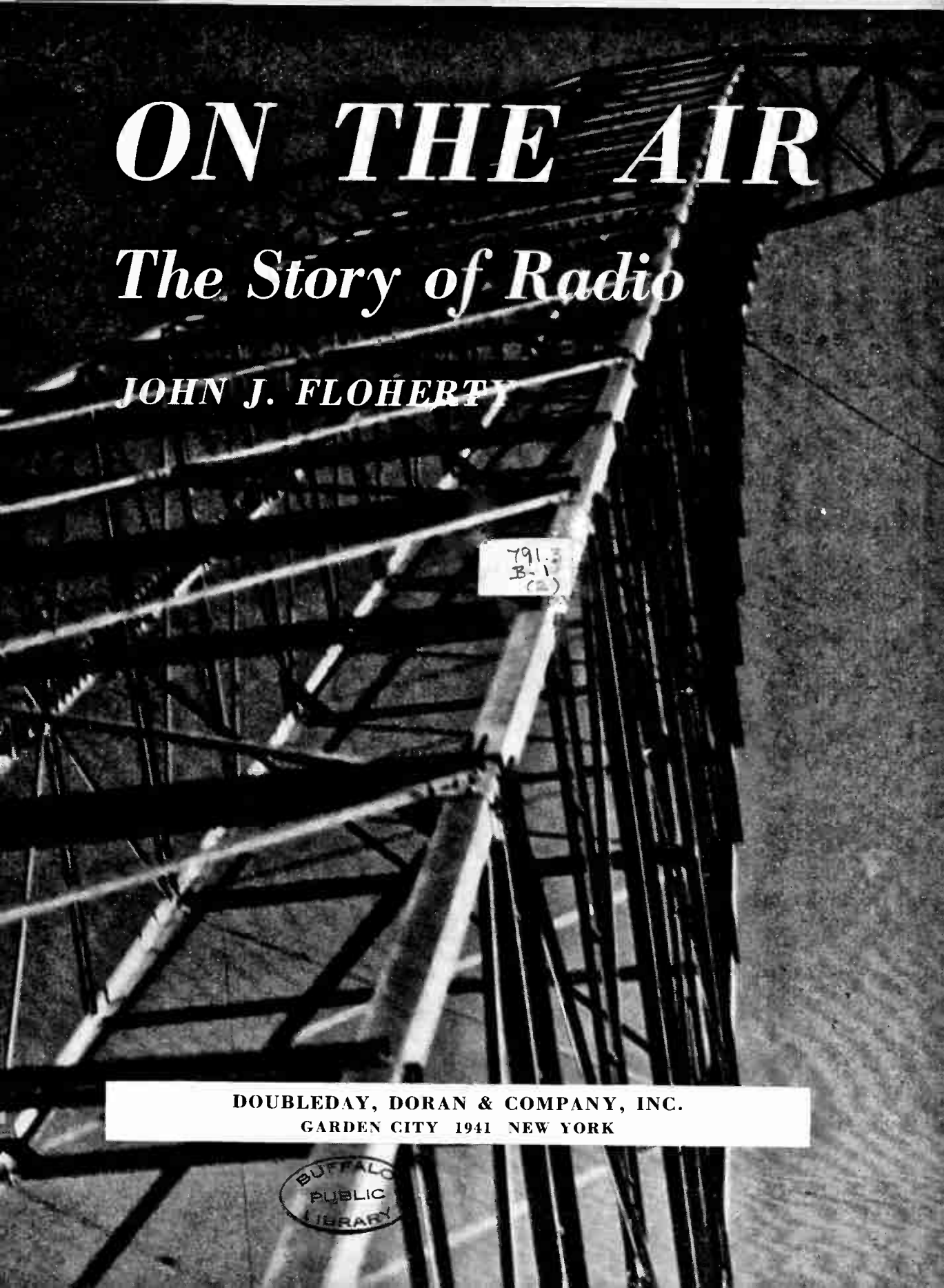

ON THE AIR

The Story of Radio

JOHN J. FLOHERTY

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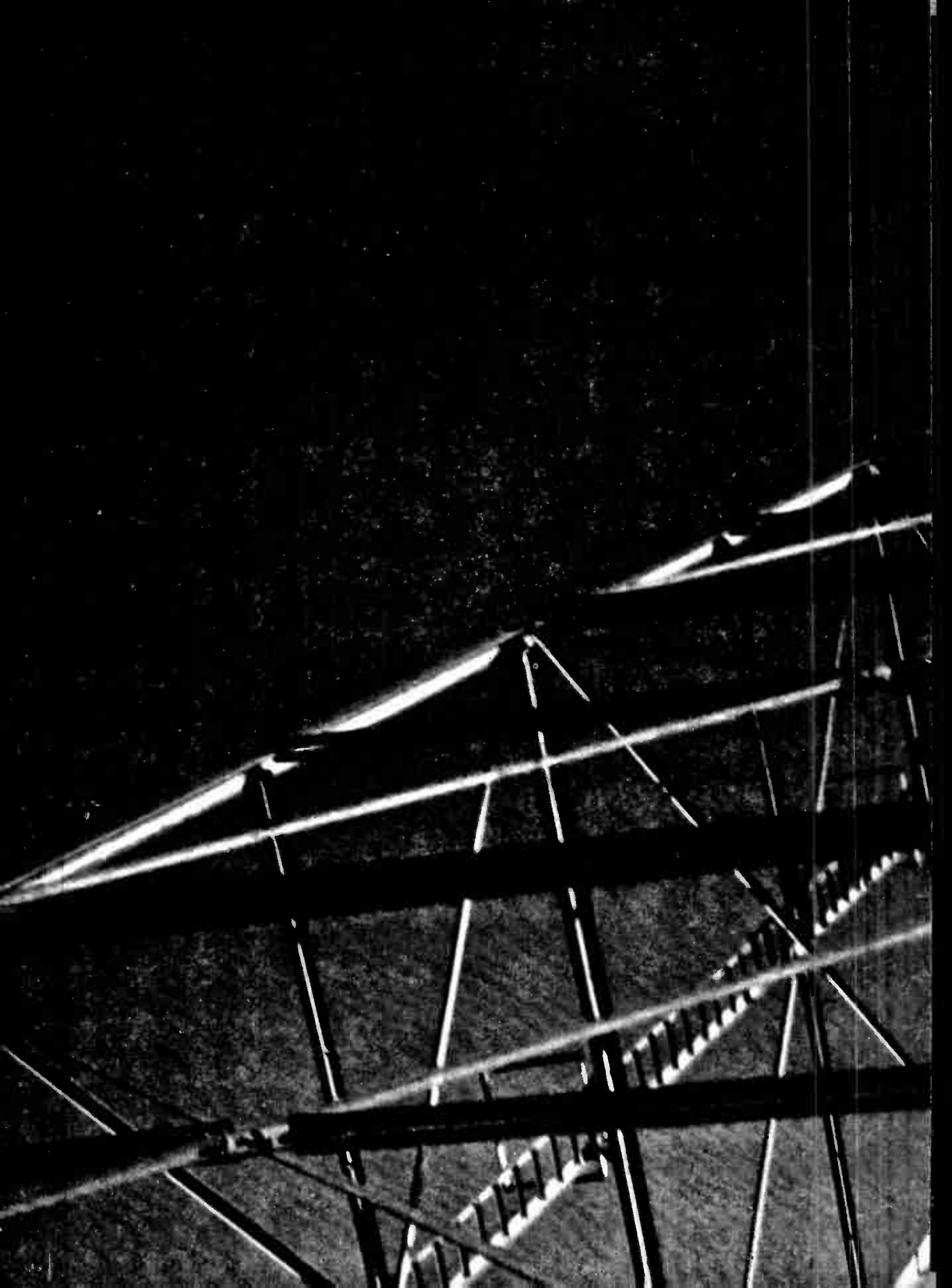


ON THE AIR

The Story of Radio

Books by
JOHN J. FLOHERTY

FIRE FIGHTERS!
BOARD THE AIRLINER
GUARDSMEN OF THE COAST
MOVIEMAKERS
POLICE!
ON THE AIR, *The Story of Radio*

PRINTED AT THE *Country Life Press*, GARDEN CITY, N. Y., U. S. A.

ACKNOWLEDGMENT

IN DOING this book I merely browsed through this wonderland of science, a veritable Aladdin's palace where at every step I saw marvels and miracles that bewildered me.

Scientists, engineers, and executives led me by the hand, as it were, from one astonishing department to another. Laboratories that the alchemists of old would have marveled at. Instruments, things of steel and wire and glass that performed miracles before my eyes. Organizations of men and women drawn from the worlds of art and science and business, each one of them as modern as this morning's sunrise. Terms that bewildered me, figures that confused me. Achievements that were unbelievable. All impressed upon me how little I knew.

This book therefore is no scientific treatise on the subject of Radio, but is rather a homely story of what I saw and heard and felt as I made my way through mazes of our most modern of industries.

I wish to express my appreciation and thanks to those who made my fascinating but bewildering journey possible, and for their patience and helpfulness.

I wish to extend my thanks particularly to Mr. David Sarnoff, Mr. Frank E. Mullen, Mr. Frank E. Mason, Mr. Wayne Randall, and to the Radio Corporation of America.

J. J. F.

FOREWORD

By David Sarnoff, President, *Radio Corporation of America*

WHEN I WAS A LAD radio was little more than an interesting experiment, an adventure into the unknown areas of the ether. That messages could be transmitted through space without wires was almost unbelievable. Wireless communication seemed as wonderful and exciting to me as the "horseless carriage" had seemed to our parents.

Science brings fresh surprises to every new generation. The time will come when you who read this book will be saying "When I was a lad there was no . . ." No what? Some amazing new discovery, or new application of principles that we are only now commencing to understand.

Radio itself has barely made a beginning. Now it brings us many services of sound—international and domestic message communication and broadcasting; soon it will bring us sight. And after that there still will be fascinating possibilities of new powers and services in the universe of radio. We are always pioneers. Human learning is never finished. The accomplishments of today are merely stepping stones to the richer life of tomorrow.

CONTENTS

CHAPTER I

RADIO

"Three minutes to go" before program ends

ONE BITTERLY COLD DAY not so very long ago, it was December 12, 1901, three men sat huddled in a building on Signal Hill overlooking the harbor of St. Johns, Newfoundland. They were surrounded by a weird-looking collection of cumbersome electric apparatus.

One of them, a vigorous young man still in his twenties, sat tense and motionless, his eyes closed in deep concentration, holding a telephone receiver to his ear. Every nerve in his sensitive body was aquiver with hope, fear, anxiety. In the poor light that streamed in through the window from the wintry sky, he looked as if he were deep in meditation. His fingers moved sensitively over the complex instruments, with a twist of a knob here, a turn there.

The silence was deep and tense except for an occasional blast of wind that roared down from the neighboring arctic, and the dreary ticking of a clock that told the waiting group the time was 11:30.

An hour passed. Not a word was spoken. The young man with the telephone receiver was pale and almost trembling. His dark Italian eyes glowed with a spiritual fire. At times he almost stopped breathing and, tilting his head, leaned forward, listening for the message for which he had waited and of which he had dreamed for years.

Noon passed. Minute followed minute as slowly as the years go by.

At 12:30 the young man surged forward as if a powerful electric current had shocked his trembling body. His eyes snapped shut. Life seemed to have left his body, so still was he.

"*Click, Click, Click!!!*"

Three short shrill signals were repeated ever so faintly but distinctly in his earphones.

A smile spread over his face. The triumphant light of victory was in his eye.

Lowering the telephone receiver Guglielmo Marconi turned to one of his assistants.

"Take this, Kemp."

Sure enough, the signals were real. Kemp heard them, too.

"*Click, Click, Click.*"

They were repeated again and again.

Those faint clicks were the now historic "S" in Morse code that came winging across nearly 2000 miles of wintry ocean and ushered in Radio over long distances.

Almost two thousand miles away, a group of Marconi's assistants were at work at Poldhu, a village on the coast of Cornwall, England. It was their task to hurl out across the Atlantic the invisible waves that would carry that brief signal to the 400-foot aerial hooked up with Mar-

Marconi inspecting early wireless equipment in 1897

coni's receiving set, and swaying from a large kite in the subarctic gales.

The sending of that tiny message, the single letter "S," was in those days a gigantic undertaking, peppered with excitement and danger.

Through induction coils, Marconi's assistants at Poldhu produced enough power to light 300 incandescent lamps. Instead of the conventional telegraph key, the operator used a wooden lever three feet in length because of the great danger from the high-voltage apparatus.

The place was a terrifying bedlam. Viperlike flashes of man-made lightning writhed from the knobs of great Leyden jars, filling the room with a snarling, hissing roar. Crash! Crash! Crash! It thundered as the operator nervously worked his sending key, almost blinded by the intermittent glare.

Each crash of the electric torrent, as it sped on its long journey across the ocean, diminished to a faint click in the headphones worn by Marconi as he sat listening 2000 miles away.

The next day the world gasped at the miracle of it. Science, the press, and even governments applauded and wondered to what it would lead.

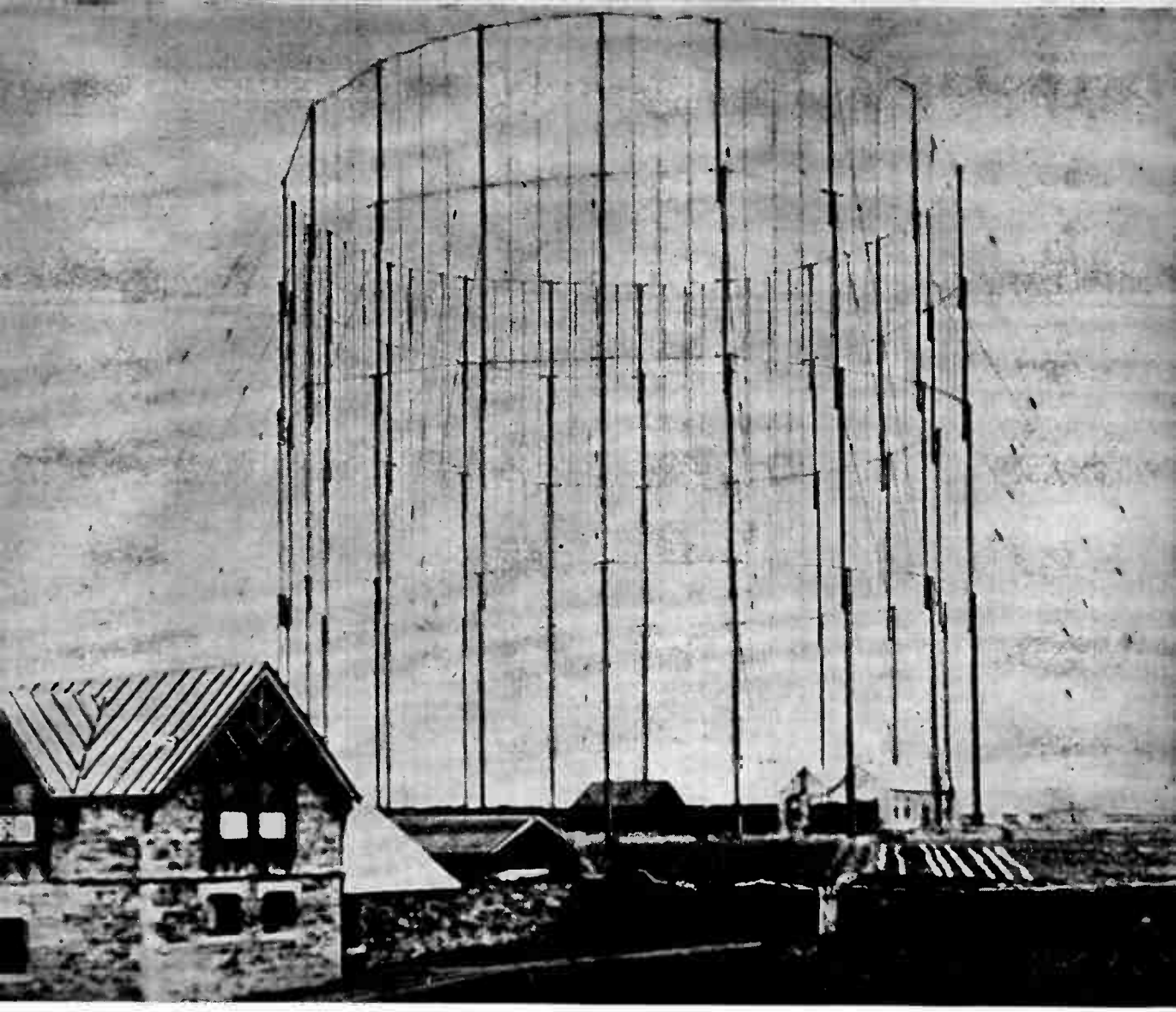
Now all of this happened just twenty-seven years after James Clark Maxwell, of the University of Edinburgh in 1867 outlined theoretically the existence of the ether wave.

In 1880 Edison discovered that under certain conditions an electronic current flowed between the filament of an electric bulb and a tinfoil coating on the outside. This was known as the "Edison Effect," and played an important part in future developments.

In 1886 Heinrich Hertz, a German physicist, stated that the ether would transmit electro-magnetic waves. To prove it he created an electric spark at one end of a room. At the other he set up a wire ring in which had been left a small opening or gap. Every time he made a spark with the aid of an induction coil, a tiny spark would jump the gap in the ring many feet away. The ether waves were the only conductor or connection between the two.

This Hertzian wave, as it has since been called, really gave future experimenters the first impetus toward sending signals between two points without any physical connection other than space.

Then came Branly Preece, Lodge, and Rhigi. Each endeavored to employ the ether as a medium through which to signal, but not one of them was successful.



First antenna structure used at Poldhu, Cornwall, England, for sending of signals across the Atlantic December 1901

It was during this period that Marconi, then a student scarcely out of his teens, was working as an assistant to Professor Rhigi who seemed to be making but slight progress in conquering the little-known ether.

Unknown to the professor, Marconi set up on his father's estate at Bologna sending and receiving instruments he had built in his spare time. To his astonishment he succeeded in sending dots and dashes through the

ether over a distance of several hundred feet. The signals were weak, but the ether was conquered. That was in 1894.

From that point the development sounds like a fairy tale. In 1896 in England Marconi sent signals over a distance of more than two miles.

The following year a radio message was sent to a ship ten miles out to sea. In the same year the distance was increased to twenty-four miles.

In April 1899 wireless, as it was then called, established itself in the consciousness of the world when it was used for the first time in calling aid to a vessel in distress at sea. The steamer *R. F. Matthews* collided with the Goodman Sands Lightship. A vessel twelve miles away heard the call and hurried to the assistance of the sinking lightship, taking off her crew before she went down. Few vessels had radio in those days since it was still in the experimental stage.

About this time two British naval vessels succeeded in communicating with each other while eighty-five miles apart.

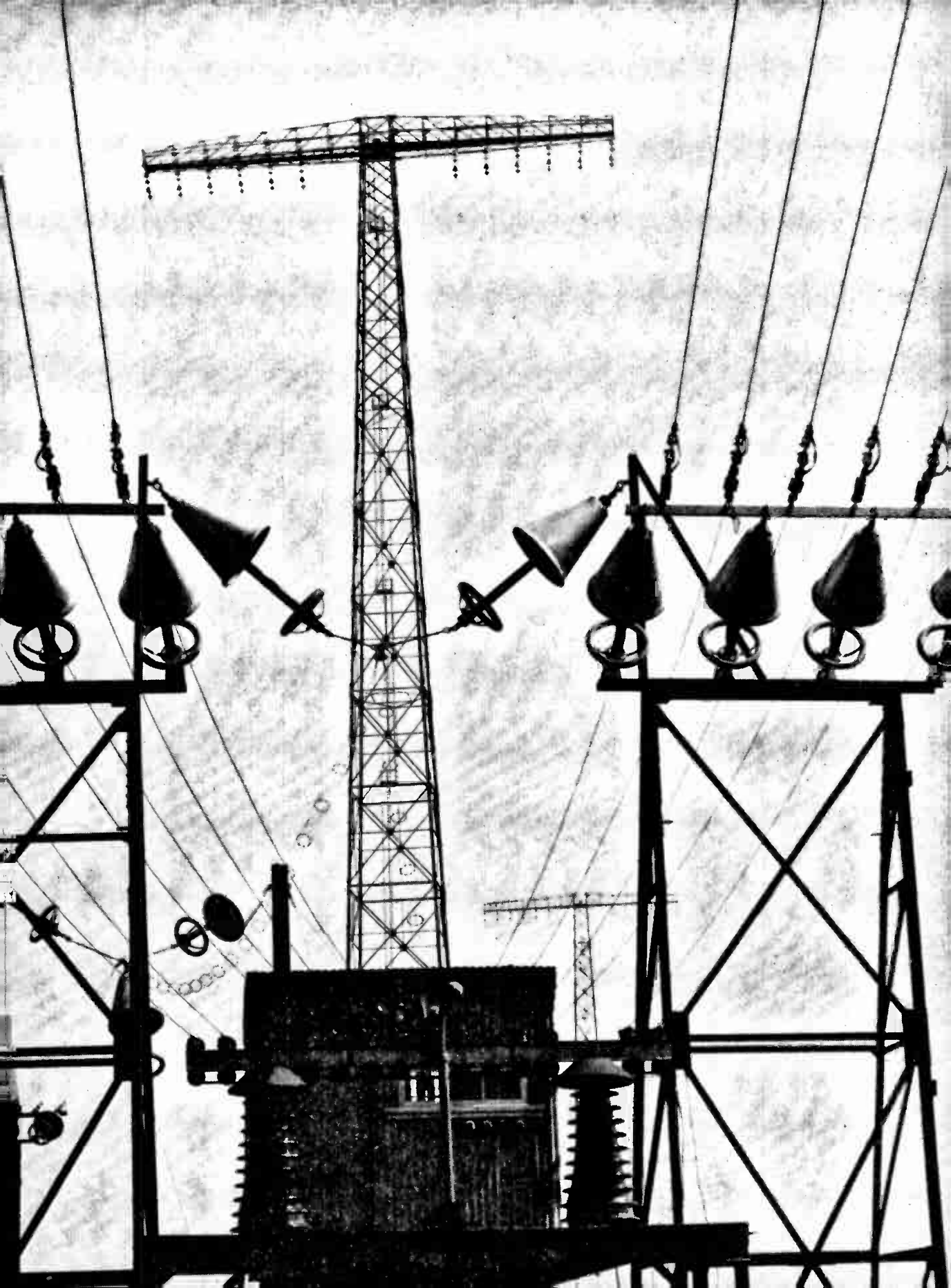
In 1898 the first news dispatches had been sent from the deck of the steamer *Flying Huntress* to the Dublin *Express*, describing the Kingstown regatta some twenty-five miles offshore. More than five hundred dispatches were sent in Morse code during the regatta.

