in sending news dispatches to European newspapers via the newly invented telegraph and by carrier pigeon.

Paul Reuter, son of a rabbi, was born in Germany and while still a youth forsook banking for journalism. Daily

European newspapers, then in their infancy, regarded him as a boy wonder. His telegraphed reports of the fluctuations of the money and produce markets, the daily developments of political and diplomatic intrigue and the restless spirit engendered by near revolt and actual revolution in western Europe, gave him high and profitable rank among the news distributors of his day.

Success spurred his ambition to still greater heights. The rapid growth of population in America indicated clearly a ready market for telegraphic news from Europe. With his accustomed drive Reuter petitioned the French Government to give him a long-term concession for the operation of a cable between France and the United States in co-operation with the Anglo-American Telegraph Company. Thanks to powerful friends in government circles, his request was granted.

Familiar with the problems and losses that beset Field during his cable-laying experience, Reuter was convinced that the *Great Eastern* was the only ship afloat that had the capacity and facilities for laying a transoceanic cable.

Investigation revealed that since the completion of Field's second cable, the big ship had undergone a strange and at times a degrading change. Chartered by a French syndicate, she had been restored to her former splendor as a luxury passenger ship. Passengers fought shy of her, however, and once more she had been reduced to a state of poverty.

Still resplendent in gold leaf and glitter, she had been used in turn as a kind of floating saloon and gambling casino, a commercial exhibition hall where manufacturers and merchants displayed their wares and then as a cheap honky-tonk, a Coney Island afloat. After that an enterprising merchant had chartered her as a sea-going clothing emporium sailing from port to port. Her sides were used

as huge billboards carrying the merchant's name in letters high as a two-story house.

It was in this low estate that Reuter found her. A charter was arranged with Reuter's newly formed French Atlantic Cable Company and Gooch, who still owned her. Workmen began at once to rip out her ornate salons and staterooms to make way for the huge iron tanks that later were to hold 3000 miles of cable.

Readied for sea, the *Great Eastern,* now fully restored to usefulness, left the Thames River for Brest, France—the eastern terminus of the cable. The twenty-four-day run across the Atlantic to St. Pierre Island off Newfoundland was accomplished without incident worthy of entry in the ship's log. Except for an occasional squall, the weather was fine, the sea quiescent.

Safely landed at St. Pierre, the cable was spliced to an extension from Duxbury, a village on the coast of Massachusetts. Within twenty-four hours after the union of the cables news of worldwide import was being flashed between the United States and France. Newspapers on both sides of the ocean hailed Reuter's cable as the greatest contribution to journalism since the invention of the printing press.

The *Great Eastern,* too, came in for her share of the acclaim. Without her size, power and carrying capacity, the cables spanning the Atlantic might never have been completed.

Even while the Reuter cable was in the paper stage, Britain was worrying about her loosely integrated empire. Communications with her far-scattered possessions were rudimentary and inefficient. A hodgepodge of submarine cables and telegraph land wires controlled by several governments between Britain and India took more than a week to convey vital messages from London to Bombay.

Although an imperative need for an all-British system of communication to India was vividly apparent, a penurious Parliament refused to sponsor it. Gooch, always ready to embark on a profitable venture, formulated plans for laying the much-needed cable. His construction and maintenance company could provide the necessary seven thousand miles of cable. Besides he was an owner of the *Great Eastern,* the only ship capable of doing the job. Under his leadership the British-Indian Submarine Telegraph Company was formed and capitalized at one million pounds—then the equivalent of about five million dollars —much of it supplied by Gooch himself.

The big ship, now a veteran cable-layer, was conditioned and loaded for the long haul that lay ahead. As she sailed down the Thames, crowds lined the shore to bid her God speed and good luck. Flags, flying from many vantage points, were dipped in her honor as she passed out to sea.

Nearly three months later the great vessel, travel-stained but staunch, reached Bombay. Her arrival was hailed as one of India's historic events. For days throngs of native sightseers wandered over her decks. Members of the crew were greeted in the city as heroes. Formal lunches and dinners were tendered the officers and company representatives. When the festivities were at an end, ten thousand tons of coal were loaded into the ship's bunkers. The cable was spliced to a section of cable ferried out from the terminal station on shore. And the next day at high tide the big ship put to sea, paying out the cable as she sailed.

With the co-operation of several smaller vessels the cable was laid successfully and connected with telegraph instruments in the heart of London.

Her mission finished, the good old ship once more became the great white elephant. Her owners, having no further use for her, put her up for sale. She was too big

and too costly to operate, so no buyers appeared. Gooch, still hopeful that she might be of use as a collier or cargo ship, moved her from Sheerness, where she had been anchored, to the Welsh port of Milford Haven and there she lay mouldering for several years. Her great bulk proved a menace to navigation and in her now decrepit state an eyesore in the harbor. The city authorities petitioned the courts to have her either moved or destroyed.

She was purchased as an advertising medium and taken to Liverpool. There she degenerated into a haven for questionable sideshows and all kinds of trick catchpenny enterprises.

As winter approached, the curious crowds that flocked to the once proud ship gradually dwindled away. Not even those on passing vessels gave her a glance. Finally a firm of ship-wreckers, seeing a fortune in the thousands of tons of metal used in her construction, bought her for a few thousand pounds.

Like vultures, feasting on the flesh of a dead animal, the wreckers tore the gallant old vessel apart bit by bit. In a few months nothing remained but a number of steel bones protruding from the mud. And so ended the *Great Eastern,* staunch ally of the daring men who fought the battle against distance.

5

LEAPING THE ATLANTIC

ON THE NIGHT OF APRIL 24, 1874, LIGHTS shone brightly in the roomy home of the Marconis. A tiny baby boy had been born and joy spread like summer lightning among the family and servants on the estate, one of the most beautiful near Bologna.

In due time and with proper ceremonies the newcomer was christened Guglielmo. At the end of his second year the little fellow, although quite sound physically, lacked the normal robustness of a two-year-old. He rarely romped or ran or yelled. Even at that early age he seemed to have studious tendencies. He showed more interest in *how* his toys functioned than in *what* they were designed to do.

In his eager quest for knowledge he often dismembered them just to see what made them go or how they were assembled. Sometimes he would sit in the sunlight deliberately creating shifting shadows of his chubby fingers on the piazza floor. Birds in flight fascinated him; their chirrupings and warblings held him spellbound.

At school age, he was entrusted to a spinster governess whom he often drove almost to distraction by his questions. His whole interest was in finding out about things. When he had learned to read and write, he spent many hours seated in the shade of an ancient cypress with an open book propped against his knees. He visited frequently the cluttered workshop of Giovanni, the handy man and gardener on the Marconi estate, watching carefully the usage and care of every tool, the sharpening of axe and scythe.

Later, in that very workshop, the ten-year-old Marconi tinkered with odds and ends of wood or wires or scraps of metal and fashioned objects meaningless to his elders. These beginnings, however, indicated that the lad had an active and inventive mind. At thirteen, quite proficient in the use of tools, he fitted up an unused room in the big house as his own shop and included in it some very mysterious laboratory equipment.

About that time he learned that a German physicist, Heinrich Hertz proclaimed that the ether would conduct electro-magnetic waves. To prove his discovery, Hertz, with the aid of an induction coil created a tiny electric spark at one end of a large room. A wire ring in which had been left a small gap, was set up about thirty feet away. Each time Hertz threw the switch, a tiny spark jumped the gap in the distant ring. The ether was the only conductor between the ring and the coil.

The reports of Hertz's demonstration had a deep and

lasting effect on the boy. He spent many hours daily in reading and research on the subject, much to the detriment of his school work. It did not take him long to learn that no one knew exactly what are the components of the ether. Men knew that it is an invisible, odorless, tasteless body occupying all space. It is present everywhere, even in a vacuum. Its waves pass through solids and liquids as if they did not exist—the highest mountain, the deepest ocean can not impede its mad rush to the ends of the universe at a speed of seven-and-a-half times around the earth between the ticks of a clock. But what the ether is, they did not know.

The more deeply engrossed the boy became, the greater was his frustration. He grew so wan and listless that his parents decided to send him off to school at Leghorn where a family friend, a professor could take the lad under his wing. The change of environment failed to diminish young Marconi's passion for science. After a few futile months he was sent to the University of Bologna, where he became assistant to Professor Righi, one of a group of scientists then attempting to solve the problem of using the ether as a medium through which to send a recognizable signal. Although they represented the best scientific brains in Europe, not one of them was successful.

Unknown to Professor Righi, Marconi, still in his teens, set up in his home workshop on his father's estate the sending and receiving instruments he had made during his spare time.

Then followed a period of complete absorption during which the budding scientist devoted every waking hour to study and experiment. His early efforts to conquer the ether brought only disappointment. One failure followed another and each drew from him the same old question

he had asked so often when a small child, WHY? Why did he fail?

After months of trial and error, when his courage was at low ebb, he entered his workshop late one night. On the bench was an intricate electrical set-up that had failed him earlier in the evening. Frowning with annoyance, he decided to dismantle it and start all over again. As he disconnected a terminal, he was startled to see a tiny spark flash in the receiver some ten feet away. It was the first sign of victory. Again the question, "Why?" It took days to discover the answer.

From that point the development sounds like a fairy-tale. Little by little the distance between transmitter and receiver was increased and with each increase came new problems. By 1894 Marconi was sending dots and dashes over a distance of three hundred feet. The signals were weak, but wireless communication was established, the ether was conquered.

Two years later the young inventor sent dot-dash messages over a distance of nearly three miles. The following year a message was sent to a vessel at sea off the coast of England and in a matter of months the distance was increased to twenty-four miles.

It was not until April, 1899, that Marconi's "wireless" startled the world and established itself as a godsend to those who braved the perils of the sea. In 1899 during a heavy fog on the English Channel the steamship *R. F. Matthews* collided with the lightship stationed on Goodwin Sands shoal. Thanks to the foresight of the British Admiralty, the light vessel was equipped with Marconi's wireless. Only a few of the thousands of ships on the sea were similarly equipped. Through good fortune a merchant vessel fifteen miles away had wireless installed. The operator while idly twiddling the dials heard in Morse

Code the distress signal from the sinking lightship. The merchant ship at full speed ahead rushed to the assistance of the doomed vessel. Just as the last of the crew was taken off, she began to break apart and settle into the deadly sands of the shoal.

Within a month two British naval vessels succeeded in communicating with each other while eighty-five miles apart. The *Dublin Express,* quick to see the value of instantaneous news communications, chartered the steamer *Flying Huntress* as a dispatching center for minute-to-minute reports of the Kingstown Regatta held twenty-five miles off shore. More than five hundred dispatches in Morse Code, gave a mile-to-mile description of the yacht races.

In March of that eventful year Marconi sent a number of wireless messages from Boulogne, France, to South Foreland, England, a distance of thirty-two miles.

Although encouraged by the limited success of his invention, Marconi began to dream of greater achievements. Communications, carried by cable across the North Atlantic, were slow, cumbersome and at that time unreliable, particularly at night when the signal faded mysteriously to a point where it was often indecipherable.

The North Atlantic became a challenge; the two thousand miles of treacherous ocean between the European and American continents were a formidable barrier that must be hurdled. The project seemed to be far beyond the bounds of the possible. After deep study and concentration Marconi tapped the wellspring of his inventive genius and began work on a highly sensitive detector capable of picking up the faintest vibrations of the ether. Handicapped by lack of facilities in his native Italy, he came to the United States to continue the building of the detector on which his hopes and heart were set. When it

was completed, the most exacting tests showed it to be up to his expectations.

In the meantime at Poldhu, a village on the coast of Cornwall, men worked furiously at building a powerful sending station. The town's single-story structures were dwarfed by a tall cylindrical cage consisting of a score of hundred-foot masts interlaced with miles of copper wire. Inside the squat buildings was installed an electrical power plant that with the aid of its battery of induction coils was capable of lighting an entire community. So heavy was the voltage generated and so great the danger that, during tests, the operator used a three-foot wooden lever instead of the conventional telegraph key to hurl the signal across the ocean. The place was a terrifying bedlam. Writhing bolts of man-made lightning hissed and crackled from knob to knob of huge Leyden jars. The air was heavy with the pleasantly pungent odor of ozone. The signal, consisting of three short discharges liberated at intervals, was the letter S in Morse Code.