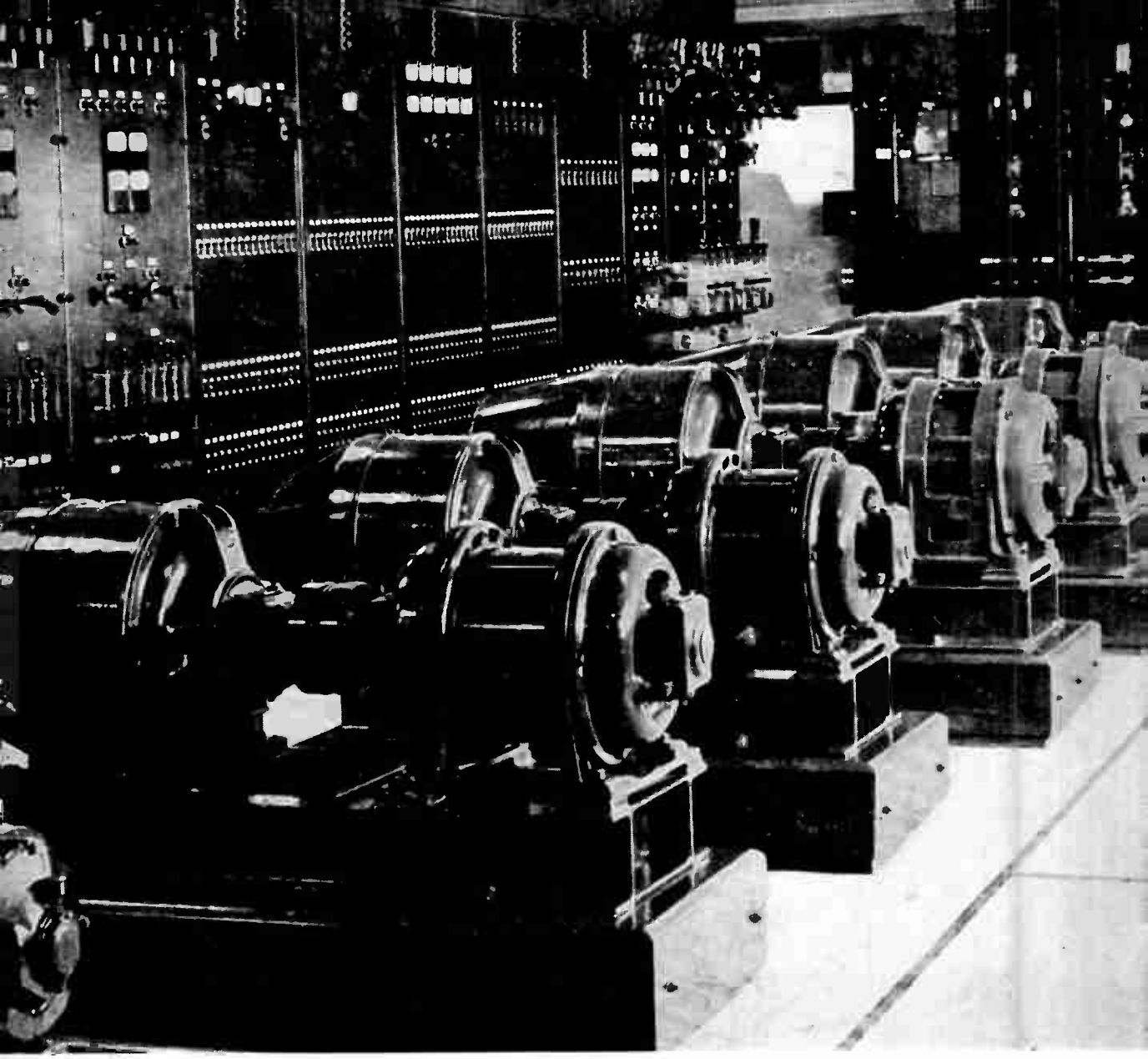
Between 1901 and until 1904 wireless developed rapidly, but this development was expressed only in distance and clarity. It was in that year that Dr. James Ambrose Fleming invented the "Fleming Valve" and applied it to the detection of radio waves. This valve was really the forerunner of the radio tube which was developed by Dr. Lee De Forest in 1904.

It was the development of the tube that gave radio its greatest impetus, for through it the staccato signal of the wireless was supplanted by sustained sound in all its tonal range as we know it today.

In 1908–9 music and voices were transmitted through the ether to a point more than three hundred miles away from the Eiffel Tower in Paris.

Long-wave antennae. Each of the huge towers is 410 feet high and 150 feet across at the top





The power generating room

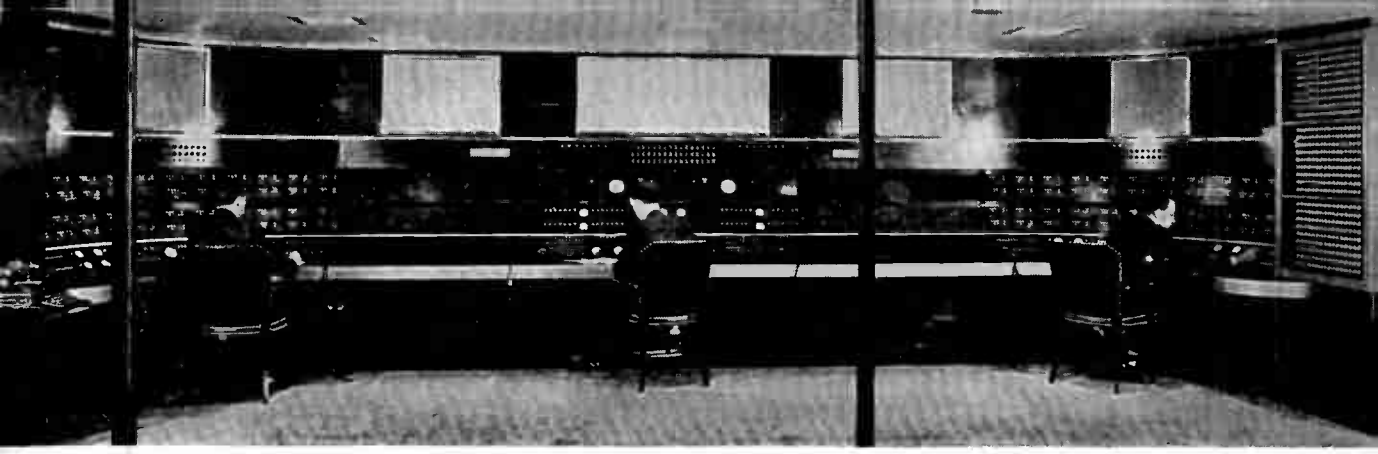
What is this ether that took over forty years of unending toil to conquer? Strictly speaking, no one knows exactly what it is. It is an invisible, odorless, tasteless body that occupies all space. It is present everywhere, even in a vacuum. Its waves pass through solids as though they did not exist. The highest mountain or the deepest ocean cannot

stop them. They travel, with the rapidity of light, seven and a half times around the earth between the ticks of a clock.

These waves have vagaries that puzzle the scientist on whom they often play strange pranks. They enjoy speeding over water and fight shy of steel buildings and heavily charged wires. Some of them love the night and fly through darkness as if the cool air refreshed them. They sulk in the sunlight and at noon will do but a third of their potential work. When they leap out from the aerials they spring off into space and, upon meeting several mysterious strata which hover a hundred miles above the earth, they seem to change their minds and bounce back again, only to continue on their way, no one knows where. The lowest and most extensive of these strata is called the Heaviside layer, named after the English scientist, Heaviside, who discovered it.

For all we know the first radio signal may still be traveling through space, and may continue to do so for millions of years, just as the light from a distant star travels millions of light-years before it becomes visible on the earth. Radio and light travel at the same speed, about 186,300 miles a second, and have many points in common.

This almost incomprehensible speed brings about some strange phenomena. Suppose you were in an auditorium in New York, listening to a musical program being broadcast on a nationwide hookup. If your seat were in the rear of the auditorium, a listener at his loud-speaker in San Francisco would actually hear the broadcast before you did, although he was more than three thousand miles away and you were about a hundred feet. The reason, of course, is that you were dependent on sound waves to carry the music to you, and sound waves travel less than a fifth of a mile a second while radio waves carried the program to the man on the Pacific Coast at the rate of one hundred and eighty-six thousand miles in the same period, or in 1/62 of the time it took the sound to come from the actual instruments to your ear.



The master control desk

All this becomes more baffling when we learn that sound, as such, does not travel through the ether at all. What really happens when a sound is transmitted from one point to another is this: Through electric impact or shock the ether is energized into waves which act somewhat like ripples that spread in concentric circles over a still pond after you drop a stone in the center of it. These waves are known in radio parlance as "carrier waves," and are the vehicles upon which sound energy, created at the transmitting end, is carried.

Let us consider for a moment what happens when the stone is dropped into the pond. There is a splash and a commotion in the water as expressed by spray and flying drops. These represent the energy transferred from the stone to the water. The waves start on their way. They run smoothly and silently and unbroken until they reach the shore where they break and reproduce in miniature the initial disturbance made by the stone-agitated water with spray and drops. The dropped stone represents the transmission of sound. The water waves represent the carrier-waves action of the ether, and the splash on the beach may be likened to the reception of the sound.

In the transmission of sound the use of heavy electrical energy is necessary. The power used on some broadcasts would be sufficient to light a fair-sized town; while at the receiving end there is such a reduction of power that some signals coming from long distances represent but

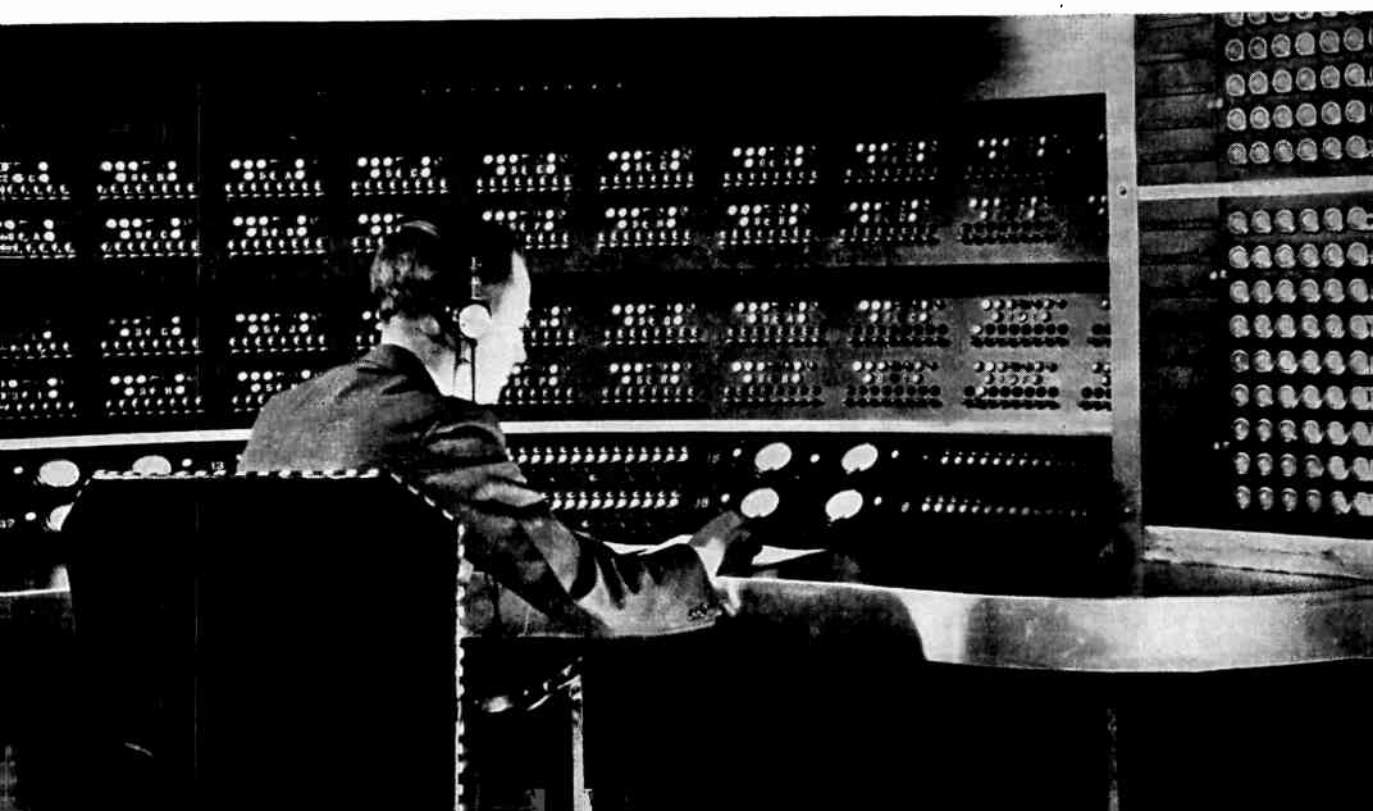
one-twenty-five millionth of a volt (a tiny flashlight battery represents about three volts). Of course such weak sound would not be audible to the human ear, so the radio engineer amplifies it. This amplification might be likened to the enlargement of a very small photograph, like a single picture in a motion-picture film to the dimensions of the huge pictures we see on the screen.

One of the marvels of modern radio is the ability of the receiving set to pick out or select a particular program from the hundreds that are continually flying through space.

This would not be possible were it not for the splendid work done by the government in regulating radio traffic. This work might in a degree be likened to traffic regulation on streets and highways where the traffic policeman keeps vehicles in certain lanes and diverts traffic away from, or around, highly congested areas.

In radio, the highway lanes are called wave bands. The radio traffic policeman is known as the Federal Communications Commission.

Close-up view of the master control desk



Before a broadcasting station can go on the air it is assigned to a highway or wave band outside of which it may not go, for to do so would mean a collision with another program, just as two automobiles would collide if they attempted to occupy the same spot on the same traffic lane. This collision is what is known in radio as interference.

These radio highways are numbered just as the highways across the country are numbered. The radio signposts, however, are on the dials of the receiving set, and thanks to the marvels of modern manufacture may be depended on to guide the listener through the infinite highways of space.

Of course these similes may not be exact parallels. The scientist-engineer could doubtless tell us in his language the story of what happens between reception and transmission in a way that would be scientifically accurate but so complex that we should understand but little of it. It may be well, therefore, to keep the pond and the photograph in mind as we proceed.

Modern radio can be divided into two major divisions—broadcasting and communications.

Traffic department of a large broadcasting studio

CHAPTER II

BROADCASTING

This signal means "Make a local" by announcing "This is station WJZ" or whatever the call letters happen to be

RADIO BROADCASTING confines itself almost entirely to the fields of entertainment, education, and information, while the communications division devotes itself to point-to-point radio telegraph, radio telephone, ship-to-shore, ship-to-ship, and shore-to-ship radio telegraphy, facsimile communication in several forms, one of which is sending weather maps to ships at sea, sending photographs, drawings, and documents to distant points, radio direction finders and medical service by radio, about each of which we shall have more to say later.

The word "broadcast" as applied to radio is one of the most beautifully chosen in our language. If you consult the dictionary you will see

that it is a word of agricultural origin and means: "a casting or throwing of seed in all directions, as from the hand in sowing."

The harvest that this sowing, or broadcasting, shall bring in the years to come must in its abundance be of great benefit to humanity. It is the most far-reaching medium yet devised by man for the dissemination of thought and ideas to the peoples of the earth.

Broadcasting as we know it today had its birth on November 2, 1920, when the returns of the presidential election of that year were broadcast from station KDKA in East Pittsburgh. So successful was this initial effort that other stations came on the air in rapid succession until 1922 when there were four hundred of them operating. By July 1, 1936 the number of broadcasting stations had grown to 656.

What a thrill it was in those early days to sit at the wireless set and, by the turn of a knob, fly as on a magic carpet from city to city or state to state. Quality of program did not matter so much then as did the number of cities tuned in.

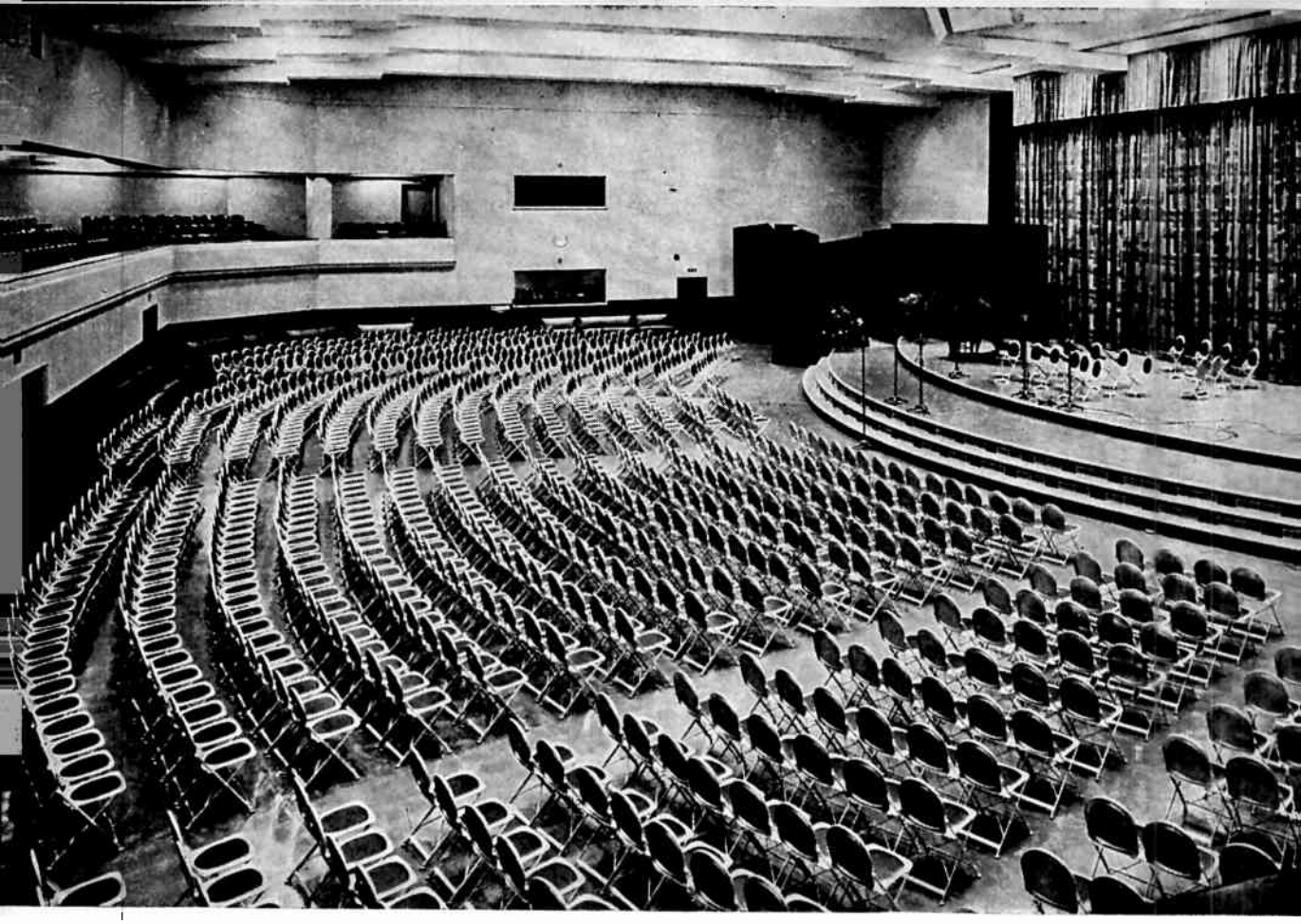
That was before the days of sponsors, when even the stations themselves were more concerned with the scientific success of radio than they were in its mounting costs.

As the novelty wore off the public began to demand better entertainment. This cost money. So taking their lead from the publishers of newspapers and periodicals the broadcasting companies sold advertising time on the air just as the publisher sells advertising space in his publications. Here was the revenue that enabled the broadcasters to employ the very best talent without cost to the listener. In England, where there is practically no advertising on the air, the owner of a radio set pays to the government a tax or license fee, part of which is turned over to the broadcasters to help defray their talent expense. The first sponsored program was broadcast over WEAF in New York in 1922.