On the other side of the Atlantic (this was April, 1901) three men sat huddled in a small building on Signal Hill overlooking the harbor of St. Johns, Newfoundland. The day was bitterly cold. A sub-arctic gale rattled the windows and whistled through the chinks. Four hundred feet above the roof a large kite supported a slender wire ærial that led to a strange collection of instruments arranged on a long table.

Marconi, the youngest of the men, sat nervously adjusting the supersensitive detector. The black head-phones, clamped over his ears, emphasized the pallor of his face and the fire of expectancy in his dark Italian eyes.

An hour passed. Not a word was spoken. The hands of a white-faced clock on the wall crept slowly toward the zero hour. On the dot of 12:30 P.M. the young inventor

hunched forward, scarcely breathing as the seconds passed. Then he stiffened as if from an electric shock. Through the ear-phones came three faint clicks that were repeated again and again at one-second intervals—"Dit—dit—dit"—"Dit—dit—dit," the prearranged signal, the letters S in Morse, were winging with the speed of light across the stormy ocean from Poldhu, 2,000 miles away. Having listened entranced for several minutes, Marconi removed the head-phones.

"Here, Kemp, take these!" he said to one of his assistants. Kemp, jittery as a titmouse, adjusted the receivers and listened. The signal was repeated over and over again.

"You win, Maestro!" he said. "I did not believe it could be done."

The tensions and anxieties of months now removed, the three young men laughed and cried and danced with joy, unmindful of the cold and the battering storm now raging outside. That night marked the beginning of a new epoch in long-distance communications.

The news of Marconi's victory spread like a prairie fire to the ends of the earth. Even the non-scientific mind could easily grasp its implications. If the single letter S could be hurled through the ether thousands of miles across the sea, so could the rest of the alphabet be transmitted in message form from continent to continent.

The successful reception of the three-dot signal from England was but a small beginning of the gigantic task that lay ahead. Months of intensive development work was carried on day and night. Transmitters of greater power and detectors with more sensitivity were designed and built. Little by little the signal was strengthened and clarified. Simple words were sent and received. Soon whole sentences and later lengthy dispatches came winging through the ether with the speed of light. Commercial

as well as scientific success seemed to be just around the corner. Spirits were high among the workers on both sides of the ocean—in Poldhu, England, and at Signal Hill, Newfoundland.

Then one day two sullen looking men arrived unexpectedly at Signal Hill. They announced they had come on official business and wished to see Signor Marconi. They were ushered into the operating room where Marconi, wearing ear-phones, was seated at an instrument-cluttered table. Without a word one of the men drew a document from his pocket and thrust it in front of the inventor.

As he read what was evidently a legal paper, he paled slightly; his broad forehead wore a wrinkled frown. It was apparent that the Anglo-American Cable Company, holding a government-approved monopoly on transoceanic communications, was serving notice that he and his elaborate installations must withdraw from Newfoundland at once. When he had read the document, he folded it neatly and laid it aside saying, "Thank you, gentlemen. Good day!"

A realist, Marconi knew that he had no alternative but to move all his delicate paraphernalia to some spot outside the jurisdiction of Newfoundland. Previous scouting and surveys indicated that a favorable location was to be found on Cape Breton Island at Glace Bay some three hundred miles to the southwest and in the jurisdiction of Nova Scotia.

Instruments and all other equipment were dismantled at once and in a few days were loaded on the deck of a chartered steam trawler that was to transport it to its new location at Glace Bay.

Weeks of heart-breaking labor passed before the new station was ready to resume its appointed task. When it

was again in operation, Marconi left for Europe, so that on his return trip he could gauge the carrying power of the signal from Poldhu. He installed ultra-sensitive receiving equipment in his quarters on the crack steamship *Philadelphia.* He spent endless hours at his instruments, recording at frequent intervals the clarity and quality of the signal as the ship reeled off the miles on her voyage westward. Worded messages came in clearly at 1,551 miles and disconnected signals at 2,099 miles. Marconi knew then that the success of his long dream since boyhood was close at hand. The superior transmission and receiving facilities at Glace Bay and Poldhu assured the sending of worded messages back and forth across the Atlantic.

On December 21, 1902, the first commercial transatlantic radiograms were sent out from Glace Bay. Then success followed success. Within a year Marconi had built and equipped a high-powered station at Wellfleet, Cape Cod. Its first official message was a greeting from President Theodore Roosevelt to King Edward VII of England.

Wireless communication was now an accomplished fact, scientifically and commercially. Industrially, however, it was still an infant. Long and tedious development lay ahead. Marconi carried on his experiments and inventions, continually improving "radiography" as he called it. Much of his time was devoted to the study of the form or pattern of ether waves and their relation to the electrical energy that created them.

In 1906 he developed the "persistent wave system" by which the form of the wave-energy sent out from the transmitters could be governed. The result was greatly increased distances over which wireless messages could be sent and received with greater clarity. A year later the "Marconi Commercial Wireless System" was officially

opened for communications between Nova Scotia and Ireland.

Although now deeply involved in a commercial enterprise, Marconi continued his research and experiments. By 1910 his detector was radically improved and a receiver was built on a new principle. These inventions made possible a Marconi wireless station in Argentina that received messages from a distance of 5000 miles.

One evening while at work on his new detector, then at the point of completion, he sat late, listening and making microscopic adjustments for the improvement of the incoming signal. Weary and heavy-eyed, but elated at his success, he left his laboratory at midnight. The following day he called two of his technical assistants to demonstrate to them the result of his labor.

He tuned in on a station from which usually came a clear strong signal. Only a fluttering buzz came in through his head-phones. He made delicate adjustments here and there but they resulted only in a chaos of electronic squeals and stutterings. A careful inspection of the station equipment revealed that every detail was in perfect working order. It became obvious that the trouble lay in the ultrasensitive detector and that dismantling it meant hours of the most precise work. Marconi, never one to accept defeat without a struggle, set about taking apart the instrument on which he had spent endless hours in designing and assembling.

Testing each individual part with extreme care, he became so engrossed he forgot time and place. Now and then he paused to brush away a tiny gnat, one of those almost invisible insects that sometimes make life unbearable at the seashore. While examining an extremely critical adjustment he discovered a tiny speck of matter no bigger than a pin point. Inspecting it under a magnifying

glass, he found it to be one of the little winged pests. It was ensconed in, of all places, the most sensitive part of the instrument, into which it had crawled or flown during the preceding night. It was as if an inquisitive mouse had brought an express train to a standstill. With the gnat removed the gateway to perfect reception was opened again. In dealing with larger affairs in the years to come, Marconi never forgot his near defeat by one of God's smallest creatures.

Even while weaving his web of worldwide communications, Marconi continued his experiments and the development of his numerous inventions. Among the more important of these was a "duplex," by which messages could be sent and received at the same time with the same apparatus without conflict.

England, the United States and several countries of continental Europe and South America showered him with honors. Degrees were conferred upon him by the great universities of the world. Even the famous Thomas A. Edison considered it an honor to serve officially in one of his companies. When World War I engulfed the world, Marconi devoted all his efforts, scientific and humanitarian, to the great cause. Italy placed him in charge of all its wireless operations, but his services were at the disposal of all who were engaged in the struggle for freedom.

Guglielmo Marconi, father of radio, passed away in Rome July 20, 1937, at the age of sixty-seven.

Nearly all great inventions were preceded by scientific discoveries that contributed generously to the inventor's ultimate success. For instance: some twenty-seven years before Marconi bridged the Atlantic with his historic three-dot signal S, James Clark Maxwell of the University of Edinburgh outlined theoretically the existence of elec-

tronic waves. In 1880, Edison discovered a flow of electrons between the filament of an electric bulb and a tinfoil coating on the *outside* of the glass, although glass was known to be a non-conductor of electric energy. The mysterious phenomenon was titled the "Edison effect." It played an important role in the development of radio. Then came Heinrich Hertz, who in 1886 demonstrated the conductivity of ether waves. Marconi in turn was a contributor to the fund of scientific knowledge from which came radio as we know it today. Marconi's wireless was primarily a medium of communication. Like Morse's telegraph, it carried its messages in a series of dots and dashes representing the letters of the alphabet and numerals.

Simple as the signals were, they carried and still carry many of the world's most vital messages. A friend of mine who was a passenger on the ill-fated *S.S. Titanic* has told me often of the great sea tragedy in which 1,517 lives were lost. He was among those saved through the miracle of wireless. He related the heroism, the noble deeds and the fortitude with which men and women faced inevitable death. His most lasting impression, however, was the continued plea for rescue, the SOS winging out across the ocean from the wireless shack on the hurricane deck.

"Dit —dit —dit, Da —da —da, Dit —dit —dit" penetrated the bedlam of panicky passengers. It was interrupted occasionally by a broadcast of the ship's position, an unintelligible clutter of dots and dashes. On the upper deck a frightened five-year-old clung to her mother's skirt. The repeated high-pitched notes of the wireless seemed to fascinate her. Looking up at her distraught mother, she asked, "Mommy, is that God?" "Yes, darling," the woman replied. "That is God in His mercy." Mother and child were hustled into a lifeboat and were among those saved.

From the moment the crack liner ripped open her belly on a floating mass of ice hidden in the darkness, the hope of every soul on board was centered, not on the captain or the crew, but on the wireless operator, Jack Binns, who stuck to his key and went down with his ship.

During the investigations that ensued, a curiously tragic quirk of fate was revealed. The *Titanic*'s SOS was picked up by the steamships *Carpathia* and *California* but both vessels were many hours from the scene. Nevertheless they hurried at top speed to the rescue. When they arrived, hundreds of persons had perished but many scores of survivors were taken from lifeboats that had drifted over a wide area.

Further investigation of the disaster revealed later that another radio-equipped ship was actually but a few miles beyond the horizon, oblivious of the plight of the sinking liner. The wireless operator, who had ended his watch, was asleep in his berth only a few feet from his instruments.

At that time the law required that ships carrying more than fifty persons be equipped with radio telegraph apparatus and a skilled operator. Soon after the *Titanic* disaster that law was amended. Instead of one operator standing a single watch, two operators standing alternating watches became obligatory. Also each ship was required to have auxiliary wireless equipment to be operated independently of the ship's power supply.

Because of its dramatic relation to safety at sea and the resulting publicity, marine radio telegraphy captured the imagination of millions. Numerous systems sprang up overnight. Frustrated scientists, sensing new worlds to conquer, flocked into the field. Amateurs, finding that only elementary equipment was needed to receive dot-dash messages, crowded by thousands into the field of radio.

A couple of dry-cell batteries, a tuning coil, a crystal or in an emergency a small piece of coal, a slender length of wire, known as a "cat's whisker," and a pair of ear-phones were all that was necessary to set up a receiving station. A wire ærial, suspended from the house to a tree or pole, marked the home of a "ham," as the budding Marconis were called.

As far back as 1904, Sir John Fleming, a British scientist, invented a rectifier tube that became known as the "Fleming valve." It was the first serious attempt to send the human voice and other sounds over ether waves. However, it was at best merely a step in the right direction. Without any means of amplification its signals were so weak as to be almost inaudible.

Within two years Dr. Lee deForest invented a three-electrode amplifier tube capable of giving the signal the desired volume. While the DeForest tube was an important advance in the art of radio telephony, it was far from perfect. In fact it took years of persistent labor before it was developed to the point where the public could enjoy radio programs as we know them today. The first of those programs came from Station KDKA, Pittsburgh, in 1920. They were received almost entirely on amateur-built receiving sets.

The next few years saw a phenomenal growth in the sale of radio parts to amateurs. Indeed the retailing of equipment to budding scientists became a sizable industry. A curious hobby suddenly infiltrated youth circles. Teen-age boys and occasionally girls showed scientific traits hitherto unsuspected. The complex study of radio vied with the Three Rs. A new vocabulary spread like wildfire. "Amps" and "ohms," "kilowatts" and "kilocycles," "heterodynes" and "super-heterodynes," "amplifiers" and "rectifiers" replaced the slangy jargon of the period. Their

elders sat awed while the youngsters with screw-driver, pliers and soldering-iron worked miracles and brought from afar and into the home the voices and music of popular artists and the words of the great and near great.

An executive of one of the leading broadcasting companies told me recently that many of radio's best technicians and administrators today began as "hams" in the early days when radio was considered by some people to be only a pseudo-scientific fad that would have its day in the sun and then disappear in the shadows of time. Instead it grew into a huge industry, embodying commercial communications, broadcasting and manufacturing

6

IDEAS WORTH BILLIONS

IN DOWNTOWN NEW YORK CITY—A STONE'S throw from the Hudson River—stands a large building known to science the world over. Architecturally it is old-fashioned. On sunless days its brick and mortar façade looks almost forbidding. Within its four walls, however, a small army of scientists, engineers and technicians lend the place an intellectual brilliance that is dazzling. Revered by many as the "House of Miracles," it is a direct descendant of the shabby little laboratory in Boston where Alexander Graham Bell nearly eighty years ago sent the first spoken words over a wire. Listed in the phone directory as the Bell Telephone Laboratories, Inc., it is

more familiarly known in scientific, industrial and military circles as "BTL."

Although the scene of hundreds of activities that at first glance seem to be totally unrelated, its overall purpose is the development and improvement of practically every form of modern communication, with particular emphasis on the telephone.

Believe it or not, the humble telephone in our home or office is a relative by blood or by marriage with radar, sonar, loran, shoran, radio, television and a host of marvels of communication widely used today by our armed forces, industry, commerce, journalism and entertainment. When the War Department wanted a photographic record of the performance of the atom bomb released in Bikini, it turned to the BTL and presto! out of the hat came a camera that took 8000 pictures of the blast every second. When talking pictures were still but a dream, BTL gave speech to the actor shadows on the screen and a new industry was born.

The safety of the millions who travel by railroad depends in great part on the ability of the rails to withstand the enormous stresses to which they are subjected. Those stresses defied accurate calculation until BTL devised an instrument so sensitive it can detect how much a rail bends when one's little finger presses down on it.

Accurate time is vital in many of the sciences and in certain industries. Timepieces developed during several centuries failed to register accurately the passing of time over long periods. BTL scientists, using a vibrating quartz crystal not dissimilar to those used in telephony, created an instrument that keeps time so perfectly that it varies less than a second a year.

Prospecting for oil or iron ore was a slow and tedious job for men on the ground until BTL came along with a

magnetic detector that could be operated in an airplane. With the new instrument a whole county could be prospected while the men on the ground probed a ten-acre farm.

These are but a few of the hundreds of scientific items that have been contributed by BTL to a grateful world. Strangely enough, all are related directly or indirectly to the telephone. Much of the material and many of the vital parts that have gone into the construction of each prototype, have come from the brimming stockrooms of Bell Telephone Laboratories.

Prior to 1907 the Laboratories were located in Boston. Then small and practically unknown outside the adolescent telephone industry, they led a more or less precarious existence. In those days laboratories in industry, now so common, were considered by many as mere ornamentation. In spite of stubborn opposition, clear heads and aggressive foresight were responsible for moving the Laboratories to New York. The guiding spirit was John Carty, an irrepressible Irishman of brain, brawn and a battling temperament. "Jack Carty" as he was known to his people, was also an engineer of unusual ability to whom the impossible was only something a little more difficult.

Appointed Chief Engineer of the newly opened Laboratories, he ruled with a mailed fist carefully swathed in velvet. Considering his budget inadequate, he bullied his economy-minded directors into giving him a substantial increase. He scoured the continents for the best available scientists and engineers, paying them generously but wisely.

Under Carty's guidance the Laboratories flourished. New ideas and new techniques were explored. Improvements in the existing telephone system were almost of daily occurrence. Lines were extended to greater and

greater distances. When it became possible for Denver to speak to New York, the event was hailed by Press and public as a seven-day wonder. When news of it reached San Francisco, the city fathers were even then preparing for a fabulous International Exposition to commemorate their city's resurrection from the ashes of the great fire that had almost destroyed it a few years before. They called on Carty to extend his lines so that on the opening day San Francisco could talk to New York. Here was a challenge! No one knew better than the Chief Engineer that such a project was almost an impossibility. Without amplifiers, which did not then exist, the extension would require 300,000 tons of copper wire and an expenditure of 100 million dollars. Knowing that the opening of the Exposition would not occur for two years, Carty replied quite casually, "Gentlemen, we'll see what we can do."

On returning to New York he gathered his staff around him and in his quiet but forceful manner laid the problem before them. "Can't be done!" said one, "Out of the question!" said another. A third added, "It might be done if only we had good amplifying units, but we haven't."

"All right!" replied Carty. "Let's get busy and turn out some kind of amplifying device that will work!"

Months passed and despite many attempts to make a satisfactory amplifier, none was successful. The prospect of San Francisco talking with New York looked dark indeed.

One day a young man, carrying a small package, entered Carty's office. "My name is Lee de Forest," he said shyly. "I have something here I think will interest you."

"What is it?" asked Carty.

"An amplifier."

"Will it work?"

The young man stiffened slightly. "Of course it will or

I would not be here." He took from the package a small glass bulb. Within it was an arrangement of wires and metal and resin unlike anything Carty had ever seen.

When he had explained the electronic principle of the gadget, De Forest added, "I will leave this tube with you for a few days while you think it over." Then he left.

Carty sat for some time gazing at the silly looking little object of glass and metal. There was a strange glitter in his eyes. "Maybe it will work," he muttered to himself. "If it does, oh boy!" He rang for several of his most expert assistants. After an hour of consultation one of them said, "If we convert it into a high vacuum tube, it will work. It is the answer to our problem."

Men worked day and night converting the De Forest tube into one of the most revolutionary devices of modern times. In its modified state it could not only magnify the telephoned voice over long distances but could perform scores of miracles never dreamed of by science or industry.

In less than a week De Forest was invited to Carty's office. The company was willing to pay $50,000 to the young inventor for a license that would entitle it to the exclusive use of the vacuum tube for telephone application. It was merely an installment on the fortune that followed.

Within the year a telephone line that spanned the continent was completed. Every few hundred miles for its entire length a De Forest amplifying tube had been installed. Each of the tubes on receiving the fading signal, refreshed and strengthened it and sent it on its way for the next stage of its long journey.

The transcontinental line was officially opened for commercial use in 1915, and so San Francisco acquired its heart's desire: it could speak with cities on the eastern seaboard three thousand miles away.

While elated with his accomplishment, Carty was far from satisfied. True, conversation from coast to coast was an established fact; but the voice of the speaker had an echo-like hollowness as if it were sounding off in a stone vault. Besides, the loading coils activating the vacuum tubes seemed to have a knack of attracting lightning in the most out-of-the-way places. Both were problems to be worked out in the laboratory. Dampers to eliminate echo were comparatively simple to design and install. Lightning was a different story.

Where it would strike along the line was anyone's guess. It might be a mile or several hundred miles from a repair station. There was only one way to find out; wade into the storm and hunt for the break—a tedious and time-consuming job.

Carty called a few of his best engineers into a huddle "Listen, men!" he said. "I want a contraption that will tell exactly where there is a break in the line. I know it can't be done, but I want you to do it!" His logic was hazy but his meaning was clear.

Here and there in the gloom of the BTL building, lights burned far into many hectic nights. One morning as Carty entered his office, a sleepy-eyed engineer with drawings under his arm was waiting for him. "Mister Carty," he said nervously, "I think I've got it!"

The drawings were laid on Carty's desk. The two men searched for the weak spots without finding a flaw. Carty laid down his cigar and, placing a friendly hand on the young man's shoulder, said, "I believe you've got it, son! I'll have it put in the works pronto!"

Months later lightning arrestors were installed along the entire length of the line. One evening after sundown an electrical storm of unusual violence swept over a large area, doing considerable damage. Maintenance crews

stood by, watching the newly installed instrument that would put the finger on the exact spot where a break occurred. Suddenly the indicator on a dial quivered back and forth and came to a dead stop. An engineer with slide rule and pencil did some quick calculation.

"The break is at Pole two-eight-seven!" he announced. Then consulting a map showing the course of the telephone line, he added, "It's only a couple of miles from here! Get going!"

In a matter of seconds a repair truck and crew were rushing through the rain and darkness to Pole 287, which was found as easily as a numbered house on a city street. With climbing irons adjusted, one of the crew clambered up the pole. "Sure enough, fellows, the break is here!" he shouted to the skeptical men on the ground. The break was repaired in short order.

When the crew had returned to its station, one of the men remarked, "I wouldn't have believed it!" Another replied, "That's what they said about Bell's first telephone!"

It was another victory for BTL and for the scientists and engineers who conceived and made possible a little gadget that saved thousands of hours of labor and often hardship. It also saved for the company revenue that otherwise would have been lost through interrupted service. Furthermore it saved long delay and annoyance to users of the ultra-long-distance telephone. In short, it was a typically good job well done.

The impeccable Carty was still far from satisfied with the way things were going. One evening he rounded up the best brains in his staff. "Listen!" he said in his usual gruff but kindly manner. "We think we're smart, but take it from me, we're not as smart as we think! Here we are, using thousands of miles of copper wire and hundreds

of employees to carry one measly conversation at a time when we should be sending many messages simultaneously, each on its own frequency channel.

"I know you will say it can't be done. But that has been said many times about many things that later proved to be both possible and practical. The problem is all yours now, gentlemen! Let me know when you come up with something."

Two years passed before the "something" was laid on Carty's desk. It was a plan that would give each pair of wires the capacity to carry four messages simultaneously. "That's good as far as it goes," Carty said encouragingly, "but it doesn't go far enough. Instead of four messages, I want it to carry forty or more!"

Despite the industrial confusion caused by World War I and an exodus of engineers and scientists from BTL to the armed forces, work went on in the development of Carty's pet idea—the multiple message. By war's end the goal was reached. Messages, sent simultaneously, were speeding over the wires like water through a fire hose.

Meantime the new marvel, radio, had captured the imagination, not only of the public but of many leaders in science. The Bell Laboratories, alert to even the slightest trend in science dealing with the transmission of the human voice, had spent much time and effort exploring the potentialities of wireless transmission.

Carty went overseas, a colonel in the Signal Corps. During his absence the staff at BTL had a free rein to do as they pleased in the advancement of communication facilities.

Two ambitious researchers put their heads together and devised a transmitter from materials at hand. The result was a strange and cumbersome contraption, but it worked. Its determined builders succeeded in sending a spoken

message from the United States to Honolulu and later to Paris. The Army was quick to take advantage of the newly discovered miracle. The two daring researchers were called to Washington for a conference with Army officials. The presiding officer suggested that the young men forget about transocean wireless and devote themselves to establishing telephone communication with airplanes in flight.

A few months later several planes were fitted with radio-telephone equipment and for the first time pilots could talk with the ground and with other planes in the air. Successful though it was, the project was only experimental. It was long after hostilities had ended when airplane telephony came into general use.

Returned from the war, Carty resumed command at the Laboratories. During his absence many of his best men had become converts to the belief that radio was destined to be an important if not vital link in the then existing system of communications. Already they were chatting unofficially with planes in the sky and gossiping with vessels far at sea. They had gone so far as to put opera singers on the air and some believed that instrumental music could be broadcast, although there were few homes in the United States that could boast of adequate receiving sets.

Carty, whose life was dedicated to the development of the telephone industry, looked suspiciously on radio as a potential competitor in the domestic field. To suppress the eagerness of his staff, however, would be ill advised. Inventive genius cannot be turned on or off as one would turn a water faucet.

Calling his immediate staff together, Carty made his attitude quite clear. "If you *will* dabble in this radio stuff," he said in conclusion, "why in heaven's name don't

you apply your effort in making it the servant rather than the master of the telephone system? The field of trans-atlantic telephone communication is still wide open. That is where radio might find a place that would make your effort well worth while!"

One replied, "We have succeeded already in sending spoken messages across the Atlantic, but they were far from satisfactory. Weather conditions, magnetic storms, aurora borealis and ever-present static either drowned out our signal completely or made it all but unintelligible. In fact, it's a matter of luck."

For a moment Carty was silent. The sparkle in his Irish-blue eyes told clearly that his rapid-fire brain was at work. Then with a faint touch of the brogue that was his inheritance, he said quietly, "The trouble is we all try to bite off more than we can chew. Instead of trying to leap across three thousand miles of the Atlantic, suppose we try a small jump of thirty miles across water, say, from Los Angeles to Catalina Island and then go on from there." The simplicity of his logic captured the group of assistants. A few months later radio telephone service was in practical operation between the island and the mainland.

No one suspected that soon the system would be put to a terrifying test. A violent earthquake shook the entire area, leaving wide destruction in its wake. Rumor that Catalina Island had been swallowed by the sea spread rapidly. Many on the mainland rushed to their phones to call friends or relatives living on the island. The newly installed system worked without a hitch. Alarm for the island inhabitants quieted quickly.

None was more pleased than Carty. Radio had been wedded to the telephone. Thus began a new era in communications.