The next great stride in radio was in the inauguration of the network

The announcer waits for his cue to start a program


N
B
B C



View of world's largest broadcasting studio

system. This was in 1926. This network system enabled the central broadcasting stations to send a program out over the existing telegraph and telephone wires to widely separated and distant cities. This, of course, increased the size of the audience enormously. There are at present in the United States more than 60,000 miles of aerial wires devoted to the carrying of these network broadcasts to an estimated maximum audience of about 90,000,000 persons, or about three quarters of our population.

Now let us see how one of the great broadcasting companies manages the task of pouring out into space the varied programs which are transmitted through most of the twenty-four hours.

The modern broadcasting studio is really a collection of studios, small and large, all of which are connected with a control monitor board, but each of which is serviced by its own transmitter and staff, just as if it were an independent broadcasting studio. These studios may be occupied by rehearsals or by actual broadcasts, for it must be remembered that in preparing an hour's program at least seven hours are devoted to rehearsal. Indeed companies have been known to spend forty hours in perfecting themselves in a difficult program.

Here, more than in any other industry, time is carefully measured, for in radio time is money. It is the commodity that the broadcasting company sells to the sponsor. In some of the more important broadcasts, where large groups of high-salaried musicians, directors, announcers, engineers, and others are engaged, seconds are counted like pearls. That is why you see clocks with simple but determined faces everywhere you turn in the broadcasting studio. On each of these clocks a red hand slices off the seconds with a definiteness that keeps all eyes on it when the moment of beginning or ending a program approaches. These clocks, more than a hundred in number in one station, are synchronized with a master clock that is kept where neither dust, nor moisture, nor temperature may affect it.

The microphone

Speaking of moisture and temperature, one of the marvels of the modern broadcasting studio is the amazing system of air conditioning. The air is washed, filtered, exposed to beneficent rays, heated or cooled so that temperature, humidity, and purity are constant.

In the construction of these studios great

sums are expended in the matter of sound insulation so that exterior noises may not be picked up by the microphone. They must also be echo proof and have other acoustical characteristics that will insure a faithful rendering of the sounds created within them. Where formerly heavy drapes were used for this purpose, today sliding panels around the studio are arranged so as to give the muffled sound that would occur within a closet, or the vibrant quality of music in a cathedral.

One of the most interesting things about a large broadcasting station is the variety of people, for here come flocking from the four corners of the earth types of every description. Celebrities, politicians, professors, preachers, pugilists, musicians from the piccolo player who carries his instrument in his inside pocket to the bass-horn player with his heavy load, singers of every variety, lecturers, men and women with messages, actors and actresses of stage and screen, and amateurs who hope for a chance to prove to the world that they have been overlooked. These and hundreds of others you meet from the moment you approach the broadcasting studio until you leave its vicinity. Musicians and entertainers who are employed are forever reporting for work or leaving, having finished it. Then there are radio engineers, electricians, announcers, property men, page boys, sponsors and their guests, script writers, script editors, composers, arrangers, and just plain curiosity seekers.

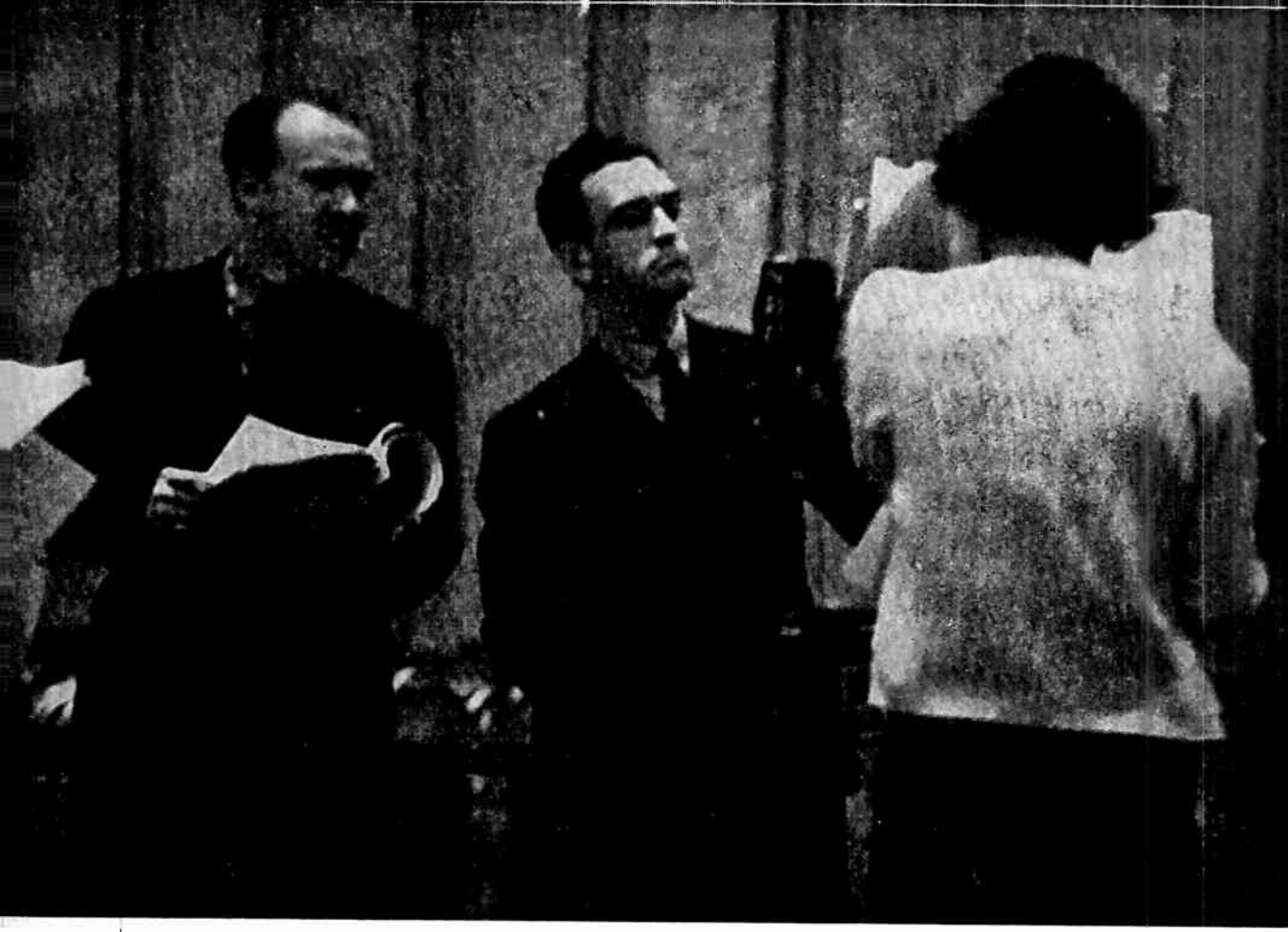
CHAPTER III

REHEARSAL

"Cut"—a signal given when the program exceeds the limit of time allotted

LET US DROP into a broadcasting studio for a rehearsal. Studios are numbered and are always designated by the number which they bear. The rehearsal which we are about to hear is taking place in studio 9. It is a room about fifty feet square. The walls are paneled in an absorbent material and all the lights are flush with the ceiling. At each end is a balcony separated from the studio by double glass panels. One of these balconies is for the use of the sponsor and his guests. The other is for visitors. Under one of the balconies is another glass panel behind which is the sound engineer and his highly complicated mixing board.

Immediately in front of the engineer's compartment stands a micro-



Actors reading "scripts" during a dramatic broadcast

phone of the "ribbon" type. Over to one side is the sound-effects man with his curious collection of sound-effects instruments.

The rehearsal is of a drama of the period of Louis XVI. At one side of the glass panel of the engineer's compartment a shelflike desk is attached to the wall. It is called the announcer's board. It has a microphone standing by for the announcer's use. Above it is the inevitable clock, the red second hand marking off the passing of time. Over at one side of the studio are the author, the director, and the announcer. They are trying to arrange the script so that the program will end exactly on the half-hour.

Six men and a woman are lounging around the studio. They are the

actors. Some of them are reading lines from their script, others are merely chatting. The announcer rehearses the reading of his announcement or "commercial," as it is called, glancing furtively at the clock as he does so.

The engineer sits at his mixing panel, casually adjusting knobs and dials, jacks and earphones.

The sound-effects man stands well away from the microphone, surrounded by his strange collection of sound-making apparatus. There is a gigantic phonograph, or turntable, as it is called. It accommodates three or more disc records. There is a door set in a frame under which castors are set so that it can be silently moved around. A heavy iron gate with bolts, latch, and lock is in an iron frame and is also on castors. It is the prison gate. A long strip of sheet iron is suspended on supports. It is the "crash" thunder. There is also a thunder drum—a huge frame over which a horsehide is stretched. On a table beside the sound man is a strangely assorted collection of sound bric-a-brac. He, too, has a script which he studies as carefully as the actors.

The director calls, "All right, all right!!"

The rehearsal is on.

The woman and two men stand before the microphone; the other members of the cast are some six or eight feet away from it.

The director, with script in hand, stands poised for the start. The red hand of the clock is at the half-hour. He waves.

The announcer stands at his board. He adjusts his microphone. He reads the "commercial"—that is, the advertising announcement that precedes the program.

The director waves to the sound-effects man who has his phonographic turntable already revolving, the record in place. He drops the needle into place on the right spot on the record—a few strains of orchestral music and the play is on.

As each character reads his lines he plays to the "mike" just as if

Sound-effects men at work

he were on a theater stage playing to a large audience. He throws himself into his part with gesture and facial expression, holding the script where he may read it most easily.

The director meanwhile "cues" or signals the "entrance" of each actor, and with hand and arm waving or swaying directs the tempo of the piece after the manner of the conductor of an orchestra.

The woman is at the mike. She is full of anguish and terror. She is being spirited away in a chaise drawn by a pair of hard-driven horses. It is night. A storm is raging. Rain, driven before a high wind, beats down on the carriage and the landscape outside. Thunder crashes and rumbles away into the distance.

"Hold it!"

The director steps forward, hand raised. He wants more fright, more tears in the woman's voice, while her captor must be more harsh and guttural.

"A little more hoofs. The horses aren't coming in strongly enough," he suggests to the sound-effects man. "Give the chaise a little more and cut down on the thunder a trifle. The wind is all right."

The sound-effects man makes notes of this on his script.

The sounds of horses' hoofs are rendered by rubber cups or half coconut shells rapped in galloping tempo on a sheet of marble or slate, or on the chest of the operator if the hoofbeats are in the distance. The

Hoofbeats are expressed in this way, the jingling keys suggest the harness

chaise is a box about a foot long and six inches square. It is mounted on chair castors and has a piece of chain attached which rattles like harness as the box is jiggled around on a table top. The realism, as the sounds from these homely objects come from the loud-speaker, is astonishing.

The rehearsal continues. As each actor reads his part he steps up to the mike. If he wants to give the effect of slight distance he moves to one side or he may read his lines as he steps away from the microphone to give the effect of leaving the scene of action. It is amazing what a large crowd a half-dozen people can simulate as they mumble incoherent nonsense around the mike and move about, varying their distance from it.

The red hand of the clock moves on. The eyes of director, announcer, production man, and actors follow it. The pace may be too fast. It is slowed down. Or it may seem to the director that it is impossible to finish within the minutes remaining. Then the script is cut, trimmed, and so shortened that the final word or beat of music falls on a particular second so that the announcer may have time to finish the program in the approved manner.

This goes on for hours while men and women toil to create from a few sheets of typewritten dialogue a picture vibrant with life and realism that the ear will telegraph to the brain of the listener without the aid of the eye.

In another studio a dramatic broadcast is about to begin. Let us look in on it.

As the red hand approaches the zero hour the doors are locked. No one may leave or enter the studio. There is a group of nervous men, some of them in their shirt sleeves, all of them intent on their parts which they hold ready for reading. The director is a tall, studious-looking person whose glasses have slid down on his nose. His hands, delicate and expressive, are nervously grasping the script which he is scanning. The sound-effects man coolly arranges his strange collection of sound-

producing equipment and places his script, which is profusely interlarded with notations, on a music stand before him. The announcer stands by his board and makes a slight adjustment in the microphone. He signals with strange gestures through the glass panel to the sound engineer in the control room. Everything is ready. The red hand has arrived at the half-hour. The broadcast is on.

The play is a battle episode during the Civil War. A short, stocky man, somewhat disheveled, grasps his script as he stands before a microphone slightly taller than he is. He is a Confederate officer—the hero. His voice is strong and resonant, and his manner of speaking is that of the soldier. As he reads his lines, he lives the part. His gestures, his tenseness, and his pallor are as of a man keeping cool under fire. Beside him is a tall, lanky individual intent on the lines of the script. He is the first sergeant.

"Bring the men up, Sergeant!"

Whereupon the sergeant, with hands slightly raised to shield his voice, thus giving the effect of distance, gives the command:

"Platoon, forward, march!"

Instantly the sound-effects man turns to one end of a frame, somewhat resembling an old-fashioned harrow, all the wooden teeth of which are loose, and raises

Marching feet

it from and lowers it to the table, with the cadence of marching feet. On the surface of the table, straw has been spread. The wooden teeth impacting on the straw give a perfect rendition of marching feet coming across a field. A signal from the director looses rifle fire. Hundreds of muskets belch forth volley after volley. They fire at will, a staccato rattle having a most terrifying effect. This is done by merely placing the needle of the phonograph on a record which has previously had actual rifle fire recorded on it. This is followed by the booming of artillery. Field piece after field piece lets go with reverberating crashes. This is picked up from another part of the same record. All of this amid the shouting, muttering, groaning, and an occasional cry of pain from the group of actors, who continually move about the stage, weaving in and out, sometimes nearer and sometimes farther away from the listening microphone. Now the artillery advances. Clank of chains, pounding hoofbeats, urgent cries of the drivers are reproduced with utmost faithfulness by the actors, while the sound-effects man, busy with his turntable, rattles a length of chain, suggesting the clanking harness of the artillery horses, the thundering of whose hoofs comes from a phonograph record.

Occasionally the announcer will make a strange grimace and place a finger on his nose. That is a signal to the director that the program is proceeding favorably. It means, in fact, that he has hit it "on the nose" both as to time and quality. Or he may hold his hands as if he were playing an accordion or pulling taffy, slowly drawing them away from each other again and again. This signals a request to "draw it out." The program is progressing too rapidly in spite of rehearsals.

When the studio is on the air no word may be spoken except by the actors or announcers because of the great sensitivity of the modern microphone which hears everything. This accounts for the silent signals of the announcer.

CHAPTER IV

SOUND EFFECTS

"Three minutes on the nose"—or three minutes to go, and the timing is just right

WHILE THE ENGINEER, the artist, and the industrialist have each contributed much to the advancement and development of radio broadcasting, it would lack much of its dramatic and entertainment value without the vital work of the sound-effects man.

He is the unsung hero of many programs. Without his weird and often crude devices, much of the thrill of radio would be lost.

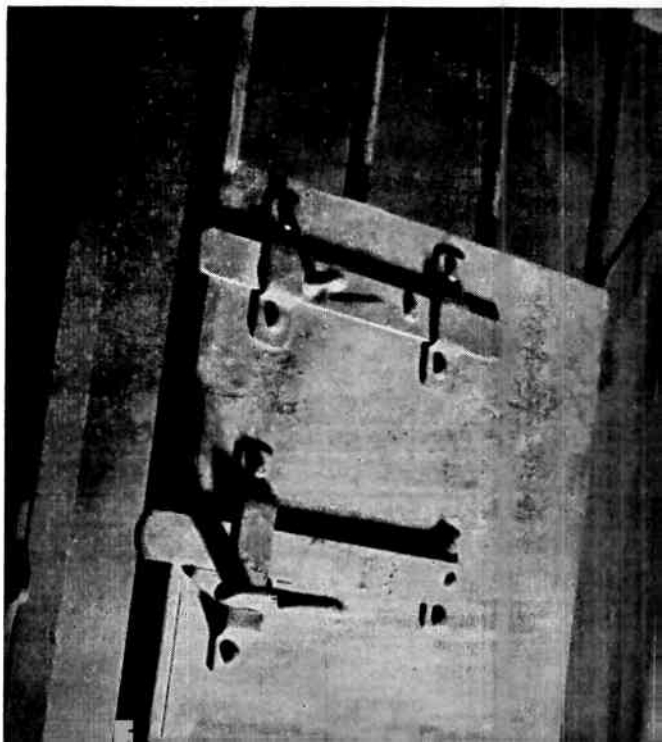
Describe over the air as graphically as you please a scene which is supposed to take place aboard a river steamboat. You may go into the details of size, appearance, color, and yet your verbal picture will be a long way from creating the throbbing, pulsing, bustling craft that the

The gravel-walk effect is secured by walking on real gravel

sound-effects man can paint in the receptive mind of the listener by a few flops of a small paddle wheel in a couple of quarts of water, a pull at a piece of chain, drawing a few feet of rope through a squeaking pulley, a subdued toot on a wooden whistle. Or, if the ship be moored, a bass-viol bow drawn in a certain way over the edges of a strawberry box will make her mooring lines squeak and strain as they hold her to the dock against the current.

The sound-effects man is a true artist. He paints his picture or creates his atmosphere with materials that are as far removed from the effects he produces as are the hog bristles of the painter's brush from the glories of the sunset he paints.

Could any combination of sound be more complex and baffling than the clatter of a rickety automobile called for



The door to a radio jail is a real one

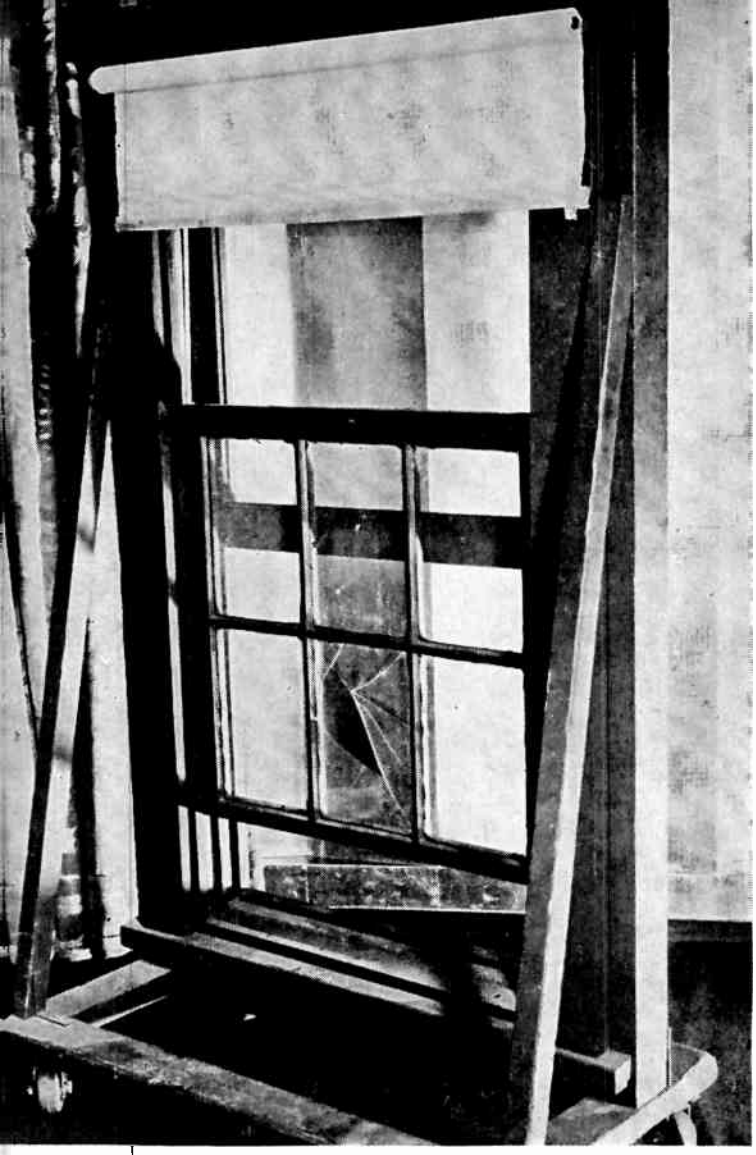
Whistles of varying pitch are used in the wind machine

How a heavy door is made to squeak on the radio

in so many radio scripts?

The sound-effects man has created an abstract that gives the essence and spirit of the "flivver" more accurately than the actual car would give.

In a heavy felt-lined box he has suspended a battered tin wash boiler on four spiral springs. Within the wash boiler he has mounted an electric motor that is thrown off balance by a counterweight on one end of the shaft. On the other end a piece of metal is loosely mounted in such a way that the irregular revolutions of the motor cause it to flop this way and that. At each flop it strikes against two pieces of metal placed for the purpose. On the bottom of the boiler loose scraps of tin and broken glass take up the clatter and add to the racket. When this strange contraption goes into action, the pounding and knocks and



Sounds of a window may be had from this practical window which may be raised or lowered

rattling that come from it are startlingly real.