Under Carty's guidance scarcely a day passed that BTL

did not bring forth some invention, innovation or development that later contributed to the building of our communications empire.

The loud-speaker or public-address system, so common today, was unknown until Carty realized how frail and weak is the human voice when speaking to large multitudes. Even as late as the days of President Wilson, who was an excellent speaker, a verbal address could be heard distinctly only by an audience of a few hundred.

On one occasion Carty, attending a track meet in the old Madison Square Garden, had a remote seat in the balcony. Some ten thousand fans were packed into the antiquated amphitheatre. An official in informal evening clothes bellowed his announcements in a foghorn voice. His words might as well have been in Hindustani as far as Carty was concerned; only an occasional word or syllable was intelligible.

Probably the only person in that large gathering who was interested in the projection of the human voice, Carty began to ponder on ways and means of letting a vast audience in on what the announcer was saying.

The following morning he called two of his most expert engineers to his office. Without preliminaries, he laid a problem in their laps. "Right here in this building," he said, "we have all the elements of a device that will magnify the human voice a thousand times. I want you to put them together so that a man talking can be heard a mile away."

Within the hour the engineers were busy in devising the first loud-speaker. They converted an ordinary telephone receiver into a makeshift microphone and connected to it a powerful De Forest amplifying tube to which in turn they connected a sensitive telephone receiver embedded at the apex of a huge megaphone.

This strange looking electronic concoction, made from telephone odds and ends, was set up on the roof of the Bell Telephone Laboratories building. The mammoth megaphone was aimed at Jersey City a mile away across the Hudson River.

Seated at the improvised microphone in a distant part of the building, an engineer spoke a few meaningless words by way of a test and then in a normal voice read from a prepared script. His words boomed out with the aural impact of cannon salvos. Pedestrians along the waterfront stopped in their tracks. Work stopped on vessels tied up at their piers as the booming voice from nowhere enveloped them. Across the river Jerseyites stood in awe as if the thunderous sounds were the voice of doom.

The startling success of the experiment spurred the engineers to still greater effort in preparing the noisy contraption for a place in the telephone system. The heavy and somewhat crude bellower set up on the roof was soon refined and cut down to a convenient size. Further experiment proved it could be operated successfully many miles from the speaker.

Before long it was in use wherever large assemblies were addressed. It found its way into ships of the Navy and into airplanes that blared advertising from the skies. Railroad stations, schools, movie theatres and race tracks welcomed it. Speakers at banquets and singers at places of entertainment hankered for it. Fire departments and Police adopted it as a part of their equipment, and eventually the voice of the P.A. (Public Address) System was heard throughout the land. I believe that in the Navy it was first christened the "Bull Horn."

President Harding, in 1921, standing at the tomb of the Unknown Soldier at Arlington, Virginia, used it to address the largest audience ever to have heard the voice of a

speaker. Here and there from New York to San Francisco hundreds of thousands of Americans listened to the President pay tribute to the war dead.

It was a period of extraordinary development in the field of communication. Carty was bombarded from all sides with suggestions and ideas. Radio was born a squealing squalling infant at KDKA, a station set up at Pittsburgh. Those that heard it on amateur-built sets numbered but a few thousand but they were entranced by the living voices and music coming in through the air.

Quick to see a popular trend, Carty soon set aside his radio prejudice. Besides, he saw in the near future the possibility of a popular alliance between broadcasting and the telephone. With his usual drive, he assigned a group of his engineers to the task of setting up a broadcasting station that would take the public by storm. In 1922 the installation was ready for operation. Its call letters were WBAY. Despite the limited number of home receivers then in the country, the new station offered a daily fare of news, entertainment and items of public interest.

Although most of the listeners heard the programs through ear-phones on homemade receiving sets, it soon became evident that broadcasting was destined to become a thriving industry. Encouraged by public interest, Station WBAY decided on a daring experiment: to broadcast a concert by one of the world's great orchestras, the New York Philharmonic. The response from listeners was overwhelming. Even the press, already suspicious of radio as a competitor, was lavish in its praise.

While the famous broadcast was still a daily topic, a prosperous real-estate agent called on the manager of Station WBAY. "I have a number of apartments and suburban homes for sale or to rent," he said. "I would

like to advertise them over the air following your program."

The manager hesitated. "You know of course that no commercial advertising has ever gone out over the air. I doubt it would be worthwhile," he said by way of discouragement.

But the real-estate man would not be put off. "I'll take a chance," he said. "What will it cost?"

The manager, fearing disapproval from the higher-ups, made a quick estimate and quoted a rate that he hoped would be prohibitive. "Ten dollars a minute," he stated. "Take it or leave it!"

"I'll take it!" snapped the agent. He drew from his pocket a list of properties he wished to advertise. "It can be read in ten minutes. I've timed it." Placing a hundred dollars on the manager's desk, he left the studio.

That evening an announcer read the first commercial ever to go on the air. The result was startling. Hundreds of inquiries piled up on the agent's desk. Within a week his properties had been either sold or rented. The hundred-dollar investment was the springboard of the fabulous business of radio advertising that has heaped the coffers of telephone companies, broadcasting stations, national advertisers and advertising agencies with untold millions of dollars.

Carty's fears of radio competition were soon dispelled. As broadcasting grew, telephone wires were leased to carry the programs throughout the country. To this day few realize that many of the radio programs to which they listen come to them not by radio but by telephone. In a coast-to-coast broadcast a program coming to Los Angeles from New York travels more than ninety percent of the distance over everyday commercial telephone lines. The

program, as heard by the listener, comes over the air only from the local broadcasting station.

Over the years the Bell Laboratories had been a kind of greenhouse in which idea-seeds had been planted, nurtured and brought to fruition in a form that often bore little relation to the original idea. An excellent example was the development of sound motion pictures, the "talkies." Telephone researchers had been baffled for a long time by a strange phenomenon—every time they changed their method of transmission, the quality of the voice on the telephone changed also. They had no means of comparing the various tonal qualities.

As usual Carty came to the rescue. "Get a phonograph recorder," he said. "Make a phonograph record of each of the changes. Then you can play them back. And there you have it!"

The remedy was not as simple as it sounded. The records of that period were scratchy, noisy and prone to give the voice a thin rasping quality. Undaunted, Carty ordered his men to get busy and develop a recording device that would preserve the true quality of the human voice.

A short time later the first electronic recorder was ready for Carty's audition. Records made with it were played back for Carty's critical ear. The tones were smooth as velvet. Voices had a human quality never heard in the old recordings.

So revolutionary was the new device, several recording companies adopted it. The record business that seemed doomed by the advent of radio, took a new lease on life. Sales of records made by the new process advanced steadily until the sale of a million recordings by a single artist became commonplace.

One day a young engineer who had worked on several

of Carty's projects entered the office of the boss. Bubbling with enthusiasm, he had an idea he wished to present to the chief in person.

"What is it?" Carty asked gruffly but expectantly.

Awed a little, the young man stammered, "Why can't we record people's voices and then play them back on our public-address system while a motion picture shows the speakers on the screen? Then we would have talking pictures true to life."

Both Carty and the young engineer knew that talking pictures based on that principle had already been shown and had flopped because the recordings were scratchy and the voices from the magnified figures on the screen had the quality of squeaking mice—all due of course to the primitive Edison recording method and the lack of amplifying equipment.

After many consultations it was decided to make several sound pictures. They would prove or disprove the practicality of the talking picture project. Musicians, vocal and instrumental, and an accomplished speaker were filmed and their work recorded. The results were astounding. The round tonal quality of the sound made the figures on the screen seem like real flesh and blood. Even the conservative Carty admitted the project looked promising.

Perfecting practical sound pictures was one thing; marketing them was something else. Hollywood, the center of silent picture production, promptly turned thumbs down on the whole project. Even successful demonstrations failed to convince the movie magnates. Some insisted the public would not be interested; others shied away from the prospect of having to spend millions of dollars fitting out sound stages and theaters with the necessary equipment. Then it was made known that many high-salaried actors, perfect in silent pictures, spoke with

a strong foreign accent, or worse still, spoke scarcely any English. A six-foot-two bad man, popular in the rip-roaring westerns, had the voice of a teen-ager. Reason after reason was given to prove that sound pictures would never replace the old silent movies.

For the moment, sound pictures seemed to be consigned to limbo indefinitely, and so they were laid on the shelf —where they remained for several years. Meanwhile Carty, on whom age was stealthily creeping, turned over the reins of direction to a little wisp of a man, Frank B. Jewett, who took over the presidency of the Bell Telephone Laboratories, Inc.

In appearance, manner and background Jewett was Carty's opposite. Though small in stature and gentle of voice, he was a giant in the world of scientific research. Having spent most of his adult life with BTL, he was dedicated to the improvement of the telephone and its many services. In a short time he made many revolutionary changes not only in the physical equipment of the vast business but in its methods as well.

Some of his researchers whose faith in sound pictures had never wavered, reminded Jewett often of the fabulous future that lay in store for them. The president replied, "Have patience. Some day the tide will turn and your faith will be rewarded."

One rainy morning a telephone executive from the West Coast arrived at the Laboratories. Among the many things shown him were a number of the sound pictures made on the premises several years previously. Alone in the darkened projection room, he sat in wonderment at the perfect blending of sound and picture. At the end of the demonstration he left abruptly and within the hour he was on his way to Hollywood.

He hurried to the offices of the Warner Brothers, then

leaders in the motion picture industry. Seated with his friend, Sam Warner, the telephone executive held forth on the miraculous fidelity of the sound pictures he had seen and heard. Finally he persuaded Sam to leave for New York at once and see the miracle for himself.

When he arrived at the Laboratories, Sam Warner was shown the sound "shorts" he had traveled 3000 miles to see. The moment the projectors stopped clicking, Sam sent a wire to his partner brothers, "It's a wow! It's a knockout! Come on at once and see!"

The brothers came, a little skeptical but open-minded. A showing of the sound films convinced them that a new era in motion pictures had begun.

Soon the Vitaphone Corporation was organized to arrange for licensing and to start filming its first picture, *Don Juan,* with an imposing array of movie personalities in the cast. The actors did not speak, but the New York Philharmonic Orchestra provided a musical background that established the mood of the play. The picture was hailed as a sensation and there were those who predicted that the days of the silent movie were close to their end.

Embolded by their success, the Warner Brothers went a daring step further. They produced the *Jazz Singer* in which Al Jolson gave out with his throaty lines and sobbed his sentimental songs, supported by a blue-ribbon cast. It was the first time the general public had heard actors on the screen talk while they acted. Newspaper critics were lavish in their praise. Thousands flocked to see the "talking picture" and came away filled with wonder and admiration. As news of the *Jazz Singer* spread across the country, owners of motion picture theaters were obliged to bow to the demand of their patrons that sound pictures replace the now obsolete silent movies. And so there came into being a billion dollar industry.

Jewett, always with an eye to business, watched the transformation of the movies. One evening while discussing the Jolson picture with a few of his associates, he said, "If only we could put those pictures on telephone wires, we would have something really worth while." He was well aware that a number of unsuccessful attempts had been made to send still pictures over a wire. Nevertheless he instructed some of his men to go ahead and see what they could do with the project.

With all his gentleness Jewett was a hard driver. Men worked day and night to create a device that would send photographs, maps or diagrams over a telephone wire and that would reproduce them faithfully at the other end.

After months of arduous effort the group succeeded in transmitting a photograph some three miles. It was fuzzy and indistinct, however. Later the distance was increased to several hundred miles, but the expense was prohibitive.

Jewett placed the project in the hands of Dr. Ives, then the country's number one authority on optics. Working with a hand-picked group of scientists and engineers, Ives succeeded in designing and assembling a machine no larger than a typewriter that could send and receive pictures of good quality from coast to coast at moderate cost. It was another BTL achievement but it was also without a market. For a while it looked as if it would have to be consigned to the shelf as were the sound pictures.

Things looked bleak for the "Wirephoto Machine" as it was then called, until the day Kent Cooper, directing head of Associated Press, saw a demonstration of it by mere chance. When he had observed a number of pictures sent out over telephone wires and others being received from a distant city, he remarked quietly, "This is some-

thing we can use to send pictures rapidly to hundreds of the papers we serve with the news."

Subsequently "Wirephoto" and its electronic sister "Radiophoto" became indispensable equipment in newspaper offices, not only in the United States but in many parts of the world. Pictures of a fire in New York or of an official gathering in Washington appear in Denver, Los Angeles or London newspapers a few hours after the event is photographed. News pictures, like news itself, lose their value with each passing moment. Speed is a prime essential to the successful publishing of news.

Even before Wirephoto made its appearance, the Teletype was widely used for the rapid transmission of news and vital information of all kinds. Thus it became a considerable source of revenue to the telephone companies. Although it is now in common use, it remains a mystery to many. However, it is one of the least complex devices used in the higher echelons of modern communications. This is how it operates:

Consider an Associated Press reporter covering a story of national interest: Having gleaned the last crumb of news value, he hurries to the nearest phone or telegraph office, or he may employ a messenger or even a plane to get his story to his office. There the story is usually given to a re-write man who prepares it for transmission over the wires to hundreds of newspapers. Then it is rushed to a teletype operator who taps it out letter by letter at amazing speed on what looks like an ordinary typewriter. Each touch of a key sends out over the telephone lines an electric impulse that actuates the same alphabetical key on hundreds of widespread teletypes. In this way the copy teletyped in, say New York, is duplicated simultaneously all over the country in hundreds of newspaper offices.

Recently, Associated Press and other news agencies in-

augurated a mechanical change in newspaper publishing, equaled only by the introduction of the "Linotype" machine more than sixty years ago.

This revolutionary device known as the "Teletype-setter" sets up type in obedience to an operator a hundred or a thousand miles away. More than nine hundred newspapers now receiving news from press services, are setting up type with this new miracle machine.

At the headquarters of the news agency an operator, punching a keyboard similar to the standard teletype, perforates a tape. The perforations liberate electric impulses that go out over the telephone wires to a machine in a distant newspaper office that perforates a similar tape while printing the words on a monitoring machine so that editors can read the "taped" story. The duplicate tape is then fed into a type-setting machine that automatically sets columns of type ready to be locked in the forms and put on the presses.

Such a rapid and extensive system of press communications would be impossible without the vast network of *busy* wires and cables woven across the country. I say *busy* advisedly. In New York State alone phone calls average 27 million a day and of those 26 million are local calls.

As the demand for better telephone service grew, wires and cables were loaded to the point of congestion. Try as they would, Bell engineers could crowd no more than sixteen conversations on a circuit.

"Not enough!" said Jewett, "Not enough! We must have a hundred or more channels. Be sure you get them!"

Some said it could not be done without an exorbitant expenditure on new wire circuits.

"Bosh!" said Jewett. "Go ahead and do it!"

That night two of his best young engineers sat up late

discussing the chief's ultimatum. The task had begun to look hopeless when an overhead water pipe caught the attention of one. Just for something to say, he remarked, "The chief seems to think you can run channels through a wire as you run water through a pipe."

"Hold it!" said the other excitedly. "I think you've hit it. A pipe is the answer!"

Weeks of arduous and secret labor followed. Then one morning the two engineers entered Jewett's office, carrying what appeared to be a length of copper tubing.

"What do you call that?" Jewett asked a bit dourly.

"It's a concentric conductor that will carry five hundred channels," replied one. "And what's more," interrupted the other, "it will never be affected by dampness or any atmospheric condition!"

"Not bad! Not bad!" Jewett remarked fervently. "Think you can make it carry a thousand channels?"

"We can try."

"Go ahead! Good luck!"

That was the beginning of one of the most revolutionary developments in telephone history. It was the "Coaxial Cable."

About as thick as a pipe stem, the cable consists of an outer copper tube with a slender copper wire running through its center. The wire is separated from the tube by disk insulators at intervals of about one inch.

It took several years of work in laboratory and factory before the coaxial cable was ready for practical use. In actual practice six or eight of the copper tubes are bound together in a sturdy cable sheathed in protective insulation and metal. In that form the multiple cable is capable of carrying simultaneously thousands of conversations and numerous radio broadcasts. Television likes to be exclusive, however; it demands its own private tube.

Today thousands of miles of coaxial cable lie buried deep under the topsoil of America, safe from wind and snow and the destructive forays of lightning.

Despite its somber and peaceful aspect BTL has been an invaluable ally of our armed forces. Electronic devices used in gun sighting, submarine spotting, guided missiles and even in the dreaded nuclear bomb, had their origin in the Bell Telephone Laboratories—and for good reason. Scores of devices and principles, born of the telephone, were used in many of the most effective weapons of war.

Navy scientists, who had been working secretly on radar, came to the end of their experimentation, due in part to a stingy budget. In desperation they hurried to the BTL. Insisting on the utmost secrecy, they laid their plans on the table asking the Bell men to get to work on them immediately. Silently the engineers scanned the drawings, then one spoke. "You say these plans are top secret?" "Heavens, yes!" a four-striper replied. "Why do you ask?" The engineer answered quietly, "I think you should know we have been at work on this for several years without a thought of unusual secrecy. We're always glad to help the Navy."

A week or so later a windfall of inestimable value dropped into the laps of the Bell scientists. A British mission came to America, bearing a gift that was more precious than a shipload of gold. Stripped of its wrappings, it proved at first glance to be merely a vacuum tube of unusual design and of small intrinsic value. When the Bell men saw it, they gasped in amazement for there, sparkling under the fluorescent lights, was the fabulous "Magnetron," the heart and soul of British radar—Britain's top-drawer secret.

Bombings had destroyed most of Britain's facilities for

making the magnetron. There was no alternative but to turn to America's vast manufacturing resources.

One of the mission inquired anxiously, "How many months will it take to make an exact duplicate of the tube?" Without magnetrons Britain would be at the mercy of night bombers.

"We'll get busy at once and do our best!" was the answer.

Within a week the duplicate with some improvements was finished and readied for mass production. Two months later magnetrons were being turned out by thousands.

In its effort to improve radio telephony, the Bell people had been working for several years on a device that would send out ultra-high-frequency radio waves that would travel in a straight line to a distant relay station. Interested mainly in the telephonic aspect of their experiments and research, they paid but little attention to certain phenomena that were the very essence of radar.

In contrast, war-harried Britain, considering its existing telephone system adequate, concentrated on creating unheard-of radio-wave frequencies solely for radar. And so the magnetron was born and with it a new hope for Britain's survival.

This innocent-looking tube had the power of a giant. It hurled out billion-cycle bolts that flew straight to their targets. Then bouncing back to their source, they created luminous pips on the radar-scope that pin-pointed the precise position of each enemy plane hidden in the night sky and made it sure prey for anti-aircraft fire.

When the United States became enmeshed in World War II, the magnetron proved to be a gift not only from Britain but from Heaven. In the hands of the wizards at BTL it was used in various devices from altimeters to

detectors for spotting enemy vessels and submarines. It was even coupled with guns that could make hits on invisible targets.

Like many instruments of war it was enlisted in peaceful pursuits at the end of hostilities. Today it is widely used in modified forms in the telephone, radio and television industries and in many phases in the broad field of communications.

A volume many times larger than this would be required to tell the full story of the achievements of the Bell Telephone Laboratories and the part they have played in drawing the peoples of the earth closer together through improved systems of communications. Over the years many of their most successful projects have been so gigantic in scope as to seem beyond the bounds of reasonableness. In contrast, however, a modest little gadget, no larger than the eraser on the end of a pencil, appeared one day just a few years ago. In the inner sanctum of BTL, scientists and engineers looked at it in wonder and admiration.

Now known as the "Transistor," it has proved itself to be a mighty mite in the world of electronics. It can do most of the things a vacuum tube can do and a score of other duties as well—and all on infinitesimal amounts of current. A powerful amplifier, the little giant is being used extensively in the telephone industry to boost voice signals, to generate signal tones, to modulate voice-carrying electric current and to work miracles in a hundred ways heretofore entrusted to the delicate vacuum tube. So swift has been its development, more than forty types, each with its own peculiar properties, are now in existence.

While chatting lately with an expert engineer, I asked, "What effect will the transistor have on electronic industries in years to come?"

"I believe," he said, "its effect will be as revolutionary as that of the vacuum tube or the magnetron. Because of its small size and simple structure, the physical size of electronic instruments—radios, television sets and loud speakers will be greatly reduced, also greatly simplified, thus making great savings in manufacture. In telephony and allied branches of electronics—radar, shoran and loran, —or in military applications of electronics, no living man today can predict what the effect of the transistor will be tomorrow."

"In simple terms just what *is* a transistor?" I asked.

"Essentially it is a semi-conductor, a tiny germanium crystal in contact with two slender wires that, when put in a circuit, performs miracles that only the Creator can explain."

7

MAN OF VISION

LESS THAN A YEAR BEFORE MARCONI HAD sent his historic three-dot signal hurtling out over and across the Atlantic, a nine-year-old immigrant lad entered the United States by way of Canada. Born in Czarist Russia, little David Sarnoff had never heard of the wireless wizard or of the electronic miracles he had performed. The boy had come with his devoted mother and two younger brothers to join the elder Sarnoff who had fled to the United States in search of peace and possible prosperity.

Landing at Montreal, mother and sons traveled by rail to Albany, N. Y., and from there by a Hudson River night

boat to New York City. David's first sight of the great metropolis that was to become his future home, was from the deck of the river boat.

The little family lived in a crowded tenement district, where the boy was quick to pick up a smattering of English and where he entered a school for the first time in his life. The father's meager income was not sufficient to support the family, so David, during the hours before and after school, established himself in his first business venture—selling newspapers. His neat appearance and pleasant manner attracted customers and also the enmity of the other newsboys in the neighborhood. Even at the early age of ten he showed symptoms of the diplomacy that was to be a dominant element in his future success. One by one he won over his rivals to the point where they came to look to him for leadership.

For a boy so young, the news-vending business was a hard taskmaster. Up and out every morning at four o'clock, he met the newspaper delivery trucks to get his day's quota of papers. Since rivalry was keen among the newsboys, he had to fight often for his place in line and then hustle to deliver or peddle his papers before school opened. His breakfast often consisted of a doughnut and a cup of coffee that could be purchased for two cents at a St. Andrews coffee stand.

Since free schools were unknown in Russia in those days, it was only natural that the young immigrant should be carried away by the democratic system of American public schools where all pupils were equal in the eyes of the educators. In one of the classrooms he attended, a steel engraving, a portrait of Abraham Lincoln, hung on the wall. It seemed to fascinate the boy. The careworn face and the sympathetic eyes seemed to radiate hope for the oppressed and a promise of freedom and justice for all.

Whenever Lincoln was discussed in class, the boy sat enthralled. The humble origin of the Great Emancipator born in a rickety log cabin, raised in poverty and love, educated by whatever means were at hand, appealed to him strongly. He saw in Lincoln's life a pattern he determined to follow. He read every book on Lincoln in the school library, aided by a cheap English dictionary picked up at a second-hand bookshop.

Evenings, after his newspaper route was finished, he haunted the public libraries, where he borrowed books about the life and times of his idol. The result was he soon accumulated a knowledge greater and better than that of most native-born Americans.

When he was fifteen, David's father died. Now virtual head of his family, he faced the problem of supporting his mother and two small brothers. His earnings as a newsboy were far from sufficient for their needs. He decided to look for a steady job in which there was a chance for advancement. He was without experience other than peddling newspapers and the outlook was bleak. Yet that experience might prove useful if only he could get a job in the circulation department of a newspaper. The *New York Herald* was his best selling paper and besides he read it religiously.

One morning when he had finished his deliveries, he put on his only good suit and instead of hurrying to school, he headed uptown to the Herald building, then situated on what was known as Herald Square. On the sidewalk outside the building he found a group of sightseers entranced by the rumbling presses plainly visible through large plate-glass windows. As he watched the hustling activity within and saw his favorite newspaper streaming from the presses as water through a millrace,

he had a feeling of kinship, for he reasoned he had contributed in his small way to its wide distribution.

With head held high and courage in his heart David entered the business office on the ground floor. It was a busy place that had little to do with the gathering of news. It was mostly concerned with want ads and "personals" for which the *Herald* had a widespread reputation. The clicking of a telegraph instrument drew the boy's attention to a counter in a corner of the room. It bore a printed sign reading "Postal Telegraph." Inside the counter an operator was tapping out a message.

Near by at a small desk a bespectacled man, apparently the manager, was leafing through a sheaf of telegrams. Noticing David at the counter, he asked sharply, "What can I do for you, young man?"

"I want a job," said David boldly. "Who is the man I can see about it?"

The manager eyed the young job-hunter critically and said, "I could use a smart messenger boy. Five dollars a week and ten cents an hour overtime. Take it or leave it."