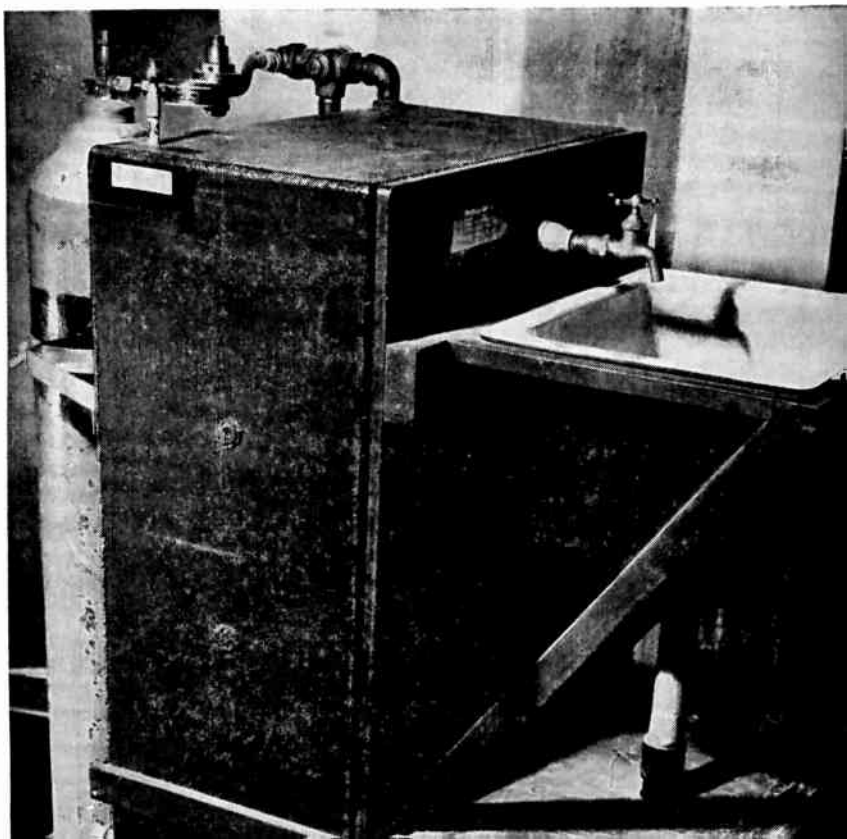
Then there is the rain machine that will give every effect, from the occasional drops at the beginning of a shower to a torrential downpour. It is convincing beyond words, and yet it consists of nothing but a box in which a framed sheet of parchment is set at the angle of a house roof. From a hopper above, ordinary birdseed is released which patters and pours down on the paper. There is a device, of course, which permits complete control of the "rainfall." When this device works in conjunction with a wind machine, the weather is indeed bad.

A hurricane is blowing. The wind machine used for this is a surprise. A crooked piece of wire about sixteen inches long is attached by one end to the shaft of a high-speed motor, the speed of which is controllable. When this wire is driven through the air at a velocity as high as 25,000 feet, or about four miles a minute, it screeches and howls, moans and wails in the most approved manner of the wind storm. It may also be tamed to a gentle zephyr by the slowing of the motor.

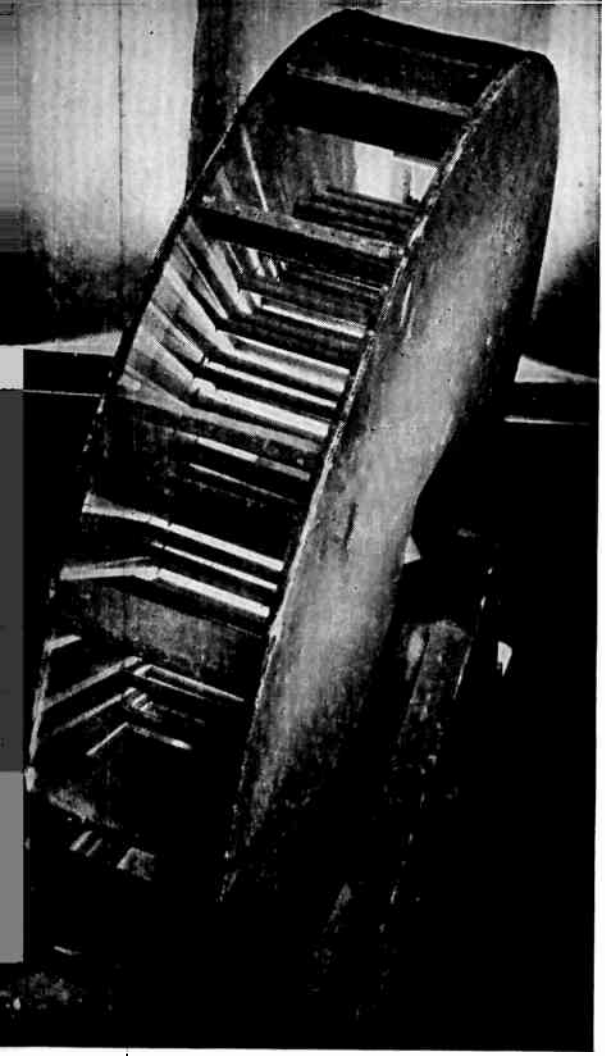
The rhythmic rolling of surf upon the beach, or the confused thunder

of a turbulent sea is reproduced on an instrument that is nothing more than a screen door pivoted on a stand in a variable horizontal position. A handful of tiny steel balls about the size of buckshot are rolled back and forth on the surface of the copper screen by a gentle and well-timed tilting. The rolling impact of the balls with the meshes sets up a hissing noise while the screen as a whole gives forth vibrant undertones. The metal of the screen is connected electrically to what is known as a "fader" or volume control like that on your radio set, so the sound man, tilting with one hand and controlling the fader with the other, can materialize a sound picture of moonlit waves rolling lazily in on a palm-bordered beach or he can, by a turn of the knob and with more violent tilting, whip the peaceful ocean into an infuriated turmoil of tumbling water in a mid-ocean gale.

Of course some sound effects are best produced by the thing or things that in life create the sound wanted. Walking on a gravel path, for instance. This much-used sound is obtained by what is known as the gravel box, a shallow box of some six feet in length containing actual



The running faucet is operated by compressed air which forces water out of the tank



The hail machine

gravel into which the sound-effects man steps, and by raising and lowering his feet gets the crunching sound desired.

Another effect in which the real thing does a better job than the synthetic is the jail gate. For this a practical iron-barred gate is used, the bolts, locks, hinges, and frame substantial enough to confine even a well-accomplished jail breaker. Each has sufficient weight and solidity to give the correct sound effects.

The house door which is opened and closed so frequently over the air is a practical door with practical hardware. The key may be turned, the doorknob operated, and the hinges made to squeak if necessary. There are many types of doors and many kinds of squeaks, from the light door of the boudoir to the heavy-timbered, iron-studded door to some vaulted medieval chamber, where its movement gives forth rasping squawks as it moves upon its rusty hinges.

For the characteristic squeak of the heavy wooden gate, the bow and strawberry box are again brought into use. This time, however, a different method of use will give the desired sound effect. The strawberry box is also used in reproducing rending crashes where splintering wood and destructive collapses and collisions are necessary.

One of the simplest and one of the most astounding effects is that of flames as expressed with a piece of cellophane six inches square that is

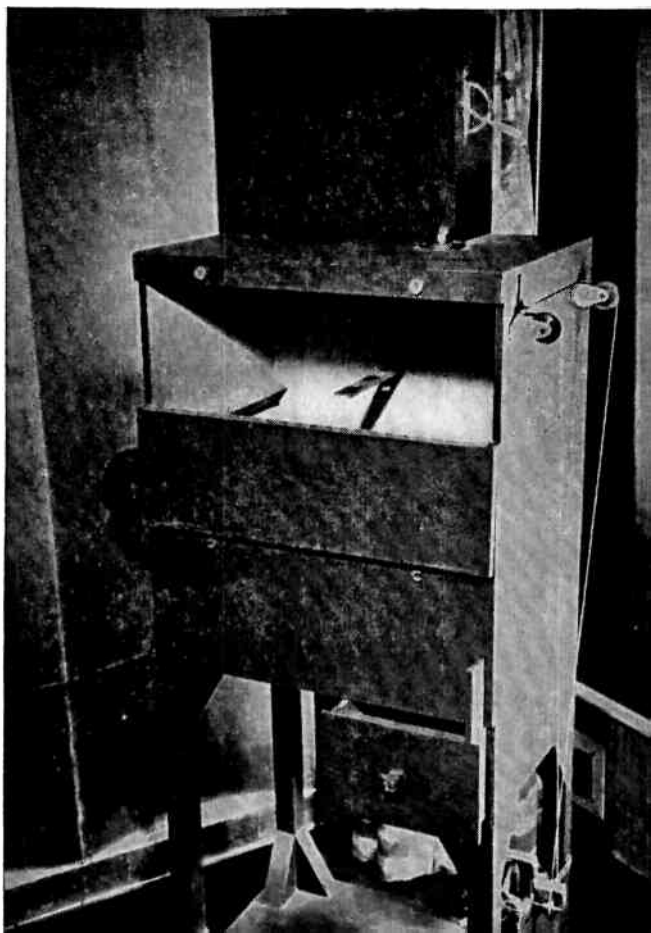
crinkled and crackled gently between the hands of the sound-effects man.

There are some effects, however, that no amount of ingenuity can produce so that they are entirely convincing. The roar of the crowd, the rumbling thunder of a train as it crashes over the switch and frog and speeds away into the distance, its wind-swept whistle blowing and changing volume and key; the tolling of a great bell like London's Big Ben, harbor noises, puffing tugs, screaming whistles, and the booming blast of the liner's siren all mingled with the rush of agitated water and the surge of large vessels moving on it—these and many other effects are picked up and recorded on phonograph discs, and are kept filed and indexed so that when the script calls for the roar of an avalanche or the droning motor whir of a diving plane, the sound man can, without a moment's delay, pick out the desired sound effect and, when ready, place the phonograph needle on the spot that has the called-for effect.

Many of these records have six or more sound effects recorded on them, each one of which is spotted so that the needle can be placed accurately upon it. These discs are operated on turntables which accommodate three or more discs which can be "played" simultaneously or singly.

Here is a partial list of effects that are usually taken from records, or recordings, as they are called in radio:

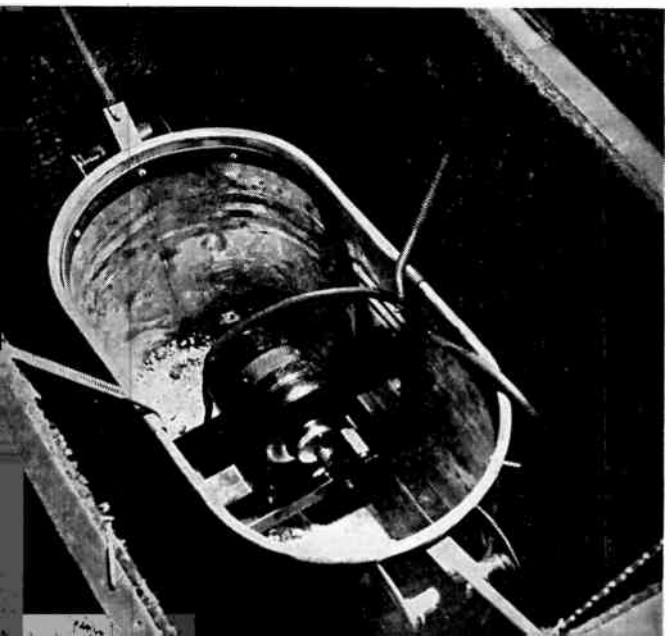
The rain machine



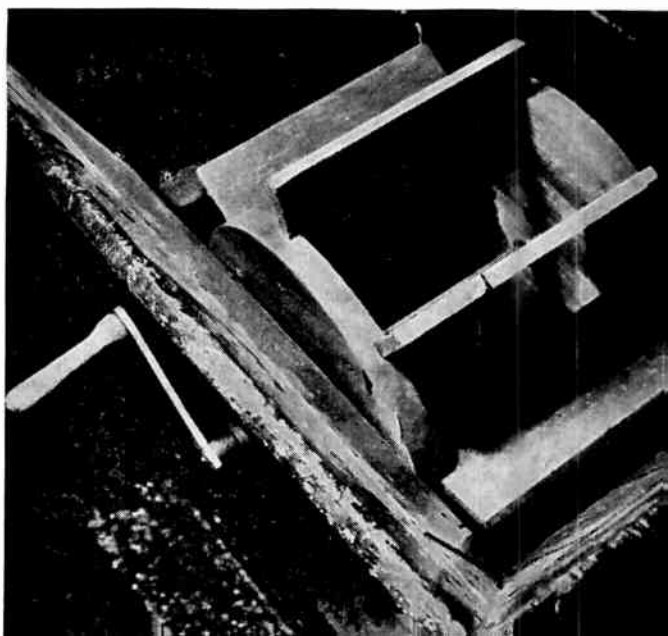
The Twentieth Century Limited with all of its characteristic locomotive sounds, entering and leaving stations, crossing bridges, going through tunnels. The sounds of ferryboat travel, including whistle, engine-room bells, clanking machinery, and ferry-slip sounds. Army airplanes and large transport planes. The roar of the crowd at baseball games, football games, and other large gatherings where there is much excitement. The cry of the sea gulls. The wailing of an infant. The nocturnal meowings of alley cats. The bark of dogs. The hoofbeats of the herd. The lowing of a single cow or of a herd of cows. The bleating of sheep. The grunting of hogs. Even the squeaking of rats has been recorded.

The sound-effects department in a large broadcasting station is reminiscent of the property department in a motion-picture studio. Shelves are lined with the most heterogeneous collection of strange odds and ends imaginable. Telephones of every type with suitable bells and buzzers. Bottles of many styles and types and sizes each partly filled with water. Liquid when poured from a milk bottle does not sound at all like liquid poured from, say, a ginger-ale bottle. Automobile horns and fire-

How the ancient automobile is expressed in radio



The paddle wheel of a river steamboat works in a gallon of water



engine sirens, every variety of bells from cow bells to ships' bells, hammers and saws and the necessary nails and wood ready to be nailed or sawed. Sewing machines, both foot and electric, row on row of china and glassware. Sheets of glass of varying sizes for breakage. Here are fog horns, tin horns, and a strange collection of whistles which imitate practically everything from a singing bird to a locomotive whistle—all ready for the sound man.

Where, one may ask, do these sound-effects men come from? What is their background? Or training? How do they get into such a curious profession, for it has really come to be a profession.

These are questions that cannot be answered in generalities. They come from all walks of life. Many of them were radio amateurs. Some of them were musicians, others were jacks of all trades, but all of them have the imitative instinct. There is nothing they can do to prepare themselves for their interesting work. The best sound-effects men, like many of our best artists, "just growed."

They have a gift of hearing things and remembering what they sound like. Merely beating a thunder drum will not produce even a fair

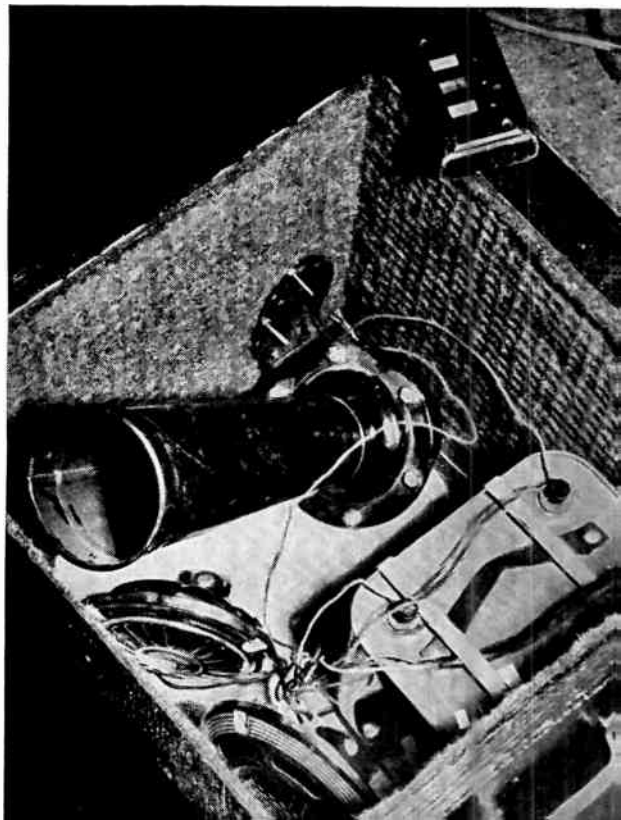
Crackling cellophane reproducing fire sounds

The thunder drum sometimes used for artillery sound

simulation of thunder any more than blowing into a trumpet will make music. There must be knowledge and fine perception back of the beating of the drum so that after the original crash it will reverberate and roll, and echo and re-echo, until by a delicate diminuendo it vanishes and is gone.

An "ear" is as necessary for sound-effects men as it is for the musician, perhaps more so, for the man on the sending side of the mike cannot hear what his audience hears thousands of miles away. He must *know*, beyond the shadow of a doubt, that the sounds he is creating, while they do not in themselves closely resemble the effects called for by the script, will, when transported by wire and air to unseen listeners, be true and in harmony with the subject being broadcast. A false note in sound effects is as discordant and disturbing as a false note on a trumpet or french horn in an orchestra.

Sound effect often heard on ships



Traffic jam is expressed by group of auto horns

CHAPTER V

MUSICAL REHEARSALS

"Half"—meaning half a minute to go

THE REHEARSALS of some of the major musical programs are, if anything, more interesting than the actual broadcast.

These rehearsals are held in the larger studios.

The whole atmosphere is one of work. There is none of the glamor of bright lights, formal dress, or enthusiastic audience.

There may be seventy-five to a hundred instrumentalists and half that many vocalists, while production men, announcers, composers, arrangers, sponsors' representatives, directors, and conductors form an assemblage that is unique in the diversity of its accomplishments.

The orchestra is divided into groups: wood winds, brasses, strings, timpani. Each group is so placed that the effect of its combined instru-

Musicians at rehearsal

ments is blended with the whole as a result of its distance from the microphone. Some instruments register more loudly and harshly than others. These are placed furthest from the microphone while other instruments of softer quality are placed closer to it.

Several microphones are used in these major broadcasts, one of which is devoted to dialogue and solos. The vocal ensemble has another. The orchestra may have two of its own, while the announcer's microphone is always close to his "board."

In broadcasts of this type, it is customary for each group—instrumental, vocal, and dramatic—to rehearse separately until each has attained the desired proficiency, then they all assemble in one large or "dress" rehearsal such as we are describing.

All the microphones are connected with the engineer's mixing board where he blends or softens or emphasizes the output of any one micro-

phone. He can, for instance, bring out the soloist's voice loud and clear while he softens the great power of the instruments to a mere whisper. He can make a small voice big or a big voice small. He can add clarity and purity to a tone. Were it not for the engineer and his mixing panel the result over the air might be disastrously disappointing.

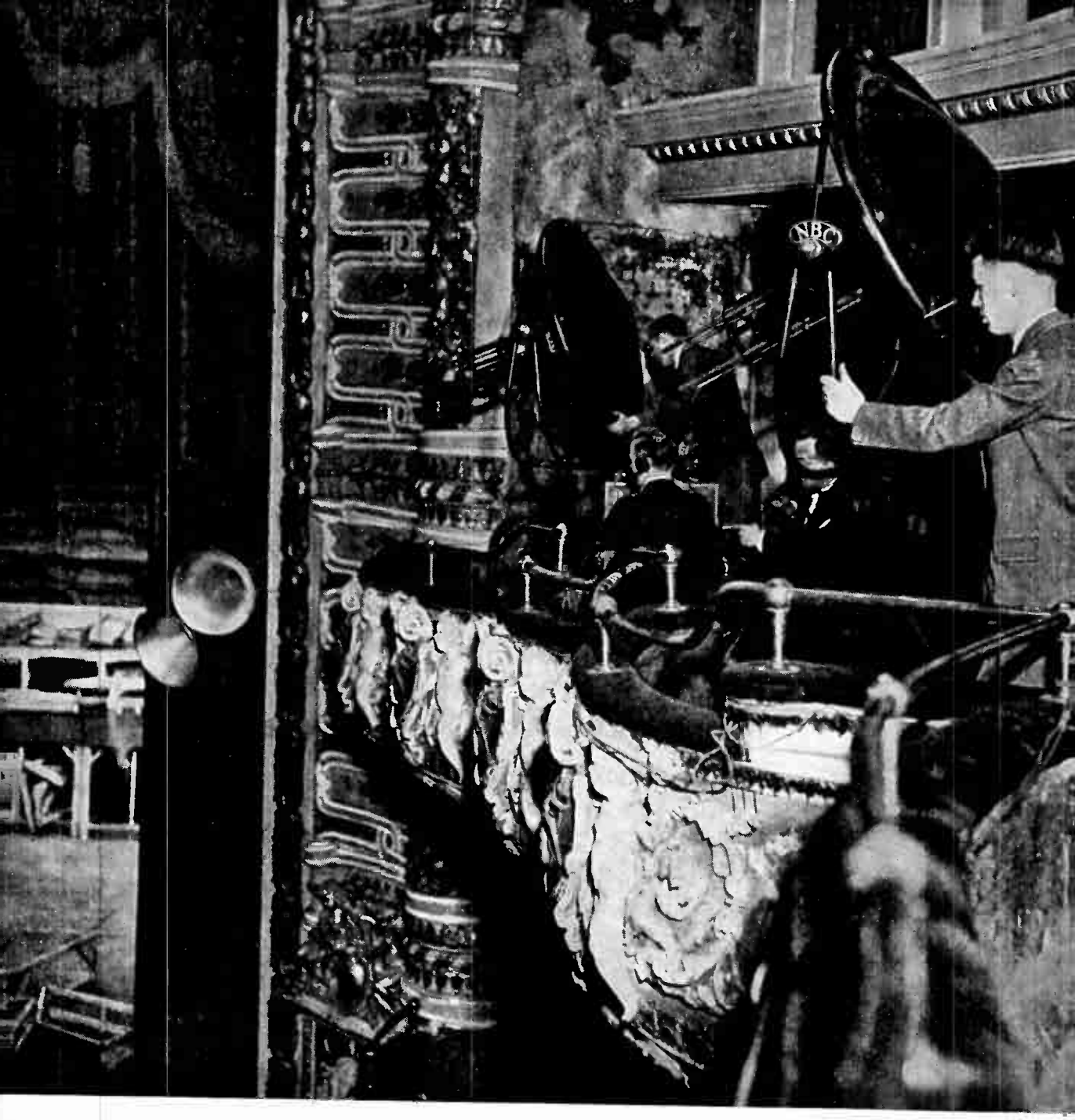
"Quiet, please!!"