Even while they spoke, David's ears were turned to the clicking telegraph instrument. With the foresight that has marked his career all through his life, he visualized himself learning telegraphy while he worked as a messenger. "I'll take it!" he said earnestly, little realizing he had opened the door to the great empire of communications that some day would look to him as its inspiration and directing head.

Even in those early days a salary of five and a half dollars a week was far from sufficient to support a family, so the boy decided to continue his newspaper delivery business, even though it meant putting in four to five hours work each morning before reporting at the Postal Telegraph office. His brothers, while still young, were old

enough to take care of themselves among the rough and tumble newsboys they had to compete with. Already they had taken over the afternoon sale of papers on their accustomed street corners.

From his first pay envelope David took two dollars and purchased a second-hand telegraph key and a book of Morse code that he studied every spare moment of his day. At night he practiced on the telegraph key for an hour or more while he lay in bed. During the day the manager permitted him to practice on the office instrument when he was not delivering messages and when traffic over the line was slack.

After six months of close application and study, David Sarnoff, messenger boy, had attained remarkable proficiency in telegraphy. He could send and receive in Morse code at a speed that equaled that of the professional operator in the office.

In the meantime "wireless" had made rapid strides since Marconi had sent his memorable three-dot signal from England to Newfoundland. Indeed wireless telegraphy had become a well-established business in America, with headquarters on William Street, New York City. It was known on both sides of the Atlantic as the Marconi Wireless Company.

One morning while scanning a copy of the *New York Herald,* David's eye caught sight of a small want ad. It read: "Wanted—a junior wireless operator. American Marconi Company." It was as if a light had been turned on in a darkened room. David saw opportunity and vistas of which he had never dreamed. Until now his heart had been set on becoming a conventional operator employed by a telegraph company, a railroad or perhaps a newspaper. The little want ad had changed his outlook. Although wireless was a mystery to him, he knew that Morse

code—in which he was expert—was used for sending and receiving messages by wireless exactly as it was in wired telegraphy.

As the two bronze figures on the clock atop the Herald Building banged out the hour of noon, David decided to forego his lunch and hurried out to what later proved to be a date with destiny. Arriving at the offices of the American Marconi Company, he went to the traffic manager to apply for the job of junior operator.

"How old are you?" the manager asked.

"I'll soon be sixteen, sir." David answered bravely.

"Too young for an operator, I'm afraid. But I have an opening for a bright office boy. The salary will be five and a half dollars a week."

Confident that in time he could make the grade, David took the job. A year later came his first step up the ladder of success; he was made junior operator.

To this day David Sarnoff insists that the year he spent as office boy was his toughest but most profitable experience. Hating the job, he devised ways and means to make it interesting. For instance, he read every letter entrusted to him for filing. His bosses approved because their bright office boy could lay his hands on any correspondence they called for. Sensitive about his limited schooling, he considered this study of office correspondence as practical education in the business, of which he was a pitifully small part.

Furthermore he was gaining knowledge of the operation of a wireless business better than he could get in any classroom. Eventually he became more familiar with the many details of the company's operations than any of the other employees. His contact, indirect though it was, with the company's activities gave him what he craved most—a better and deeper knowledge of the English language. As

a further aid, he always carried with him his cherished pocket dictionary. He never let a word slip by that he did not understand without consulting the little dog-eared volume.

From junior operator Sarnoff rose to be chief operator and at a time when "safety at sea" became more than a mere phrase. Laws were passed requiring passenger ships to carry at least two wireless operators. Emergencies at sea demand men stout of heart and with indomitable courage, whether they be officers, sailors, engineers or wireless operators.

Young Sarnoff, strong, healthy and tough as rawhide, was assigned to duty as wireless operator on ships that sailed the seven seas. Study of his records and reports convinced his superiors that he would be more valuable ashore than afloat. And so it came about that the one-time office boy was made assistant traffic manager in the very office that had given him his start some years previously.

At that time Marconi wireless was used exclusively as a commercial means of ærial communication; messages were sent and received by the dot-dash system. Although now in a managerial position, Sarnoff never missed an opportunity to do his stint at the key, sending out messages or receiving them as they came in over the air. Even in those early days of the industry, in 1916, his prophetic foresight was beginning to assert itself.

It was in that year he proposed in a memorandum to the General Manager a "radio music box to bring music into the home by wireless." The wiseacres shook their heads and brushed the proposal aside as one of Sarnoff's fanciful dreams.

When the Armistice ended the first World War, a great transformation in radio had taken place. Formerly expressing itself only in dots and dashes, it had found an

electric tongue; it had learned to talk and to sing. The new vacuum tube opened the door to radio-telephony.

The Marconi companies and the Marconi inventions, largely under British control, were taken over by the American Government during the war. Wireless telegraphy in the hands of the United States Government gave the nation an independent wartime communications service that spread across both hemispheres. At war's end it was evident that restoration of the established wireless stations to the Marconi Company might mean foreign control of our international communications. The transoceanic cables were then completely under foreign ownership.

It was at this juncture in 1919 that the United States Navy suggested the formation of an all-American communications company. Quick to see the wisdom of such a move, the General Electric Company formed the Radio Corporation of America, now world famous as RCA. The business and properties of the Marconi Company were acquired by the new corporation, with David Sarnoff as commercial manager. The chief purpose of RCA was to give the United States pre-eminence in radio communication independent of all other countries.

Commercial radio communication between the United States and foreign countries was inaugurated by RCA on March 1, 1920, when the first messages over the company's transatlantic circuits were sent between New York and London. Before the end of the year, service had been established with England, France, Norway, Hawaii, Japan and Germany. America was on its way to become the world's center of radio communications.

RCA's phenomenal success was in large part due to the encyclopedic knowledge of the entire communications industry acquired by David Sarnoff. From office boy to

commercial manager he knew every facet of every job through first-hand experience. When the great Radio Central, dedicated to worldwide communications, was completed at Rocky Point, Long Island, President Warren G. Harding formally opened it, sending a radiogram of greeting to all nations. The message was telegraphed personally by the Commercial Manager—David Sarnoff himself.

Up to that time the primary use of radio had been for point-to-point telegraphic communications, in which the comparative secrecy of the wireless code protected ordinary confidences.

The radio telephone, however, had no such secrecy. Any of the thousands owning primitive radio sets, who cared to listen, could get an earful of the most private conversation. That gave rise to the widespread idea that radio telephony would be confined to a very limited and unprofitable future. The best brains in the technical and engineering fields were importuned to come up with an answer to the problem.

Sarnoff, neither an engineer nor a technician, refused to believe the radio telephone was destined for failure. Its so-called "defect" of lacking secrecy he looked upon as a means of mass communication. He reasoned: If radio can carry speech, it can also carry music and reports of news events. With a suitable "radio music box" in the home, families could enjoy concerts, lectures, recitals, etc., from the nearest city within their radius. It was what he had visualized in 1916.

Again he laid before his directors a plan to devise, design and put on sale a practical radio receiving set for which more than a million customers would gladly pay seventy-five dollars. That would bring in an estimated 75 million dollars within a period of three years. His plan

materialized! RCA's sales of receiving instruments totaled more than 85 million dollars through the three years from 1922 through 1924.

Most of the listeners to the early broadcast programs used crystal detectors, tubeless detector sets. Development of vacuum tubes, both as sensitive detectors and amplifiers, quickly expanded the radio audience.

As early as 1920 experimental broadcasts were put on the air over the Westinghouse station KDKA at Pittsburgh. It was in that year the Harding-Cox presidential election returns were broadcast. News of the triumph of early radio kindled a broadcasting craze that spread everywhere. Immediately the endless possibilities of the new medium for entertainment and information became apparent as the midday sun. Scores of broadcasting stations sprang up almost over night. Radio listening became a national pastime.

It was in 1921 that the great awakening to the incalculable value of the radio broadcast occurred. The occasion: a prize fight. On July 2nd of that year two fistic gladiators met in a great wooden bowl hastily built at Boyle's Thirty Acres in Jersey City. With a world championship at stake, the Press of the country devoted countless columns to the forthcoming clash of the giants. One of the contenders, Jack Dempsey, was a heavyweight hurricane of speed and power. His opponent was Georges Charpentier, a Frenchman noted for his grace of motion behind which he concealed the wallop of a battering ram. Public interest in the scheduled fight rose to fever pitch.

In clubs and restaurants, on trains and in homes the paramount question was would the sledge-hammer onslaughts of Dempsey prove effective on an opponent who eluded them like a will o' the wisp? Millions of dollars were bet on the outcome while tens of thousands of fight

fans plodded through the red clay of Jersey to swelter under a July sun.

If ever there was a setup for a popular broadcast, this was it!

Undaunted by the great cost of the broadcast, Sarnoff went ahead with his pet project—installing an RCA microphone at the ringside. Major I. Andrew White, a sports authority, was employed as announcer. Knowing little of the technique of broadcasting, White had difficulty in watching the fighters and speedily reporting the blow-by-blow progress of the battle. Fearing the effect of a faltering announcer on the broadcast, Sarnoff hurried to White's side and assisted him in the rapid-fire reporting.

The lucky owners of crystal detector sets and one-tube receivers were besieged by friends and neighbors anxious to hear the fight broadcast. At the final gong the thousands who had listened in suddenly became aware that they knew more about the details of the fight than many of those who had trudged through stifling heat to the actual scene of the fight.

Those were the days when the possession of a good receiving set gave the owner a certain prestige in a community. On the morning of the Big Fight I had been playing golf at the North Hempstead Country Club at Port Washington, Long Island. Then the fortunate owner of an unusually efficient receiving set, I had planned to listen to the much heralded broadcast. Before leaving for my home a member suggested that I telephone the progress of the fight to the club. I promised to do so. The telephone in our living room was close to the radio receiver, so I could transmit to the phone every word coming in from the ringside.

At the club a member sat at a telephone relaying my reporting to about fifty members, several of whom had

abandoned their game to hear the fight. For days afterward my work was interrupted frequently by club members who had decided to install radio receiving sets in their homes. One of them eventually gave up a profitable engineering business to enter the field of radio. Today he is an executive and heavy stockholder in one of America's outstanding broadcasting companies.

That autumn, Station WJZ was opened at Newark, New Jersey. It was located in a remote corner of a Westinghouse factory. The broadcasting "studio" was housed in what resembled a small circus tent made of gray canton flannel heavily draped from a conical ceiling of the same material. It was an early attempt at sound-proofing. The studio's furnishings consisted of a piano, several wicker chairs and an electric heater. Its equipment was a control board that resembled a shoulder-high chest of drawers with a few dials and knobs here and there on its surface.

At a table at one side of the enclosure an engineer sat manipulating knobs and switches on a crude-looking control board. The microphone, a masterpiece of primitive construction, was a wooden gibbet-like affair. From the end of its outstretched arm was suspended the "mike," looking for all the world like a tomato can. The first program featured World Series bulletins, interspersed with glib remarks by a thoroughly inexperienced announcer. Crude though the "studio" was, its programs thrilled thousands, not because of their content but because they gave listeners something to tune in at certain hours of the day.

In quick succession four other broadcasting stations were opened. One of them was WBAY, the experimental station of the American Telephone and Telegraph Company in New York. Its call letters were changed later to WEAF. That was the station which in the following year broadcast the first commercial program that led to the

solution of the pressing problem—who would pay for broadcasting.

The fledgling radio now began to spread its wings as it ventured outside the studio for its programs. The Princeton-Chicago football game was the first to be broadcast from the gridiron.

In November of the same year a concert by the New York Philharmonic Orchestra was broadcast. Even the most critical of music lovers admitted that radio had proved an excellent medium for the presentation of good music. Then followed a period when radio history was being made daily. From being just a form of entertainment it was growing rapidly into a thriving industry employing thousands of people.

In the first eleven months of 1921 General Electric and Westinghouse produced for sale by RCA 5000 tubes a month. By June 1922 monthly production of tubes had increased to 200,000. During that year the American public spent about 100 million dollars for radio sets, tubes, headsets and batteries.

In 1923 radio got its greatest boost. Until that year radio reception was subject to many ailments that often made it difficult to listen to. Then came the announcement that the superheterodyne circuit developed during World War I, had been redesigned as a commercial product and that RCA would introduce it for home use. Because of its controlled volume, sharp tuning and sensitivity, the "super" took the public by storm. Thousands of the old-fashioned sets were thrown on the scrap pile.

Now the entire family or large groups of fans could listen to incoming programs without being encumbered by ear-phones. By the end of that eventful year the number of broadcasting stations had increased from 36 to more than 500. Radio, no longer a hobby or a fad, stepped into

the ranks of big business. Listeners, formerly reckoned in thousands, were now in the millions.

David Sarnoff's dream of a "radio music box" for all people had come true. Under his inspired management RCA grew and prospered. Its benign influence was felt throughout the thriving industry. On January 1, 1923, he became Vice President and General Manager. It was but another step to greater heights.

Despite his onerous administrative duties Sarnoff never failed to look far into the future. Possessed of what was almost second sight, he prophesied unheard-of developments in the field of electronics. Using all his powers of persuasion, he stimulated the scientific and engineering staffs and the board members of his company toward greater achievement, even if the goal seemed at the moment distant as the stars.

On April 5, 1923, in a report to the RCA directors, he said, "I believe that Television, which is the technical name for seeing as well as hearing by radio will come to pass in due course . . . It may be that every broadcast receiver for home use in the future will be equipped with a television adjunct by which the instrument will make it possible for those at home to see as well as hear what is going on at the broadcast station."

That was many years before the public had ever heard of TV. But the idea once planted and carefully nurtured, developed into a giant enterprise that has influenced our social, economic and political life.

Going back to those early days of radio, audiences were not too critical of the mediocre talent employed by the broadcasters. As the novelty wore off, however, listeners began to select programs that had ear appeal and better entertainment. Aware of this trend, radio stations turned to the entertainment world for talent. Station WJZ moved

from Newark, New Jersey, to studios in the theatrical center of New York City, thus making it easier for the better performers to reach the microphone. Other stations followed suit in improving the quality of their programs.

Always ahead of his time, the far-sighted Sarnoff predicted a nationwide network that would carry New York programs to people all over the United States. At his insistence the first multiple network was put in operation between New York, Schenectady, Pittsburgh and Chicago.

The year 1926 was destined to see many vital developments in the field of broadcasting. Many of the stars of first magnitude in the theater and the opera fought shy of the microphone. They considered broadcasting beneath their dignity if not actually a potential competitor.

They soon changed their minds when on New Year's Day the noted Irish tenor, John McCormack, and Lucrezia Bori, star of the Metropolitan Opera, made their debut over Station WJZ. It was an historic broadcast in more ways than one. Never had singers sung to such a large and appreciative audience and been acclaimed by such an enthusiastic press. It proved to artists who frowned on radio that the new medium could do justice to their art. Besides, singing into a "mike" was highly profitable since the studio had a means of paying them well—through the commercial sponsor.

As radio increased in popularity, broadcasters could offer sponsors "widespread circulation," since their audiences numbered millions. Advertisers grasped a new opportunity to make known their products and gain goodwill by linking their trademarks with outstanding performers, orchestras, speakers and news commentators. Radio by sheer power of public approval became one of the world's most influential advertising mediums. I have seen mailbags containing consumer replies stacked shoul-

der-high in the mailroom of a broadcasting station, the result of a single advertising announcement over the air.

Because of the uncontrolled growth of broadcasting, a period of chaos followed. Interference by overlapping stations made listening an ordeal. The air became a babel of competing programs. The protests of thousands of disgruntled listeners finally brought results. On February 23, 1926, President Coolidge signed the Dell-White Radio Bill and later created the Federal Radio Commission. Wave-lengths were regulated and order restored.

Now under Government control, radio flexed its wings in flight over greater distances. The first radio-photo was sent across the Atlantic on a commercial basis. The dirigible *Norge,* while hovering over the North Pole, sent radio greetings to the United States. The Dempsey-Tunney championship fight was broadcast by long and short wave to all parts of the world.

September 9, 1926, will always be a memorable date in the annals of radio—the National Broadcasting Company was organized as a service of RCA, to provide the best obtainable programs for broadcasting and to make them available to other stations throughout the country. And so began the system of networks that blankets the United States.

Realizing that successful broadcasting depended as much on good reception as on good programs, Sarnoff called on RCA for all of its inventiveness and all its resources to produce a receiving set that would have the best tonal quality and be available at a relatively low price. When the final model had been demonstrated to him, he remarked, "Now the richest man cannot buy for himself what the poorest man gets free by radio." At that time five million homes were radio-equipped but there were twenty-one million homes that eventually would have to

be supplied. The radio receiving set was no longer a plaything; it had become an instrument of service.

Gradually the radio network stretched out across the country from the East and from the West and finally connected at Denver, Colorado. The 1927 Rose Bowl football game at Pasadena was broadcast over a 4000-mile hook-up on New Year's Day. This was soon followed by the first coast-to-coast broadcast of the opera *Faust*.

In 1927 most of the important radio inventions and patents were in the hands of RCA. The rapid development of all phases was opening a field of enormous individual progress. The continued advance for the art and the industry hung precariously on engineering and technical problems that stemmed from the maze of new inventions and techniques.

Radio manufacturers, large and small, fearing the consequences of infringing on existing patent rights, found themselves stymied. To remedy the situation, RCA made available to competitive radio manufacturers all its inventions on a licensing basis at a very modest royalty rate.

As a result of his invaluable services to the radio industry, to RCA and to the world, David Sarnoff was selected President of the Radio Corporation of America.

In addition to his leadership as President of RCA, David Sarnoff was on active military duty twice during World War II. He served first as a colonel in the Office of the Chief Signal Officer in Washington, D. C. In March, 1944, he was assigned to overseas duty as Special Consultant on Communications at Supreme Headquarters of the Allied Expeditionary Force. In October he was awarded the Legion of Merit for his services overseas. On November 21, 1944, he was nominated Brigadier General by President Franklin D. Roosevelt and the rank was confirmed by the Senate a little more than a year later. President Tru-

man presented General Sarnoff with the Medal for Merit in recognition of his "inestimable value to the war effort."

Upon the General's return to the United States from his war service overseas, the Television Broadcasters Association presented him with a citation "for his initial vision of television as a social force and his steadfastness of leadership in the face of natural and human obstacles in bringing television to its present state of perfection." And added that "the committee wishes to call him *The Father of Television.*"

The honorable committee had forgotten that twenty years previously many of those present had pooh-poohed as an impractical dream Sarnoff's prophecy that seeing as well as hearing by radio would come to pass in due course.

8

OPPORTUNITY VOCATIONAL

CENTURIES BEFORE MAN HAD CONQUERED distance by sound with the telegraph, telephone and radio, a Dutch optician claimed the first victory in bringing far-distant objects into closer visual range. He was Hans Lippershey, who in 1608 invented the telescope. A year later Galileo developed the astronomical telescope to enable him to study at closer range the mysteries of the heavens. Not until near the end of the last century did scientists or inventors give serious thought to electrical transmission of pictures from one place to another.

The development of the photo-electric cell, however, spurred them into experimentation. The tiny cell, a new-

comer in the world of science, had the then strange property of converting light into energy. An American, G. R. Carey, was the first to transmit a blurry image over a wire. Then a British scientist demonstrated a method of sending a picture by wire. The transmitted image was so fuzzy and indistinct it was scarcely worth the effort. Two prominent British physicists failed utterly in their attempts to transmit a photograph electrically over a telegraph wire.

All the futile experiments were made with still pictures. No one seems to have even thought of sending pictures in motion until a Frenchman named Maurice le Blanc startled the scientific world by announcing that pictures in motion could be sent by wire over long-distance by taking a series of still photographs—of, say, a trotting horse—and then transmitting them rapidly in proper sequence. Although Le Blanc did not put his theory into practice, there are those who credit him with being first to conceive the basic principle of the motion picture.

At that time little was known of the newly discovered phenomenon of electronics. Heinrich Hertz merely proved they existed and that they could be measured in terms of wave lengths. But it was enough to give young Marconi a flying start toward his goal—the establishment of long-distance communications without wires and eventually spanning the Atlantic with his historic three-dot signal borne on the wings of the invisible electrons.

The first promising step in the direction of modern television was Niepkow's scanning disk—a whirling metal platter with a series of holes arranged in a slightly spiral pattern. A man walking, when viewed through the holes in the revolving disk, had a lifelike semblance of motion. The variations of light and shadow on the subject were translated into electric impulses capable of being sent out over a wire. Arriving at their destination, the process was

reversed; the electric impulses were converted back into light and shadow and so became a moving picture sent over a wire. The result, though crude, showed promise enough to tempt other inventors to carry on in perfecting the scanning-disk system. Years of trial and error, however, resulted in relegating it to the limbo of frustrated dreams.

World War I came. The infant radio was beginning to be a stalwart youngster showing great promise of becoming a successful breadwinner. Television, like so many of its valuable predecessors, was laid on the shelf and almost forgotten. At war's end radio was riding high in the field of communications. Lee de Forest came along with his vacuum tube that made the transmission of music and complex sounds possible, and radio entered the fields of entertainment and news broadcasting. Television, the poor little stepchild, was again brought into the limelight when it was discovered that the vacuum tube improved immensely the picture shown by the revolving scanner. In its rejuvenated state it was exhibited far and wide at gatherings in many parts of the country, but it was still fuzzy and shivery and far from what press reports pictured it. Its flickering caused eye-strain and viewing was difficult if not actually unpleasant. It looked for a while as if television had come to the end of the road.

About the time when television seemed to be in the doldrums, a young man Vladimir Zworykin who had studied under Rossing, the foremost authority on electronics, appeared on the scene. He got a job in the research division of the Westinghouse Company and soon distinguished himself as a student of electronics. During the nine years he spent with Westinghouse his fame spread in scientific circles. Convinced that the future of television would be along electronic rather than mechanical lines, he devoted

himself day and night to the development of an electronic device that would replace the scanning disk. In 1923 he applied for a patent on the iconoscope, the electronic eye from which has sprung all modern television.

RCA, then the world center of radio-electronic research, saw in Zworykin's invention the key to practical television and hired him forthwith. Scarcely had the young scientist begun work in his new surroundings when television began to show signs of returning health. Within a year Zworykin had developed the kinescope, or picture tube, that received the picture captured by the iconoscope and made it visible.

Although the general pattern of televising had been established, it was far from being perfected. Already many men of science were contributing to it directly or indirectly. Alexanderson, Farnsworth, Fleming, De Forest, Dumont, the Bell Laboratories—all made contributions that hastened the day of acceptable television. So far, many electronic makeshifts were used in televising. The electron camera was unknown until Zworykin, after months of labor, designed and built one that was practical in every respect. Indoor and outdoor camera shots were made and transmitted to distant points.

Television was now an accomplished fact, and yet it had its weak points. The revolutionary iconoscope was incapable of picking up a satisfactory image indoors except under a blinding volume of light that in turn created heat that made studio temperature all but unbearable. Outdoors it was effective only in brilliant sunlight.

Realizing the seriousness of this handicap, Zworykin set about creating a new type of tube that would give a perfect image even in a dim light. Soon he brought forth his most startling achievement—the "image orthicon," a device so light-sensitive it could capture a perfect image

of a subject illuminated by the flame of a match. The image orthicon was a blessing to studio workers; they could now work in comfort.

In the field bright sunshine was no longer necessary. TV mobile units covered baseball, football and political events even under lowering skies. News events were "shot" and broadcast at the very moment they happened, although at that time the number of receiving sets in American homes was pitifully small.

But there is an old saying in commercial circles: "A good product is its own best advertisement." Word of the wonder of television spread from mouth to mouth. Millions hankered to see it, but few had an opportunity.

Even before television had reached the age of adolescence World War II engulfed the world and television suffered another setback. Thousands of skilled workers who had been trained in the complexities of the young industry were swept into the activities of war.

Commercially, television was prostrate. Undaunted, however, it set out to aid in the war effort and soon became a recognized medium of mass education. In New York City and nearby communities thousands of air-raid wardens were trained nightly by television in the various techniques of safeguarding lives in the event of a raid from the sky. Sports and other events were televised for wounded service men in hospitals within range of the transmitters.

With sales at zero and production at a standstill, scientists and technicians who were exempt from military service, applied themselves diligently to invention, development and improvement of existing facilities in preparation for the boom in TV that was sure to come with the return of peace.

Prominent in the electronic industry's war work was

the development and production of radar, loran and shoran. Out of the laboratories came many instruments and devices that made history. Among them were infra-red communication and air-borne television, through which the headquarters' command could actually observe enemy terrain many miles away as it was scanned by an airborne TV camera. A multitude of electron tubes of many designs for many purposes—secret communications systems, deception and diffusion techniques, jamming and anti-jamming methods, impairment of enemy communications—were developed.