The production director is calling the rehearsal. Conversation stops. The tuning of instruments ceases. The members of the orchestra adjust their music on the stands. There is a pause, the red hand is approaching the starting time.

The announcer is standing by his board, the script of his commercial in his hand. It is the final rehearsal. Everything must go on time. There must be no slips now, for the red hand moves on. It is just as if they were on the air.

The orchestra conductor stands with baton poised, waiting like a sprinter on his mark. The musicians, each with his instrument in readi-

One of the well-known orchestras rehearses ten hours for a thirty minute program



In broadcasting the opera these reflector microphones are used

ness, watch for the beat. The red hand approaches the fifteenth second upon which the announcer finishes. Director and conductor go into action on the same instant.

The actual broadcast differs but little from the final rehearsal. There is, of course, more tenseness and a certain element of showmanship, for then an audience is present. Instead of the free-and-easy air of the rehearsal there is a formality which extends even to the attendants. There is also a decided nervousness at the approach of the zero moment, when each man and woman senses the vast audience of millions all over the country waiting for the broadcast.

The most ambitious, and perhaps the most difficult, feat of the broadcasters is the broadcasting of opera from the stage of the Metropolitan Opera House in New York City. Some idea of the magnitude of this task can be had from the fact that twelve microphones are in operation, each of which must be placed with the utmost precision.

There are mikes suspended over the pit, about thirty-five feet above the heads of the players, to pick up the orchestra; others are cradled in the footlights to pick up the soloists; still others are suspended in the flies to pick up the ensembles; while in the upper stage boxes microphones placed in huge parabolic reflectors are installed to get the general effect of the opera. All of these are connected with the now famous box in the Golden Horseshoe. This box has been converted into a miniature sound studio and is known as the control booth. It is divided into two parts which are partitioned off from each other and from the auditorium by double plate-glass panels. They are as nearly soundproof as science can make them. In one compartment, the announcer and commentator sits at his announcer's board, while in the other compartment are the sound engineer and the production engineer. The microphones used are the ordinary or ribbon type of studio microphone. Not all of the twelve are in operation at the same time, except on rare occasions.

The sound engineer and the production man study the score of the opera in advance. Then they attend rehearsals, making many notations of technical details. This is followed by a "dress rehearsal" during which they get the routine accurately set.

During the performance the production man, who is watching the score as carefully as the musical conductor, prompts the engineer who is at his mixing panel. He warns him of the entrances and tells him which orchestra sections—wood winds, brasses, or strings—will be prominent in the approaching passages and reminds him of stage "business" which is about to occur.

The engineer, meanwhile, is watching the stage through the glass panel and listening to the broadcast through his earphones. His hands are constantly manipulating the "gain" controls or knobs that control the volume of sound that he is allowing to pour into the various microphones. This co-ordination of hand and ear and sound enables him to blend the component parts of the opera into the illusion of a performance. By fading certain microphones, increasing the volume of others, by turning them on and off, the engineer can play on the material of the opera, the sound of voice and orchestra, as if it were itself an instrument. He can alter at will the apparent distance of a singer from the audience; he can smother the voice with music or make it stand out as vibrant and stirring, and bring singer and orchestra into our living room true to life.

From this mixing board the opera travels over specially engineered wire circuits to the main control room of the broadcasting station. Here it is coddled and groomed and nourished, and is sent on its way to the transmitting station, where it is prepared for transmission over thousands of miles of wires to the local broadcasting stations where it goes on the air for the final time. It still has a strange journey ahead of it; however, before it reaches the loud-speakers. It goes bounding away in the form of radio waves a hundred and twenty miles or more up into the sky

Announcer and engineer at work during Metropolitan opera broadcast

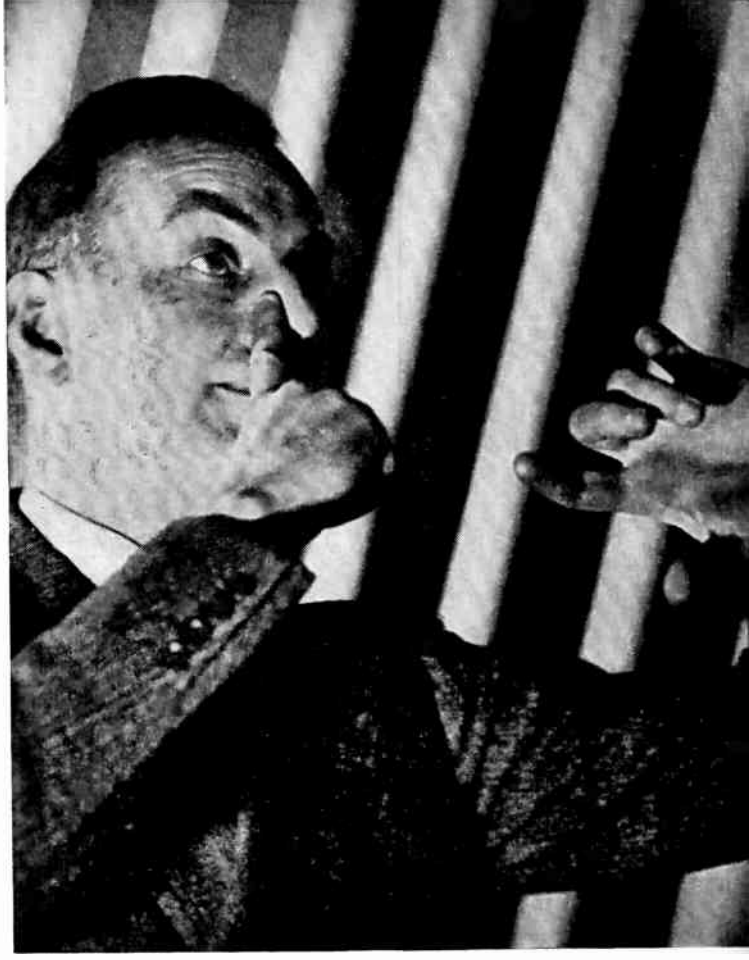
where it strikes a rippling, fluctuating stratum of ionized atoms which is the Heaviside layer of which we spoke previously. Part of it bounces off this layer back to the earth, as light does from a mirror, and, thus entering the loud-speaker, ends its long journey to the listening audience.

Although the journey is a long one it takes but a fraction of the twinkling of an eye.

Sound engineer at his control desk

CHAPTER VI

TYPES OF BROADCASTS



"Fade on the nose"—a signal to engineer that the program must be faded on time

THE AMATEUR HOUR is another type of broadcast which seems to have met with popular favor.

As its name implies, the talent used before the microphones, with the exception of the accompanist, is strictly amateur and entirely unversed in the art of broadcasting. The applicants come from all walks of life and from all parts of the country. Each one seems to be buoyed with a hope that the country will take him or her to its bosom as the Great American Radio Star. This is most apparent when they assemble to undergo a test before the microphone so that the best may be picked for the broadcast.

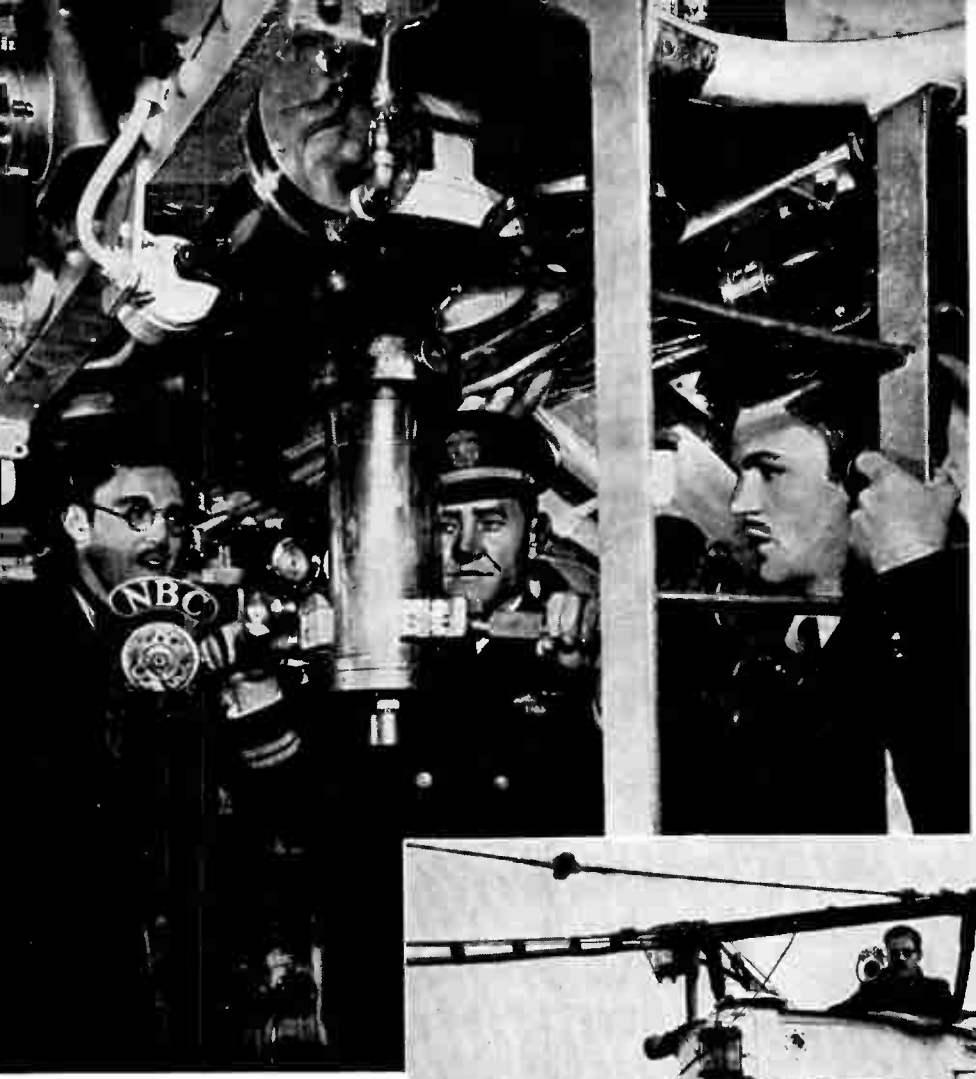
As the name of each applicant is called, a trembling and thoroughly

frightened individual steps to the microphone while the others look on in open disapproval. After giving name and address, and name or character of his selection, he is led to the mike, looking for all the world as if it were the electric chair and his time had come. The introduction on the piano often goes unheeded. The victim stares tongue-tied at the terrible instrument in front. The piano tries again while the director offers an encouraging word. A cough, a gasping start, frequently off key, breaks the silence. That at least is something. Another try, and with luck he gets through his turn. Many of them are glad when it is over.

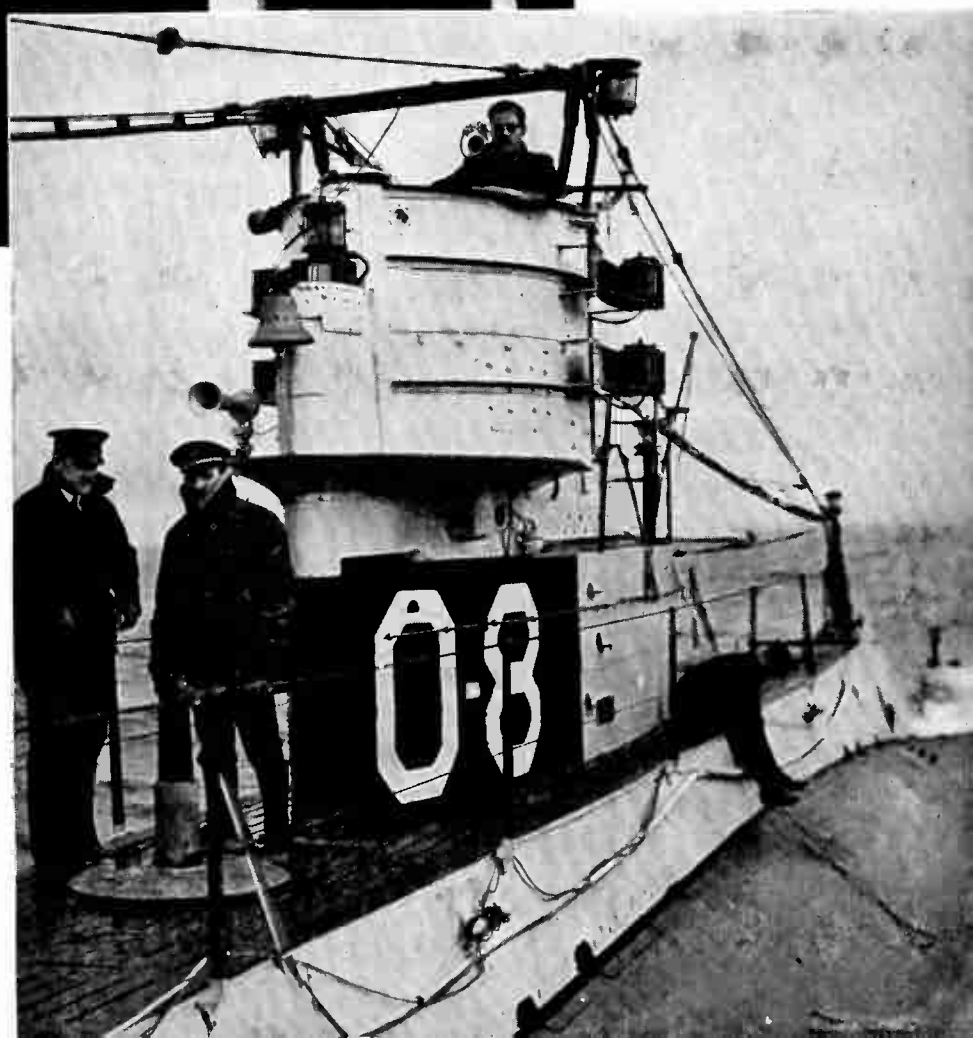
Those who are selected are called for rehearsal later, and are polished up in their act so that they are reasonably safe to put on the air. Much of the dialogue is prepared in advance, as it takes a seasoned radio artist to "ad lib" on the type of comedy dialogue these amateurs broadcast.

The extent to which this amateur broadcasting has grown is amazing. One amateur hour receives as many as 10,000 applicants a week. Several hundred are selected from these, each one of whom gets an audition or tryout. Should their act prove acceptable they are made one of a group of twenty, fifteen of whom are used. The other five are held in reserve and may get a chance the following week. The response may be gathered from the fact that as many as 30,000 votes have come by phone, telegraph, or mail for one contestant. It takes from fifty to one hundred telephone operators to handle the traffic incident to one of these broadcasts. There are about two hundred of these amateurs who are professionally engaged to go on vaudeville tours as a result of their trial on the air.

All in all the amateur hour has proven a splendid undertaking, as many young people of unusual talent have been discovered who otherwise might never have had a chance to bring before the great radio audience the gifts nature has bestowed on them.



Broadcasting from submerged submarine



Broadcasting from a submarine

Broadcasting from crater of a volcano

The broadcasting of events is a phase of this miraculous industry of which the public has but little knowledge. Let us consider the broadcasting of the annual football game at the Rose Bowl in California each year.

Events of this type, which have major news value, require much preparation in the way of establishing wire circuits from the scene of the event to the main control room of the broadcasting station more than 3000 miles away, and from there to the stations from which the stimulating story is hurled into the air.

As the observer for, let us say, WEAF reports each play, his voice is telephoned to the National Broadcasting Company's control room in New York City, which it reaches in a weakened condition. Here it is revived, enlarged, and smoothed out into a pleasant and resonant tone. It is then "piped" out through the nerves of the network to the associated broadcasting stations where it is again refreshed and rejuvenated before it is transmitted through the air, so that it reaches the listener with the proper strength and clarity. Now let us assume there is a listener at a loud-speaker a mile from the bowl and he is tuned in on the nearest network station. The sports announcer's voice that he hears traveled by telephone wire to New York, was processed, traveled all the way back to the coast, was again put through a clarifying process and then put on the air, all in less than a twenty-fifth of a second.

This event broadcasting comes to our loud-speakers from all kinds of sources. The arrival of a foreign dirigible is described by verbal reporters from many angles and viewpoints. The crowds, the waiting ground crews, the great mooring mast, are described from the ground, from the air, or from the roof of the giant dock, or hangar as it is sometimes incorrectly called.

Through the marvels of special microphones we can hear the drone of the monster's motors, the sharp commands of her officer against that most stimulating background, the roar of the crowd.

A great convention, the after-dinner speeches of a banquet. The funeral services attending the burial of a king beyond the seas. The words of a monarch as he addresses his subjects, or the blow-by-blow report of a prize fight come to us as we sit in our homes oblivious of the great effort, great expense, and great achievements of science necessary to the accomplishment of some of these remarkable broadcasts.

There seems to be no limit to the broadcaster's field of action. The winged words may come flying to us from the steely blue cold of the stratosphere, or from a submarine deep down under the surface of the sea. Up from the dark, damp passages of a coal mine, or down from the sulphurous lip of a volcano the story of the man with the mike comes to us bringing the four corners of the earth, even the frozen wastes of the antarctic, into our living room.

Broadcasting army air maneuvers

CHAPTER VII

BEHIND THE MICROPHONE

"Enforced appreciation"—signal for applause from the audience in the radio studio

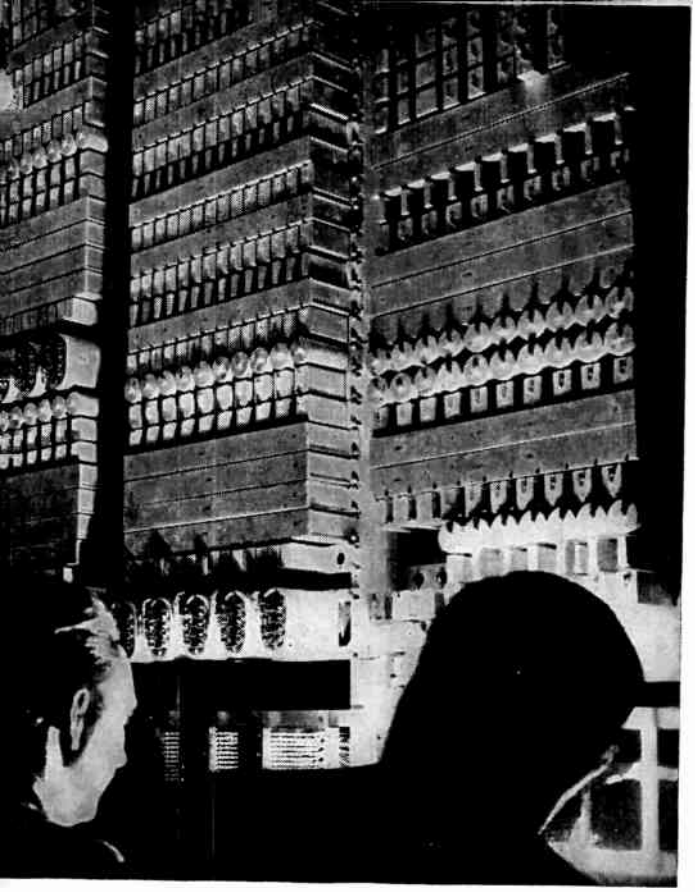
AS RADIO broadcasting developed from its fledgling state, the great electrical laboratories, seeing the possibilities of its future, began to turn their attention to the development and improvement of broadcasting equipment. Microphones that were marvels in reproducing fidelity of tone were soon obtainable. Giant vacuum tubes in which the high temperature was lowered by water cooling were developed. Transmitting stations were equipped with apparatus that, in control and power, exceeded the fondest dreams of the engineers of a few years earlier. Great networks of interconnecting telephone lines, blanketing the country like a huge spider web, were engineered. Receiving equipment kept pace with the transmitters, and the radio audience grew by millions. Broad-

The announcer signals for the orchestra to play softly while he makes his credit announcement

casting became an industry with an income that was in the hundreds of millions.

After its initial rapid growth, but while still in its adolescence, our government took it under its wing. Congress passed the Radio Act in 1927 through which the Federal Radio Commission began to clear up the great confusion that existed by allocating wave lengths, regulating power transmitters, and establishing zones and classes.

In the field of broadcasting the one individual of whom we are most conscious is the announcer. He is as much a part of the program as is the artist or the speaker. He opens the program, closes it, and sometimes comments on it in a manner that is both professional and pleasant to hear.



Backstage in the studio. Relays which operate broadcast apparatus

Thousands of young men apply every year to the broadcasting companies for the position of announcer. There is a rigid inquiry into the applicant's qualifications.

A college education or its equivalent is essential, as is a reasonable knowledge of two languages. Voice and diction are most important, of course, but that vague something which for want of a better name is called radio personality is beyond doubt the most valuable of all the assets.

The announcer must be at all times complete master of the situation during a broadcast. Should confusion arise in the studio he must keep the program going without a break, he must hold the audience. He must be on the alert to see that no forbidden material goes out. He is responsible for starting the program on the dot and finishing it on the split second. There must be no waiting on the air. The great audience will not sit and stare at a mute receiver no matter how good the program promises to be. If, therefore, the unforeseen happens and the program is interrupted or delayed, the announcer switches over to a "stand-by" orchestra or pianist to hold the audience.

These "stand bys" are always on duty during broadcasting hours.

Some announcers are endowed with fine reportorial ability. These are the men we hear describing thrilling or important events. They have

the faculty of co-ordinating sight and speech so that they can send to listening millions a well-drawn word picture of the event they are witnessing.

Announcers are as a rule paid for their services exclusively by the broadcasting companies. There are a few companies who permit their announcers to accept fees from sponsors, the size of the fee being dependent on the importance of the program.

Then there are announcers who work directly for sponsors. These are the princelings of the profession, as they have been known to receive as high as $1000 for a broadcast.

Before the announcer proceeds to the studio for a broadcast, he reports at the announcer's department a reasonable time before the appointed broadcasting hour. There he consults the "log book" from which he gathers all essential particulars of the broadcast. He then reports to the studio and stands ready at his announcer's control panel. He adjusts his earphones and listens for the end of the preceding program which is broadcast elsewhere and which is announced by the ringing of the chimes.

Then there is a lapse of twenty seconds between the first note of the chime and the beginning of his program, during which he plugs in his channel which connects the studio with the network or other stations from which the program is to be broadcast.

It is not generally known that much of the material that goes on the air is recorded on discs similar to those used on a phonograph. This is done for many reasons.

A speaker may wish to have an accurate record of his talk before the microphone; or a singer may, for comparative or critical reasons, wish to hear his or her voice as the radio audience hears it. Then it is sometimes found expedient to record, or make an electrical transcription of a program, after which the record is mailed to several broadcasting centers to

be put on the air at varying hours of the day or days of the week. Commentators, too, frequently have their programs recorded as a precaution against misquotations and consequent libel suits. Many of the leading comedians have their programs recorded ahead of their performance before the mike so that they can polish and improve their lines and observe the tempo which is so important to the success of such programs.

Testing in repair department

When a recording is made, the person or group that is being recorded work in one of the regular studios and before the standard microphone. The sound engineer whom we mention elsewhere "pipes" or connects the microphone into which the program is delivered with the recording department. Here along the walls are what are known as recording tables. Discs are whirling away at a rapid rate as they absorb on their sensitive surfaces a true reproduction of the programs that are being put on elsewhere in the building or in another part of the country or of the world.

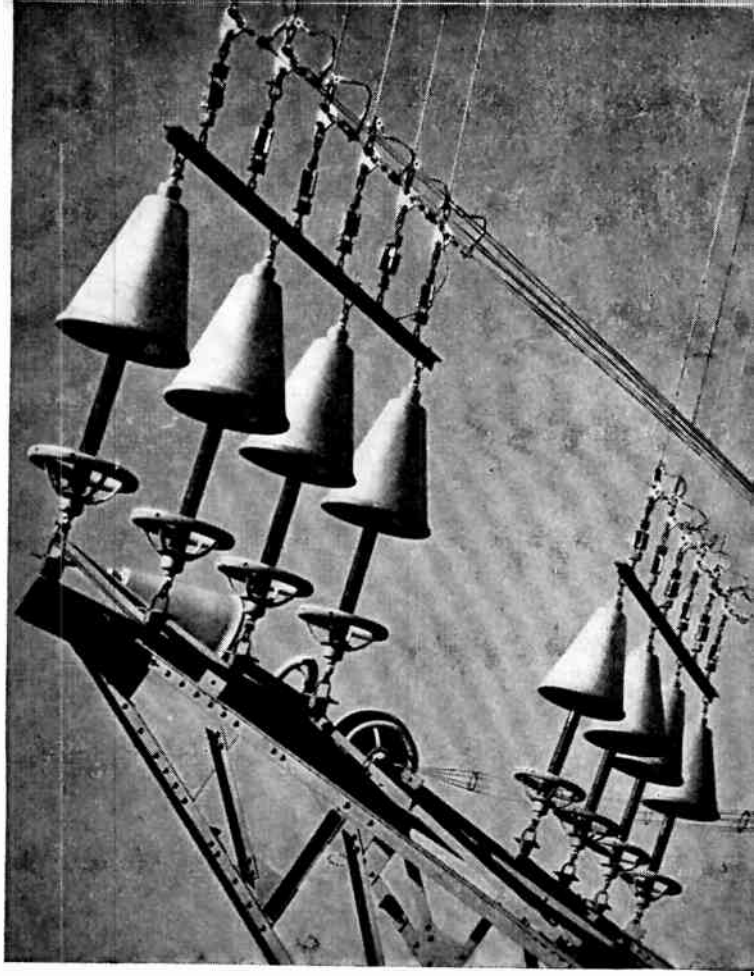
In another place in this department are the reproducing machines which "play back" the records and send the contents with the speed of light wherever they are to be heard.

Notwithstanding all of the incoming and outgoing sound, the recording room is a place of silence. Panel boards, recording and reproducing machines, and apparatus of formidable appearance are everywhere all in full action, yet never a sound comes from one of them.

"Stretch." When the program is running short this gesture means lengthen it

CHAPTER VIII

COMMUNICATIONS

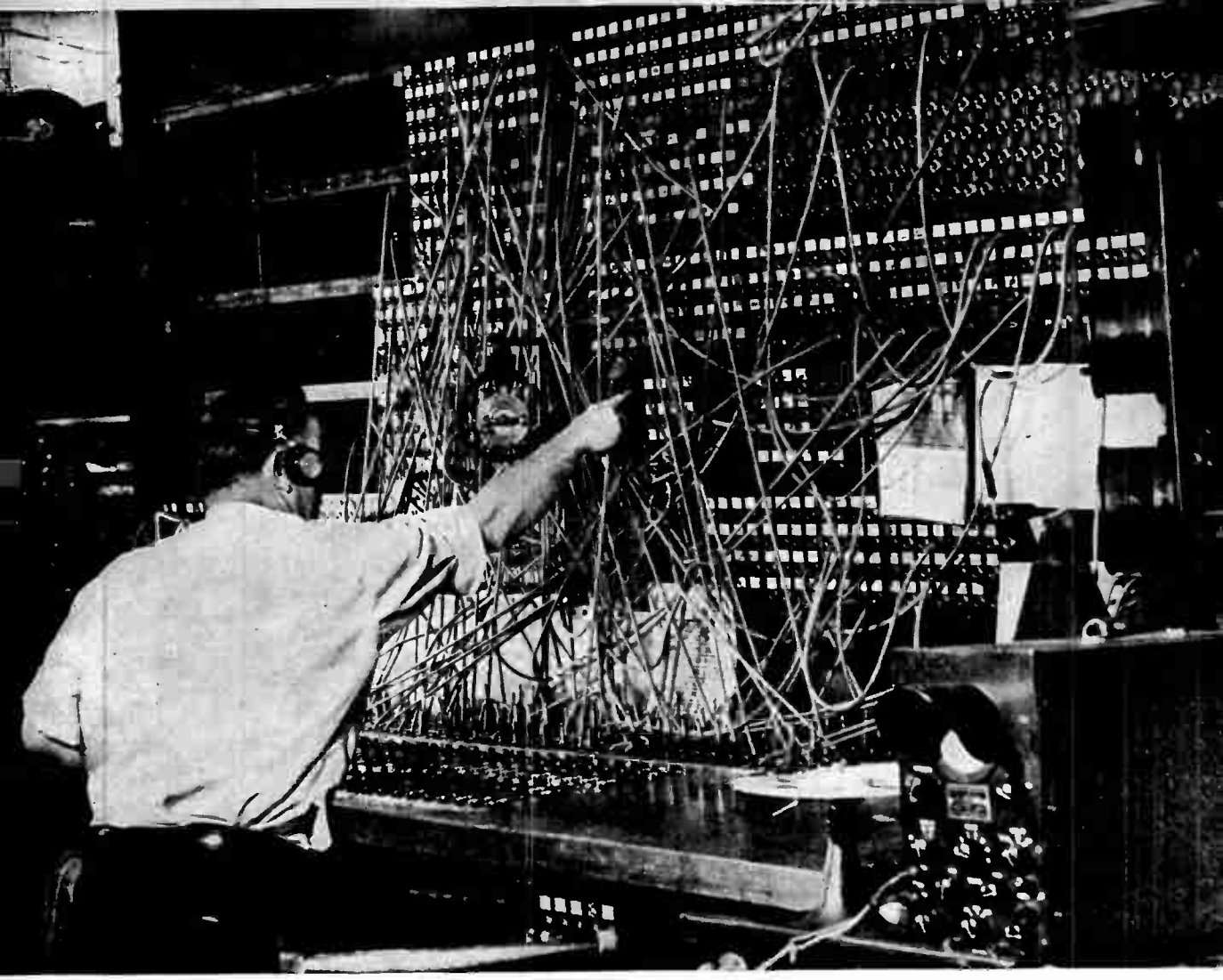


Insulators on the long-wave antenna at the transmitting station

WHEN in 1901 Marconi, on that cold winter morning at St. Johns, received the famous "S" signal from across the Atlantic he listened for the first faint trickle of a cataract of radio electric energy that was later to flow in a great torrent around the earth, bringing men and nations closer to each other, setting aside the barriers of distance, and overcoming the physical obstacles of mountain range and ocean.

Where that single letter "S" of the three little dots could go, all of the twenty-four other letters of the alphabet could go, and numerals as well. International radio communication was born.

The days of its infancy were marked by bickerings and jealousies



At the transatlantic receiving station signals coming through the many receivers are routed to the central operating room through this switchboard

as nations awoke to the great part it was destined to play in the affairs of the world.

Space had been conquered. The operator at his sending key could reach out an invisible finger and with the speed of light write his message clearly and boldly at the other end of the world.

In 1903 the American Marconi Company built a station on Cape Cod with the object of establishing communication between the United States and England.

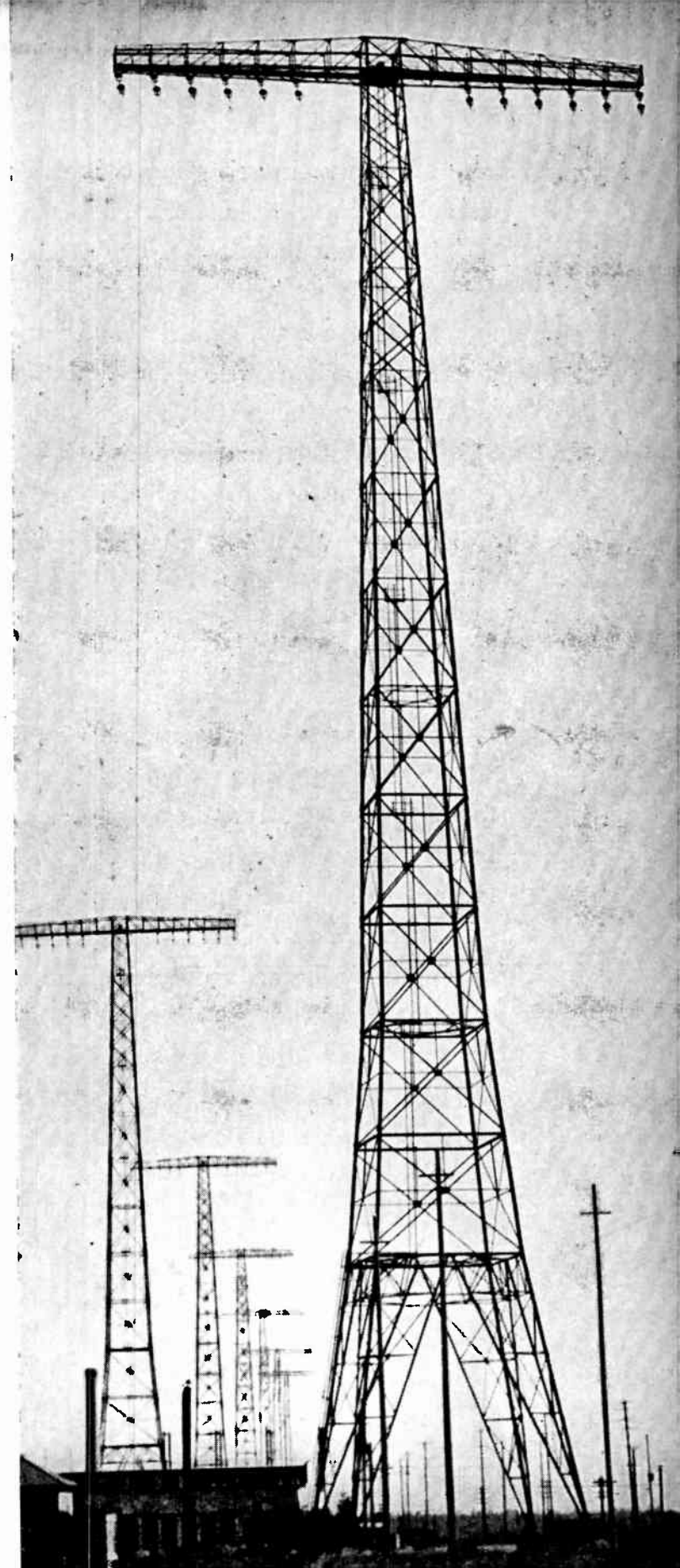
In the autumn of 1907 England linked Ireland and Newfoundland with a limited public-communication service.

Soon after 1908 Fessenden established a transmitter station at Brant Rock, Massachusetts, that had its correspondent at Mackrehanish, Scotland.

Germany stepped into the picture in 1912 and was soon followed by Norway.

The year 1914 saw San Francisco and Hawaii hooked up by radio. The world was becoming smaller. After that each year saw the invisible web spun and extended all over the earth until today the United States and its insular territories are linked with forty-five foreign countries.

Radio communications, while they never faltered or deviated a hair's breadth from the plan of ultimately girdling the earth, were har-



Long-wave transmitting antennae

assed by natural phenomena that made the whole project sometimes seem hardly worth the effort.

Static was the greatest bugbear. It came and went as it pleased. Sometimes it was caused or intensified by sunspots; again the aurora borealis took a hand. Electrical and magnetic disturbances in the atmosphere were also responsible at times for drowning out all signals in a crackling roar. Radio men scratched their heads and kept on experimenting, investigating, and investing. It seemed as though the spirits of space were putting up a strong fight against the invaders of their infinite territory. Science won, however, through the invention and perfecting of new instruments, new types of aerials, and new sending and receiving apparatus. Today radio communication is carried on with the same matter-of-fact definiteness as making a telephone call to a friend's house a quarter of a mile away.

Perhaps the easiest way to get a picture of what actually happens when you telegraph by radio from New York to London, let us say, is to follow the message from the moment you turn it over to a messenger boy, having written it carefully, of course, preferably in "print" capitals with lots of space between words and lines.

It goes first to the receiving desk where the words are counted and the address is checked to insure delivery. The cost is about the same as a cable message. The time of receipt is stamped on it. If you are in a hurry for a reply, a red label with *urgent* in bold letters is attached to it.

It is then shot through a pneumatic tube to the operating room, which is one of the most remarkable spots in the entire world of radio.

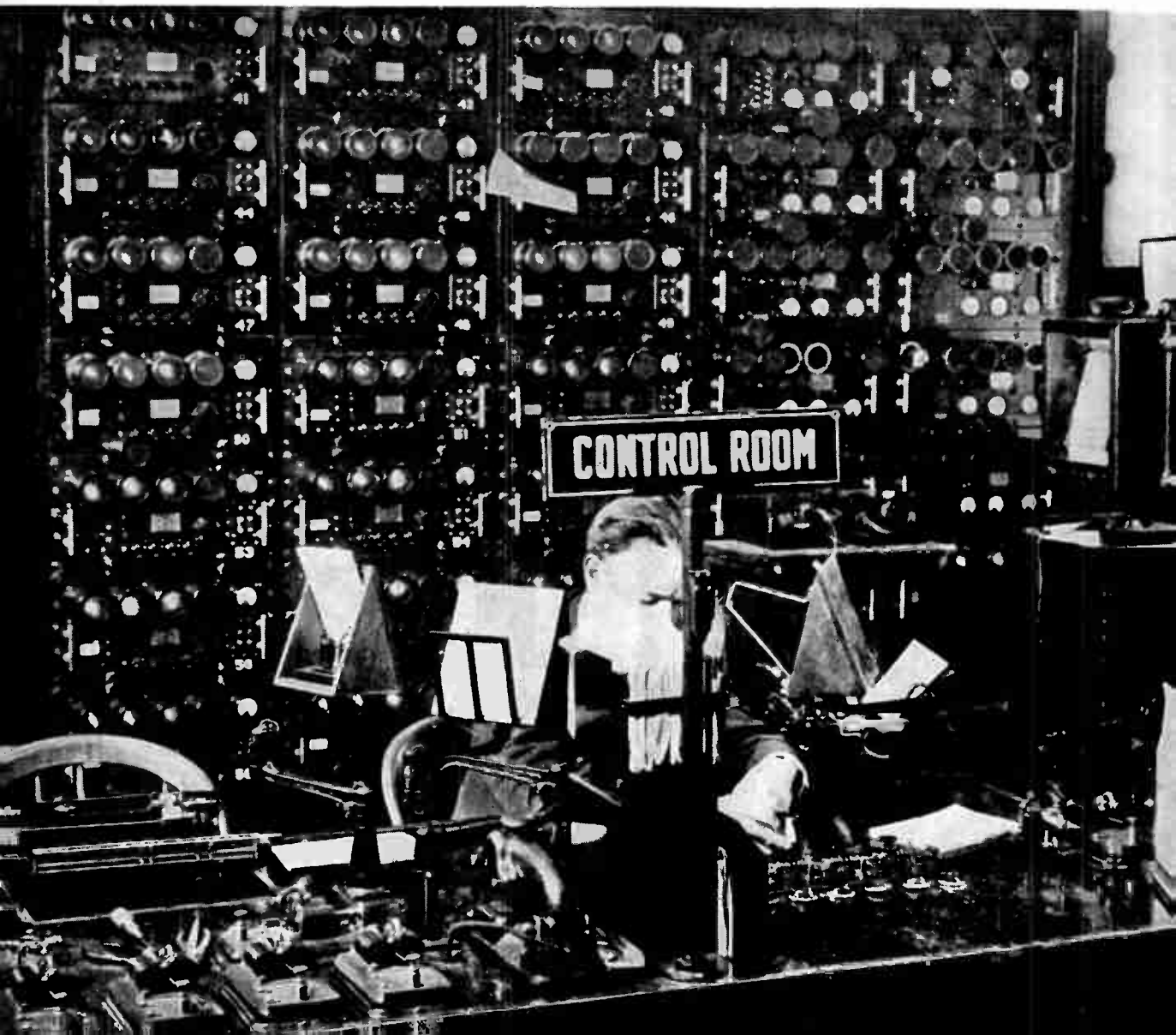
As you approach it you hear the clicking of scores of typewriters and a hesitant clatter from numerous unfamiliar machines. As you open the door the first thing that claims your attention is the number of signs all over the place, designating the sections devoted to traffic with certain countries. The signs are strong, bold, and very plain. It suggests a con-

The operator in the foreground is transcribing the wavy line on a receiving tape into the words of a message

vention hall with banners, emblazoned with the names of the states identifying their groups.

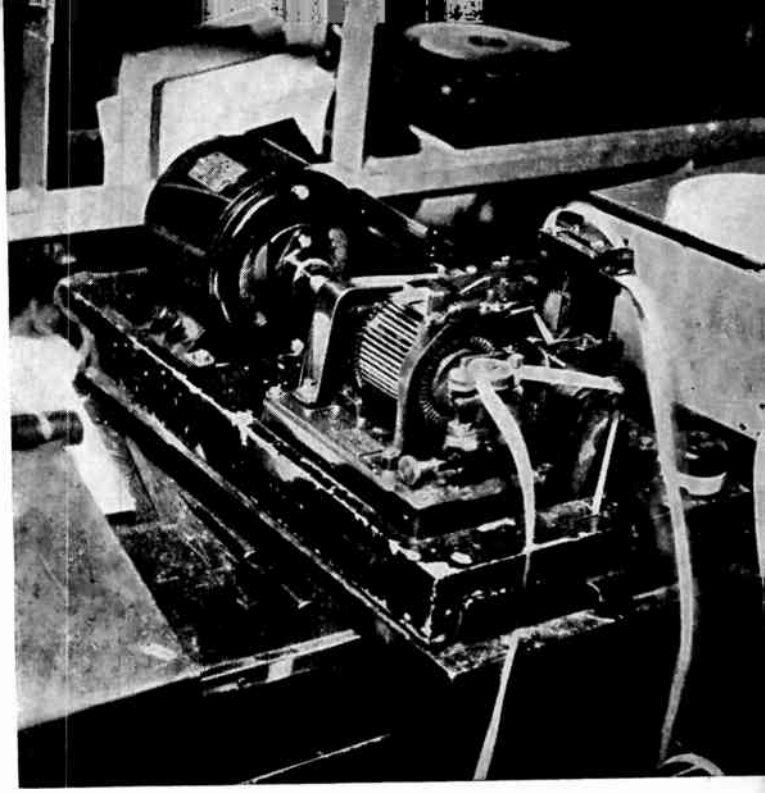
Belgium, Czechoslovakia, France, Germany, Great Britain, Holland, Italy, Norway, Poland, Sweden, Portugal, Russia, Spain, Switzerland, Syria, Turkey, Argentina, Brazil, Chile, Colombia, Cuba, Curaçao, Dominican Republic, Guatemala, Haiti, Mexico, Panama, Puerto Rico, and Venezuela, each is represented by a sign.