Chief among the industry's contributions was radar. As early as 1934, micro-wave apparatus was used in a series of reflective tests in co-operation with the Army Signal Corps. Radar is the seeing eye that reveals in fog, darkness or heavy clouds any subject its micro-wave beam strikes. It may be likened in a limited sense to an electric flashlight in the hands of a person on a very dark night. Probing the darkness, the light beam strikes, full on, a window in a distant building and is reflected back to its source where it enters the eye of the holder of the light. Of course in heavy fog or dense clouds light penetrates only a very short distance and there disintegrates. An electronic beam finds its target regardless of atmospheric conditions and bounces back to its source where it indicates on the radar-scope not only the position of the target but its distance.

Realizing the vast importance of radar both in defense and attack, the U.S. Navy requested that all future work on it be carried on under the strictest secrecy. The purchases of radar equipment by Government agencies eventually totaled $3,700,000,000.

During the later stages of World War II a highly efficient system, a first cousin to radar, was developed. Known as shoran, it operated on the reflective or echo-

tuning principle and was soon found to equal visual bombing in accuracy under normal conditions. In peacetime, shoran has become a new radar yardstick for world mapping. It is now widely used by the U.S. Coast and Geodetic Survey and is so perfected that it can measure distances up to 250 miles with pin-point accuracy.

During a recent interview, a well-known electronic engineer said:

"In our battle against distance the electron has been our staunchest ally. It has enabled us to perform scientific feats the mere mention of which would have been ridiculed a generation ago. It has ushered in an age of miracles that will affect not only our economy and our culture but our health and our lives."

"What are some of these miracles?" I asked.

"One of them is an advanced system of communications known as Ultrafax. It was developed by the Radio Corporation of America, and combines television, radio relay and photography. It can handle huge volumes of traffic at speeds up to a million words a minute. When fully perfected, this system will be capable of transmitting in facsimile the equivalent of forty tons of air mail from coast to coast in a single working day. It promises to be as significant a milestone in high-speed transmission of communications as was the splitting of the atom in the world of energy.

"Then there are the electronic computers, huge robots that can add, subtract, multiply, divide and memorize their computations in such a manner that they are immediately available for another operation. These modern robots promise to revolutionize and simplify the clerical work of insurance companies, banks, tax bureaus, stock exchanges and business in general. In merchandizing organizations a single electronic computer can do the com-

bined accounting of receivables, payables, purchase and stock controls. They have saved millions of dollars in industry. A type of computer known as the Typhoon in use by the United States Navy has saved the Government an estimated 250 million dollars in guided-missiles computations alone."

"In what way does television contribute to our industrial economy besides being a powerful advertising medium based on its educational and entertainment value?" I inquired.

"In many ways," the engineer replied. "The Vidicon, a pint-sized TV camera, is used in industries where there is danger of exposing workers to intense heat, lethal gasses or nuclear radiation. A Vidicon is set up as an observer. It televises what it sees to a monitor or screen in the office of the plant superintendent or manager. In many prisons the little snooper camera takes the place of guards. Set up outside the cell of a recalcitrant prisoner, it keeps him under constant observation twenty-four hours a day. Or it may cover an entire cell block, the prison shops or the exercise yard. In many cases it has been found to be more efficient than the guards in reporting lapse of morale or incipient revolt.

"Many banks have found it much more efficient than uniformed attendants since it keeps not only the customers but the bank employees under observation. Other banks with several branches have found closed-circuit TV invaluable in expediting the day's business and in the detection of fraudulent checks. Department stores have found the little Vidicon worth its weight in gold in broadcasting to monitors in its various departments special offerings for the benefit of customers throughout the store. For instance, a customer in, say, the glove department, is watching the monitor and sees an attractive model wear-

ing a reasonably priced housedress and hurries to the garment department on the second floor to make a purchase."

"You mentioned our health and our safety," I said. "Would you explain?"

He resumed: "For generations, medicine and science and even industry have depended on the microscope to reveal the mysteries of the many invisible micro-organisms that affect our health and often our lives. Despite the best efforts of the microbe hunters certain bacteria, bacilli and viruses had defied them. The game of hide-and-seek had deteriorated into blindman's buff with the scientists blindfolded because in their best microscopes magnification was pitifully small, rarely exceeding a few hundred diameters.

"Then came the electron microscope, an affair of gigantic proportions that, when compared with the standard old-fashioned microscope is a cannon versus a cap pistol. Its extremely high degree of light contrast is invaluable in photographing viruses and the internal structure of bacteria at magnifications up to 350,000 diameters. Hailed as one of the greatest scientific tools of this century, more than five hundred of those giant 'scopes are now being used in hospital and college laboratories, Government bureaus, and advanced scientific research projects throughout the world."

Curious as to how an electronic device could be used in the actual saving of lives, I asked the engineer to cite an example.

Smiling knowingly, he said, "It will come as a surprise to many to learn that radar speed meters are now in use by police in forty-two states and in Canada. The object? To reduce the death rate resulting from automobile speeding.

"The unwitting speed demon sees no police car in his

rear-view mirror. But his speed is clocked accurately just the same. A mile or two farther on he is amazed to find a patrol car waiting for him with an accurate record of his driving speed over a certain section of highway.

"The unseen traffic cop is an aluminum boxlike affair weighing forty pounds and fitted with two separate antennæ. It rests snugly in the trunk of a prowl car.

"As the speeding car approaches, the radar speed meter sends out high-frequency radio waves from one of the antennæ. This signal bounces off the speeding car, changes frequency and is reflected back to the prowl car to be picked up by the receiving antenna. The difference between the two frequencies tells accurately the illegal speed of the guilty car.

"At the same time a recorder rates in red ink the speed over a specified distance. The prowl-car officer radiophones a description and the license number of the speeding car to the patrol station ahead of it, adding of course the illegal speed at which it was traveling. An arrest or a summons follows, leaving the reckless driver mystified as to how a police car that was nowhere in his vicinity could tell so accurately his high driving speed.

"In the states where radar meters are now in use, there is no doubt as to their effectiveness. Judges and juries have declared the radar meters competent witnesses and strictly legal. In some communities Chambers of Commerce and Automobile Associations have protested that the radar meter is unfair. In other towns auto dealers and storekeepers insist that many drivers detour away from the radar guarded area, thus depriving the community of their patronage.

"On the other hand, police reports are unanimous in their praise of radar control of the speeders. In Gary, Indiana, the radar system cut traffic deaths to more than half

during the first year of its operation. The Commissioner of Public Safety of the State of Mississippi has declared, 'Radar has cut down traffic deaths tremendously. On the stretch between Clarksville and the Tennessee state line it has resulted in a seventy percent reduction of the annual death rate.' "

That evening my friend the engineer and I dined at a quiet little restaurant that was patronized mostly by people in television and radio. At nearby tables were seated several celebrities of the air—actors, directors, musicians and a star comedian, a lonely picture of moroseness. There were cameramen and electricians, script girls and glamorous secretaries to radio and TV bigwigs. The air was also filled with subdued shop-talk—new sponsors, new contracts, new stars, new jobs and the fabulous salaries for the few who had reached the top.

During the course of our conversation I learned that the engineer had been obsessed from early boyhood with a determination to make radio and the study of electronics his life-work. When he was fourteen he had built and sold several crystal radio sets. With the money he earned he had set up a sort of radio hospital in the basement of his home and soon had a flattering list of satisfied customers.

While in high school he worked nights in a local radio repair shop and soon established himself as a first-class trouble-shooter. After graduating from college with an engineer's degree, he went forth bravely to face the world and get himself a job.

At that period employment was at low ebb. On a mere hunch he went to the local telephone company. "I'm an engineer!" he said boldly to the manager, "but I'll take any kind of job you have to offer." The manager looked

at him critically for a moment. "I think you'll do," he said. "Come around in the morning."

Assigned to a maintenance crew, he soon realized he must learn the hard way. A recent storm had left a tangle of wires and fallen poles in its wake. His work had little to do with the art of telephony; it was just bone labor, chopping, cutting, sawing, lifting and hauling under the eye of a hard-boiled foreman who drove his men mercilessly. After several months of work in the open he was assigned to an indoor job—the assembly of a new switchboard—his role that of unskilled helper.

Soon it became evident to his fellow workers that he was expert with a soldering iron and that he had a sound knowledge of circuits. In a matter of months he was recognized as one of the most proficient members of the working staff. An ardent collector of books and pamphlets dealing with electronics, he acquired through the dean of his alma mater an imposing brochure titled *Your Career in Bell Telephone Laboratories.* Its preface, a message "to the young scientist and engineer," was signed by the president.

As he studied the contents that outlined the vast achievements of the Laboratories not only in the field of telephony but the broader phases of science and its contributions to human welfare and to our armed forces, he saw for the first time his future clearly defined. His mind was made up. From that moment it was "Bell or Bust!"

Enclosed in the brochure was an application form and qualifications record. The applicant was required to answer a long list of questions dealing with his educational background, college activities, non-college activities, employment and business experience, active military service, etc., etc. With meticulous care and neatness he filled out the blank and mailed it to the Employment Director.

Anxious days of waiting for an answer dragged by. One evening a letter came from the Director. It was a request to come to New York for a personal interview.

A week later he was enrolled as a member of one of the world's greatest organizations devoted to science. Close application and a consuming desire for knowledge made his progress unusually rapid. In less than two years his name was coupled with several outstanding electronic developments. His research in the application of the transistor added to his fame and placed his name high in the roster of men of achievement.

When I had finished making notes on the engineer's story, I ventured a few questions. "How would you rate the broad field of communications from a vocational point of view?"

"For any young man or young woman desiring steady employment with agreeable working conditions and assured advancement not only in responsibility but in pay, I would recommend it. It is a stable industry as necessary to our daily life as food, clothing or housing. Without our present systems of communications the commercial, industrial and financial world would fall apart like a house of cards. Without adequate communications our military machine would be as baffled as a deaf man in a group of vociferous conspirators. Our system of communications might be likened to the nerve system of the human animal. The breakdown of the one would mean the disintegration of the whole beyond repair."

"Can you give us some idea of the number of jobs in the communications industry?" I asked.

"That would be impossible," he said. "But I can give you some idea of the magnitude of employment. From that you can draw your own conclusions. The American Telephone and Telegraph Company employs more than

eight hundred thousand persons. The Radio Corporation of America has a payroll of fifty thousand persons in its various enterprises. But it purchases needed materials from five thousand manufacturers large and small who employ hundreds of thousands of workers. And don't forget there are some five thousand independent telephone companies whose employees also run into large figures. Only our military establishment knows the exact number of men and women assigned to military communications. Add to these the unknown numbers of operators and technicians employed by private industry to carry on its communications and you have a total of several millions who depend for their bread and butter on the power of the little electron that asserts itself unhindered by distance or time or space."

"One more question!" I interrupted. "For those of an inventive or scientific turn of mind, what opportunity does the communications field offer today?"

"Opportunities are greater and more numerous today than at any time in the history of the industry. Most of the great inventions and developments in communications have come about through a process of evolution. If it had not been for the discovery and study of electric phenomena by Galvani, Volta and Faraday, Samuel Morse would not have abandoned his palette and easel in order to invent and perfect the telegraph. Alexander Graham Bell began his career in an attempt to make Morse's telegraph more efficient. While at work on his 'harmonic' telegraph he stumbled on the principle of the telephone. Heinrich Hertz's discovery of electronic waves spurred Marconi into the development of wireless capable of sending messages by the dot-dash system known as Morse Code. Then came Fleming with his valve that enabled wireless to carry actual sounds faintly though audibly. De Forest's vacuum

tube went the valve one better. It could amplify the transmitted sound and give it a clarity hitherto unknown.

"As early as 1875 a scientist named Carey made a brave attempt at television by using a screen composed of a large number of silenium cells each electrically energized. While the device was a failure, its inventor established the fact that, to be televised, a picture or subject must be divided into a great number of component parts, each of which must be transmitted separately to a receiving device that would put them together again. Many years later Vladimir Zworykin developed an electric eye that he called the iconoscope which did electronically what Carey attempted to do electrically. Then in due time there came from the same fertile brain the image orthicon, the heart and soul of present-day television.

"And so this sequence of men and ideas still goes on, giving each succeeding generation of scientists, inventors, engineers and technicians an ever-growing backlog of experience and data on which to draw and build."

As we parted, my friend the engineer said, "Don't forget that our efforts to conquer distance are still in the initial stage. What the future will bring, no man knows, but every advance seems eventually to lead to another."