The control room is the watch tower of the receiving station



If your message were going to the Far East, it would be sent in the other direction, west from San Francisco. There is no spot in the world connected directly with so many foreign countries as is this remarkable room.

Your message reaches the transmitting operator under the Great Britain sign who is working the London circuit. Beside his typewriter are two strange-looking machines, both synchronized with the typewriter, so that when the operator strikes the keys on the typewriter one of the machines perforates a paper ribbon with the corresponding letters in Morse. As the ribbon is perforated it is automatically fed into the second machine where it operates like the paper roll on a player piano, but instead of music it is sending out electrical impulses in the form of dots and dashes.

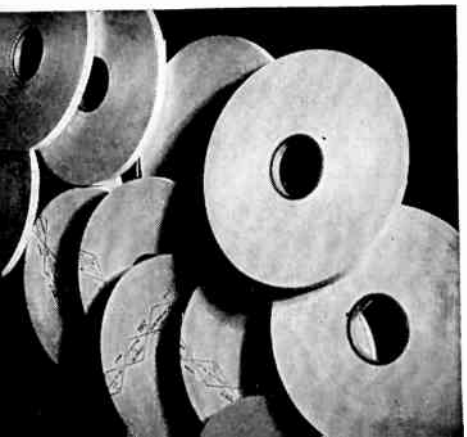


This device converts received dots and dashes directly into letters and words on a paper tape

These impulses must have something more than energy before they can be transmitted. They must have tone or sound, so the direct current impulses are converted into tone impulses which are enlarged or amplified, and used to "key" or tune the transmitter.

Now these dots and dashes have still to make a long journey to the transmitting station which is more than sixty miles away.

Here, as in broadcasting, the signal is strengthened, built up and sent out as a



Rolls of paper tape on which the dots and dashes of incoming messages are recorded

radio wave that will leap across the Atlantic in one-eighth of a second. It is treated for clarity and proper tone quality with the aid of a strange instrument, the oscillograph, which enables the radio engineer to see the behavior of the radio waves even though they are, as we said, invisible. On the surface of its illuminated disc, a green line of light quivers and curves and plays along the horizontal diameter of the disc. The behavior of the green line varies with the characteristics of the radio signal. It weaves itself into beautiful and intricate patterns that are smooth, clear, and well defined, or it may show a line that is disturbed and unhealthy. It is a sort of visual stethoscope applied over the heart of radio.

After its passage through this bewildering place it leaps to the antennae high up on gigantic towers and is hurled into space.

The transmitting plant of the Radio Corporation of America at Rocky Point, Long Island, actually covers more ground with its physical equipment than any commercial plant in the world. Five thousand acres are devoted to it. Its enormous T-shaped towers are visible for miles around as they stretch off into the landscape a fifth of a mile apart.

Approaching it from the south it looks like a forest of Douglas firs that have been denuded of limb and branch. Masts, a thousand of them, rising a hundred feet or more straight and strong as the masts of a clipper ship, fill the landscape and in places merge into solid groups as they go into the distance. As one draws nearer to this strange forest, great spider webs are seen to spread between them. Insulators of glass and porcelain, tens of thousands of them, glisten and sparkle against the sky like dewdrops in gossamer on a summer's morning.

In one place the masts and antennae and insulators suggest a bejeweled fan. In another an oval necklace of diamonds. Between the high steel towers green copper wires, delicate as a silk thread at their great height, swoop in vanishing curves. In fine weather it is an inspiring sight,

A rigger at the transmitting station starts a long climb to the top of one of the 410-foot towers

On some radio circuits the received signals are automatically translated into printed letters on a paper tape. An operator is shown here pasting a tape containing a message on a Radiogram blank

but when in winter tons of ice form on the wires it is heartache for the men who maintain them. Science came to their rescue, however, by sending a strong electric current through the wires, thereby causing heat which melts the ice.

There are three groups of antennae used at once for reception from any one point. These groups are far removed from each other so that, should the signal "fade" or become weaker on one unit, another will receive it clear and strong. It is in this way that the terrible bugaboo of radio "fading" has been overcome. Only a comparatively short time ago, less

Messages come by belt to this position where they are recorded and then hastened on their way

than ten years, when an incoming signal faded it was gone and nothing could be done about it. Today, as a result of multiple aerials and receivers, traffic comes in with the definiteness and regularity of a factory whistle.

Now let us suppose the person to whom you radioed in London replies without delay. His message goes through the same process of transmission over there and comes winging across from the other side to be picked up by the receiving antennae of which we have just spoken. From the antennae it comes directly into the receiving department near by. It is weak and tired and travel stained, and hardly in a fit condition to be relayed to New York, so it is rejuvenated and strengthened, or amplified as they say, and is then put on the wire to New York where it reaches the same office from which your message was sent.

Here is another spot where radio becomes almost uncanny and suggestive of the weird den of the alchemist of old. Three thousand miles away a man strikes, say, the letter "S" on a typewriter key. Before his finger has left the key to strike the next one a metal finger in New York writes that very letter on a ribbon of tape.

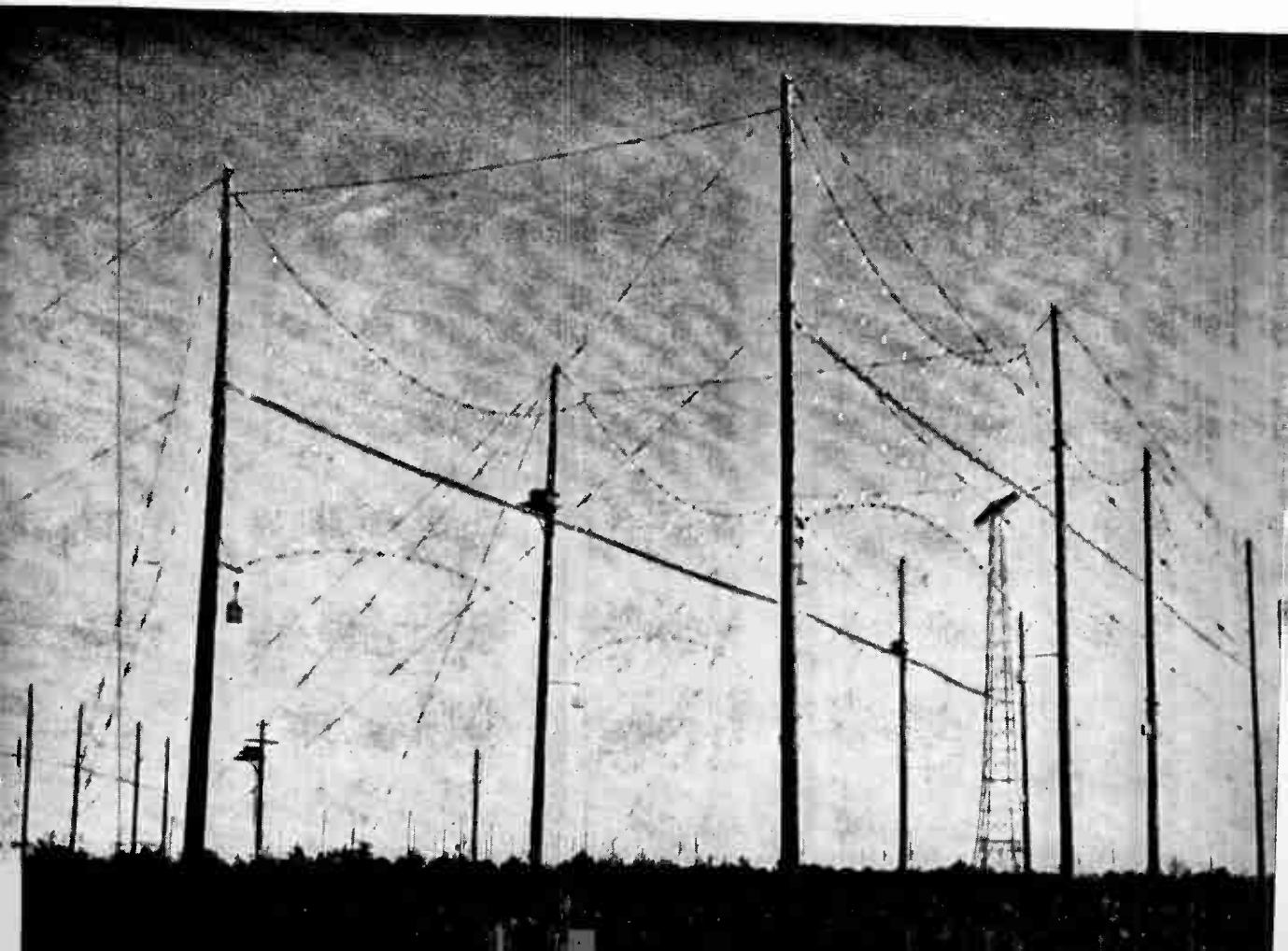
This finger operates in a most bewildering way. It writes in dots and dashes, of course, but each dot and dash is connected by a V line, because as it writes its message in ink it never leaves the paper ribbon. The ribbon comes from the receiver directly before the receiving operator who sits at his typewriter and translates the strange wiggly line into a coherent message which he typewrites on a Radiogram blank.

One of the best examples of the practicality of radio communications I know of, is an occurrence that took place in New York during the period when Admiral Byrd was in the Antarctic. One of the engineers assigned to the broadcasting of the Byrd expedition, having completed his work, left for his home. On that evening the weekly program from the South Pole was to be broadcast. Some emergency arose that necessitated the presence of the engineer at the studio. It was found that his phone

was out of order and there was no other way of reaching him quickly enough. They assumed at the studio that he would listen in on the tests from the Antarctic, so the studio radioed the operator of the expedition at the South Pole asking him to broadcast that Mr. So-and-So, the missing engineer, report at the studio in New York three miles away. The engineer got the message via the South Pole and left at once for the studio.

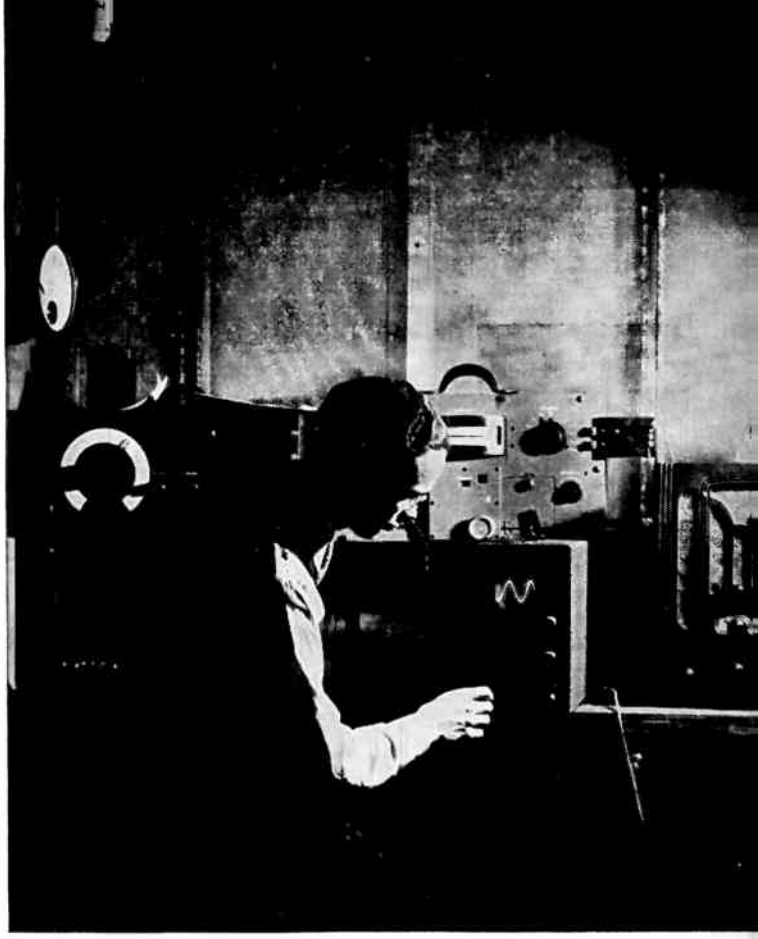
All of this type of communication is classed under the general title of "point to point" and as such it forms an important unit in the commercial as well as the political affairs of the world; consequently every country takes a decided interest in, if not actual control of, the radio facilities within its borders.

These are modern short-wave receiving antennae used in communications work



CHAPTER IX

MARINE COMMUNICATION



Engineers check up the tonal qualities of a radio receiver and make sound visual on this oscilloscope for close study

AS THREE QUARTERS of the earth's surface is under water it is not surprising that from the early days of radio it was closely connected with the sea, while today a large part of the world's radio traffic is what is termed Marine Communication.

In the days before the radio conquest of space, the sea was filled with terrors for those who journeyed on it. "Lost at sea without trace" was a frequently repeated closing word on ships that sailed away from port, never to be heard from again. At Lloyd's in London a large bell was tolled mournfully to announce to the underwriters that such and such a ship, long overdue, was officially considered lost. The only means

of communication the ship of those days had with shore, once she left "soundings," was by asking a passing ship to report her to her owners. Sometimes these ships passed in the night or some miles from each other, making communication impossible. In case of distress or disaster they had to depend on flares and rockets and sometimes the shooting of small cannon as distress signals. These, of course, were puny devices because their range was so limited.

Instead of the gay "sailing parties" that we witness today when a passenger ship is about to cross the ocean, it used to be that sorrow and fearful misgivings were evident among passengers and those who came to wish them bon voyage.

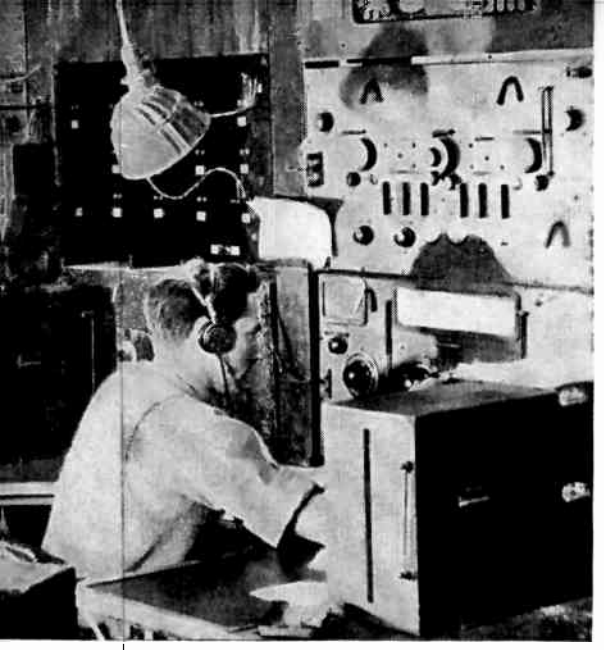
Then the blessing of radio came. The ocean was robbed of its greatest terror, isolation. Shipmasters and their passengers felt more secure in their knowledge that somewhere beyond the horizon, which was but a mere twenty miles away, were other ships which would rush to their aid in times of distress. Unfortunately, however, in the early days of radio, few ships were radio equipped, which left many of them totally deaf when the call for help went out.

When the SS *Republic* was rammed by the SS *Florida* on January 23, 1909, the primitive radio with which she was equipped brought aid that prevented loss of life. The country was so impressed with this that legislation was passed the following year requiring all vessels carrying fifty or more persons to be equipped with radio telegraph and a skilled operator.

Further legislation followed in 1912 when, after the fearful *Titanic* disaster, it was discovered that there was a radio-equipped ship near by whose operator was off watch when the *Titanic's* SOS was sent out.

So in 1912 the former legislation was amended and each vessel carrying fifty or more passengers was required to have two operators and to stand constant radio watch. Each ship was also required to have

The ship's radio operator checks the operation of his transmitter



Operators constantly check the sending stations' transmitters to make sure they are on their assigned wave lengths

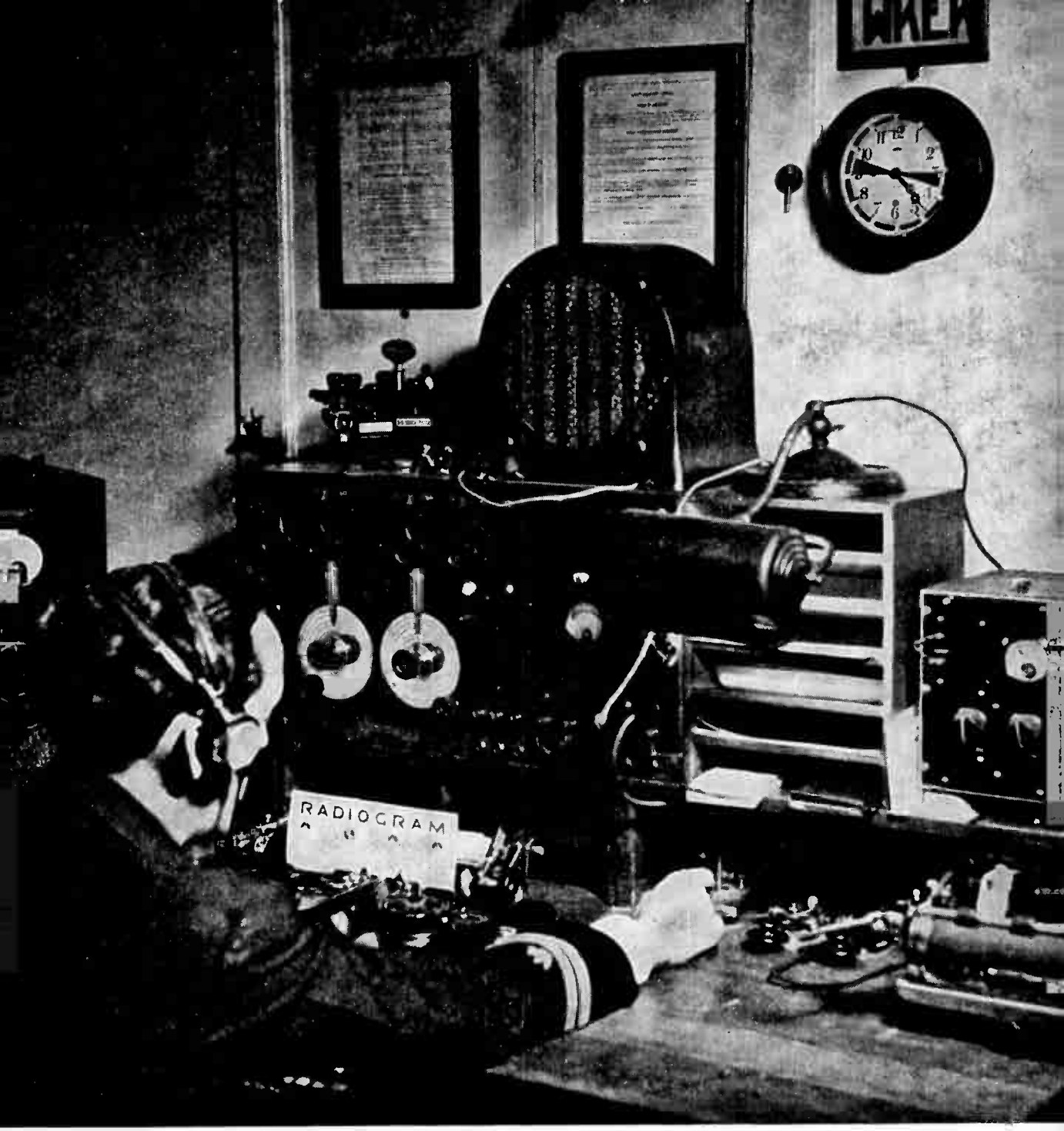
auxiliary equipment that could be operated independently of the ship's power supply. It might be truthfully said that the radio telegraph has contributed more to safety of life at sea than all other contributions to the science and art of navigation.

Let us step aboard one of the modern passenger vessels and see how radio operates for the comfort, safety, and information of those aboard.

The radio room will usually be found high up in the superstructure of the vessel, not too far from the bridge, yet not too inaccessible to the passengers. It is in charge of a chief radio man who has one or two assistants. Within the confined space of the room is crowded the last word in radio equipment both in sending and receiving. Where formerly the radio "shack," as it was called, was a curiosity spot for passengers, and the rattling crack of its powerful spark could be heard all over the vessel, it is today as well ordered and matter of fact as the purser's office. Day and night you will find an operator seated before his receiver listening for his own incoming traffic with one ear, as it were, and for the distress call which may come at any moment with the other.

In every hour of the twenty-four there are two silent periods when all radio traffic in marine communication ceases. Then the headphones are clapped on more tightly, for during the three minutes of each period of silence the call of distress or the stand-by signal may more easily be heard, particularly if the distressed vessel is operating with failing power.

An operator who through forgetfulness or any other cause trespassed



Radio operator at his post in the ship's radio room

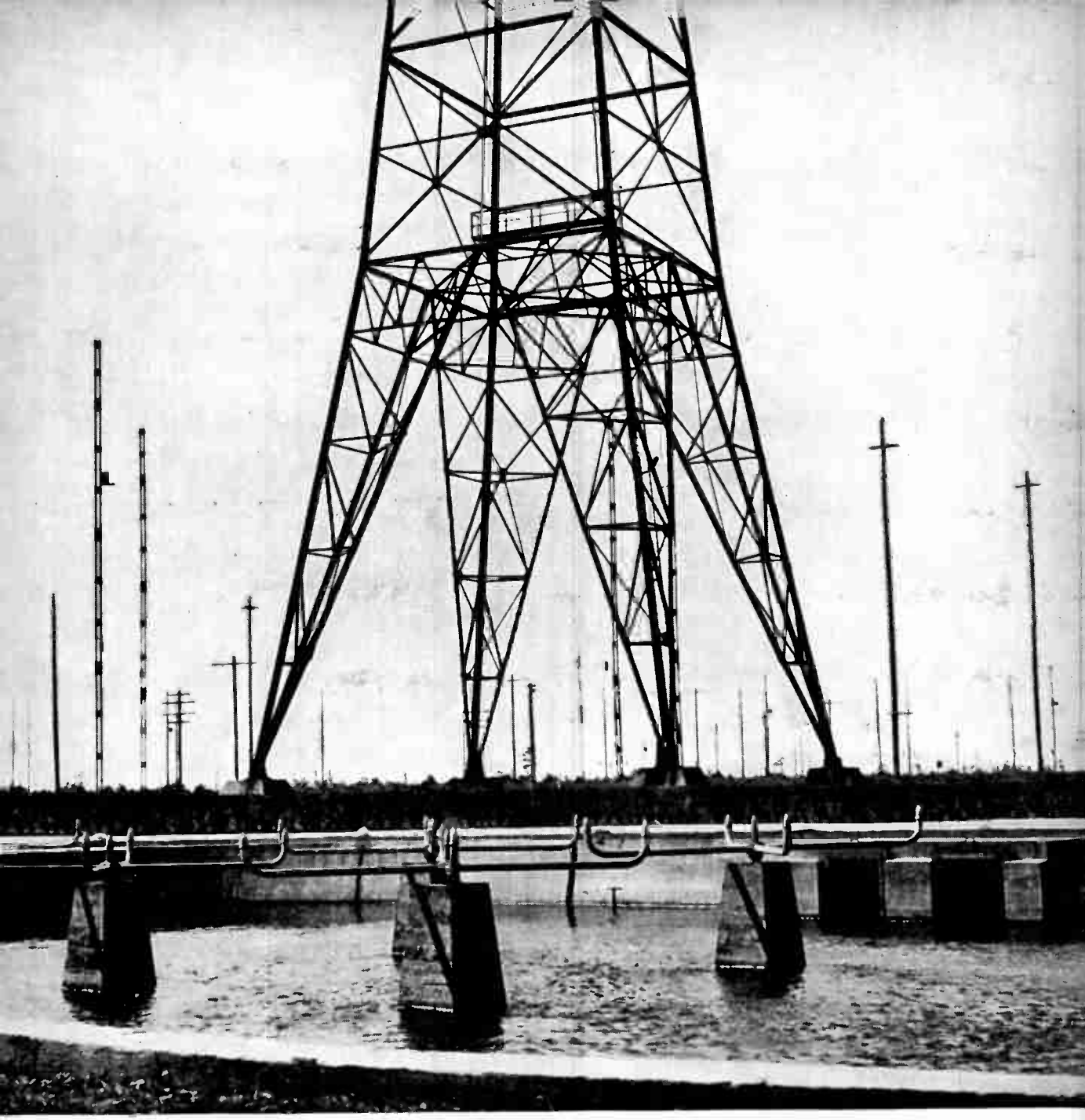
with his signals on this sacredly guarded period of silence, would be looked upon as a renegade to the traditions of radio. At the end of the silent period his headphones would begin to buzz with calls from ships' operators for hundreds of miles around. He would be told in the strange and abbreviated language of the key what they thought of him, and their thoughts would not be flattering. This jealous guarding of the period of silence may be accounted for by the fact that every operator feels that it may be his turn someday to be on the sending end of an SOS when failing power may make his signal weak. Then silence to him is truly golden.

The "stand-by" or "attention" signal is Q which means, "be on the lookout for my call, we are having trouble and *may* need help."

The distress signal is the well-known SOS, which is the international call for assistance. The letters SOS, which in international Morse are . . . – – – . . . , mean nothing in themselves. They are not an abbreviation of any phrase or words such as "Save our ship," or "Save our souls," as many believe. The reason this particular combination of letters was selected is because they give a sharp, easily recognized signal which when repeated can be picked out from among the great volume of traffic signals which are always flying around.

There have been rare but harrowing instances where a ship in the immediate neighborhood of a vessel that was in trouble failed to hear the distress signal. Never once has this tragic happening been due to the failure of radio. It was owing to the fact that there was only one operator on the ship that was called and he had "turned in" for his much-needed sleep, thereby missing the SOS from the ship in distress.

In that men cannot work continuously and without rest during a voyage, and carrying two operators on small vessels places a burden on the ship owners, particularly cargo vessels, this problem of unheard distress signals was a grave one until the automatic alarm was developed.



A "cooling pond" lowers the temperature of water used to cool the tubes and machinery in the high-power radio transmitters

With this instrument installed the lone operator on a small ship may go to bed without the terrible fear of sleeping through the tragic period when a near-by ship is pleading for immediate help.

The operation of this automatic signal device is simple enough. In the first place, it has a signal all of its own known as the International Distress Signal. It consists of twelve dashes, each having a duration of four seconds, with one interval of one second between them. Where the operator leaves his set for any purpose he throws the alarm into the circuit and it at once begins to function automatically. It will disregard all signals but the twelve long dashes. When these come, a relay switches on a clattering gong which can be heard a considerable distance from the radio room. Then the operator can jump to his post, listen for position and particulars, report to the captain, and dispatch the welcome news of speedy assistance to the ship in distress.

The radio room on a modern passenger vessel is a busy place, for besides the general radio correspondence of the passengers it attends to the radio business of the ship such as routing, cargo information, weather reports, and reports of the daily position and the probable time of arrival.

The news of the day, or press service as it is called, must be picked up, printed, and distributed to the passengers. Then, for those interested in the financial market, the brokerage service, buying and selling orders, and market quotations. There is also a medical service through which free emergency medical advice is sent to ships that carry no doctor. Even gifts are radioed from aboard ship to friends or relatives ashore. The sender may select a gift from a catalogue carried aboard and choose a prepared greeting appropriate to the occasion. Through arrangements made with stores in many cities, the gift and greeting are delivered at once while the sender is thousands of miles away.

These radio men have in time of emergency and distress proven

The ship's officer takes a bearing on the radio direction finder

themselves to be worthy of the best traditions of the sea. They have clung to their posts on many occasions when the floors and walls of the radio room were blistering and smoking from the heat of a burning ship. They have stayed at their keys for long and miserable hours, hanging on by main strength, as the water rose within the vessel because of a heavy list. They have continued to send out the call for help as they saw the last boat pull away from the doomed vessel and then have waited for her to sink as did Jack Phillips on the *Titanic*, who went down with her.

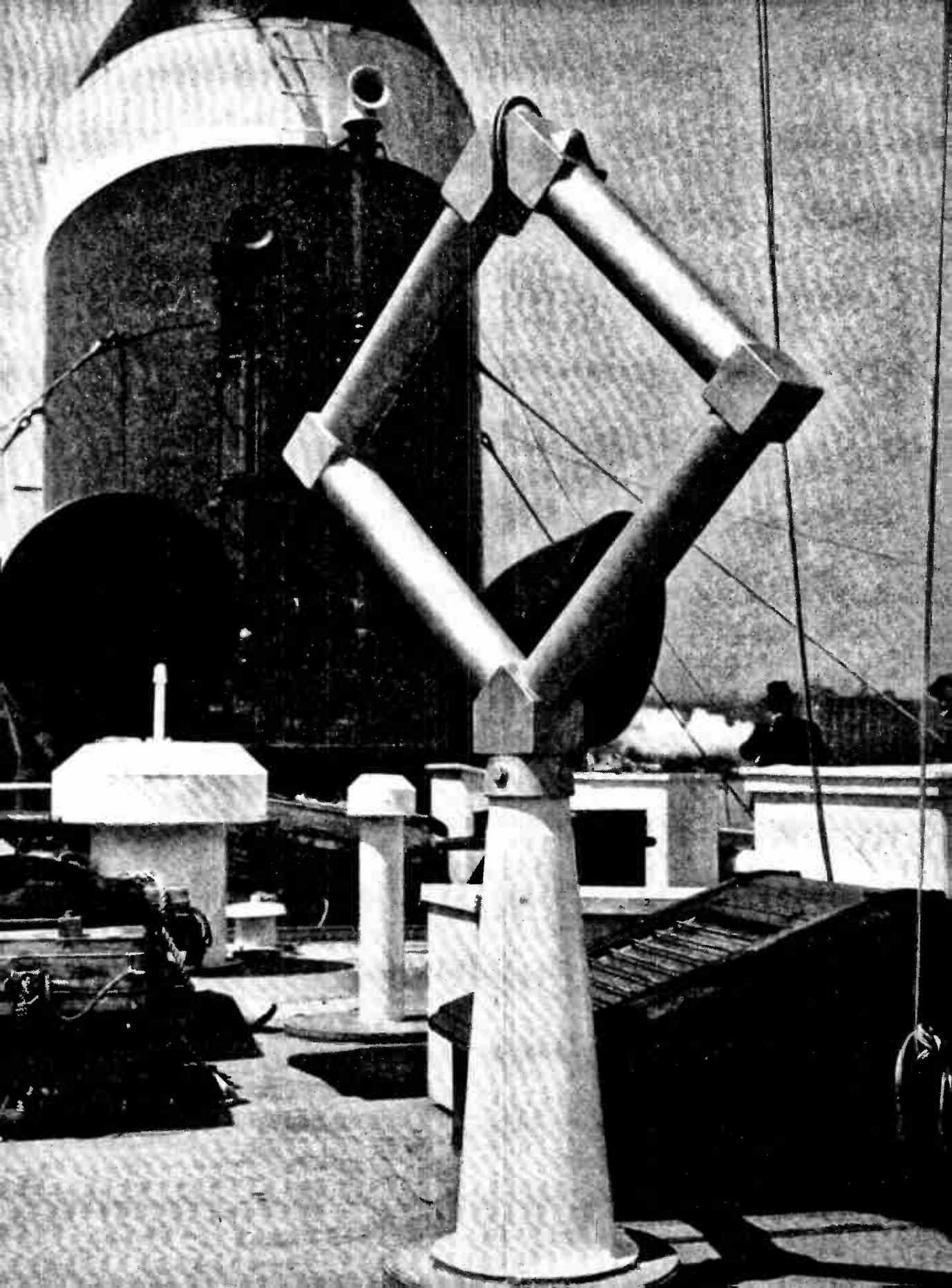
There is a monument in Battery Park, New York, to these radio heroes who gave up their lives that others might be saved from the sea. More than twenty names are graven on the bronze tablet.

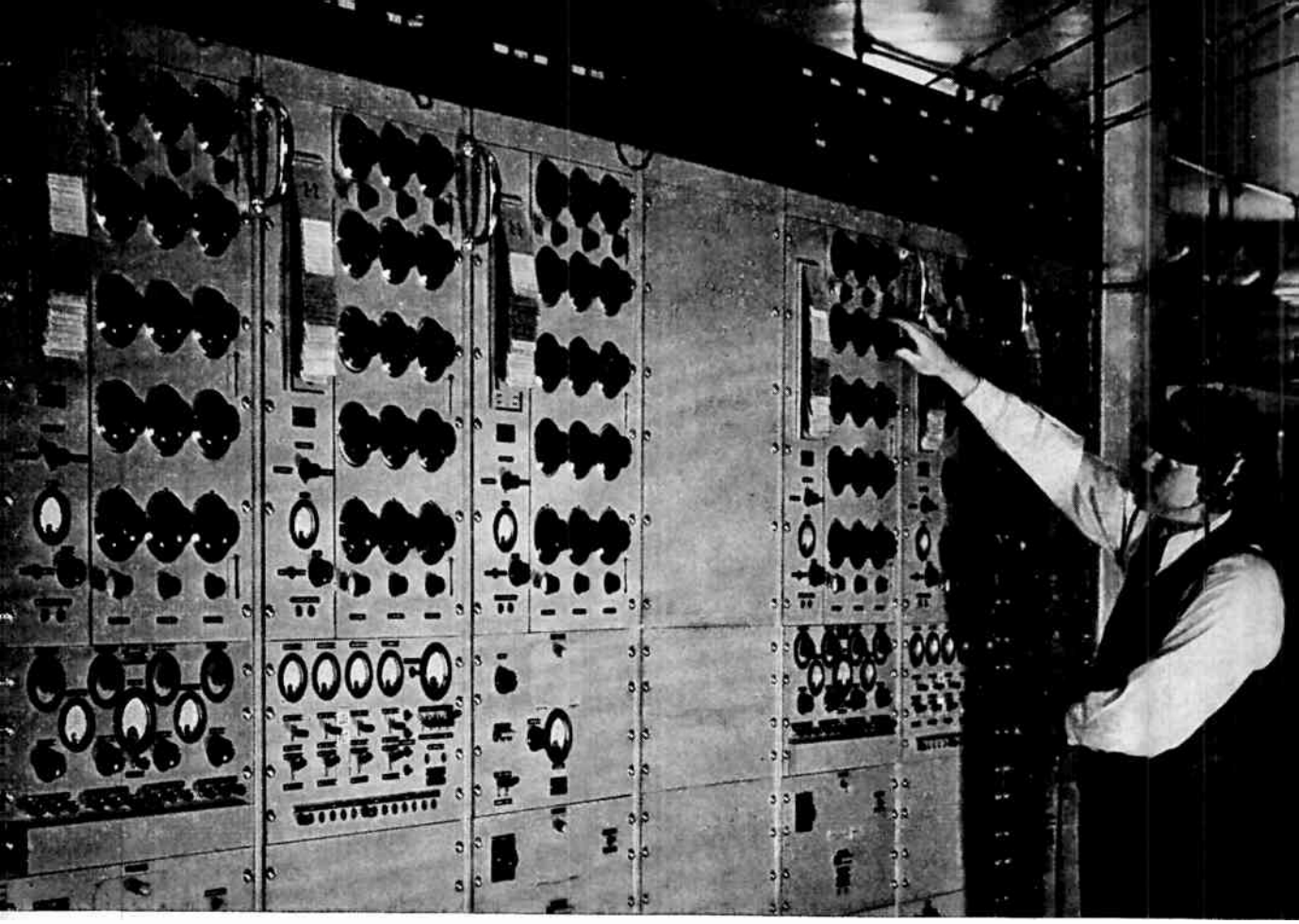
There is another radio device used on all modern ships which, although it is rather simple in appearance and in operation, has had a far-reaching effect in making sea travel safer and navigation more accurate.

It is the direction finder. Usually installed on the bridge or in the chartroom it is used in obtaining radio bearings or, as its name implies, the true direction of two or more points on shore from the ship. The ship is, of course, always at the focal or meeting point of these lines of direction. It consists of a rotating "loop" which picks up the signal from lighthouse or lightship, which transmits periodically for radio direction-finder purposes. The loop is connected to a highly sensitive and selective radio receiver which can be adjusted to the desired signal. It has the peculiar radio property of giving a maximum signal when its edge is toward the source, and diminishing the loudness of the signal as it is turned on its axis, until it reaches a well-defined minimum or "null" as its broadside is turned toward the source of the signal.

Now let us suppose a ship is one hundred miles off the coast of New Jersey. The weather is foggy or rainy. The captain has not seen the sun nor stars for days. Wind, tide, and currents are always throwing a ship off her course. He desires to make the port of New York. Before the days

This rotating loop antenna is controlled from the radio direction finder in the chart-room below



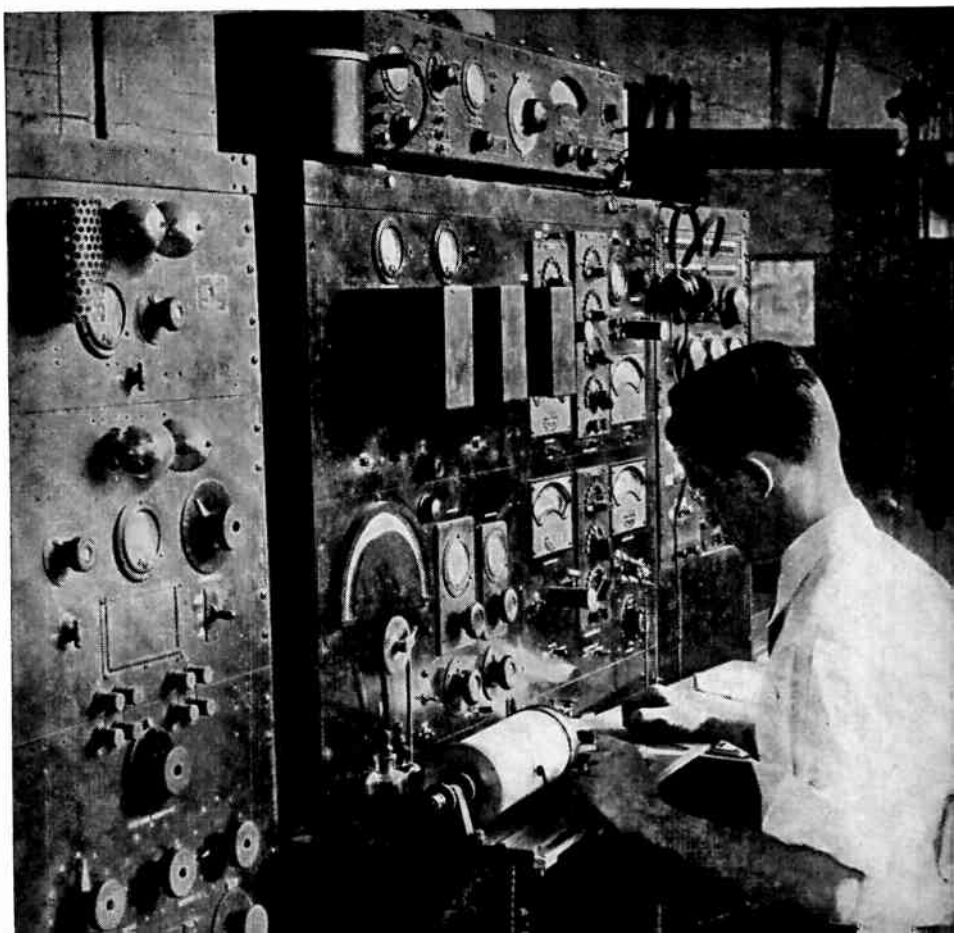


A bank of "diversity" receivers in the receiving station

of the direction finder that man would be in a tight spot. So tight, in fact, that it was a gamble whether he would pile up on the Jersey or Long Island shores, or grope around in the ship traffic lanes until the sun came out. So frequently did this happen that large salvage companies had salvaging equipment, such as tugs, lighters, and derricks, with large crews on duty day and night waiting for word that a ship was ashore along the coast. Then, like a fire department running to a fire, the fleet would set out full speed to the scene of the wreck. Since the advent of the direction finder these great organizations with their ponderous equipment have either gone out of business or gone into other lines of work.

The operation of the direction finder is surprisingly simple. It is

usually worked by one of the ship's officers although the radio men must check it and keep it in repair. Two shore signal stations are selected. The finder is tuned in on the intermittent note of one and then on the other. After the first station is found and tuned, the officer turns a horizontal wheel which is connected by a shaft which goes through the deck above to the loop, a square rectangle of metal tube within which is coiled the antennae wire. This antennae loop picks up the signal. The officer turns first one way and then another, feeling for the minimum of signal power or the maximum of silence. When he has found it he consults a compass face which is in the lower part of the instrument. A pointer shows on this face the exact direction in which the loop is pointing. A line is drawn accurately on the chart in that direction, one end of it starting at the station on which the instrument is tuned. The operation is repeated with another radio signal station and again a line is drawn. The point at which these two lines intersect is the position of the ship



Measuring acoustic characteristics of radio receivers

and is called a "fix." If three stations are used, the point at which the three projected lines meet is call a "three-point fix."

Where a ship is not equipped with a radio direction finder but is equipped with radio telegraph, it may in some locations secure bearings by signaling two radio direction-finder stations on shore. These stations determine the ship's position and send it by radio to the captain.

Ever since the earliest days of shipping, weather has been a subject of most importance and concern to mariners. Wind has always played an important role, particularly in the days of sail. Fog, the terror of the seafarer, would be as deadly and as baffling today as it ever was, were it not for radio. Rain, sleet, snow, hail, all have penalties which they exact on shipping wherever it may be. Even cloudy weather has its drawbacks, for it makes navigation difficult and sometimes impossible. It is small wonder then that sailors the world over have always been weather conscious. They learned to read weather signs and omens as a child learns to read a book. They had weather superstitions in which they believed with as much fervor as the mathematician believes his figures. Many an apprentice got a lash of a rope's end for whistling when a full-sail breeze was blowing, for to whistle aboard a ship brought on wind or an increase of it. Many a hard-boiled sea captain, while laying in the doldrums' dead calm with not a stir in his sails, would pace the poop deck whistling lustily, firm in his belief that it would bring on a breeze. Finlanders were a welcome addition to any ship's crew as their presence was believed to insure favorable winds.

Consider the officer of a modern steamship today as she speeds smoothly on her way. When he is called fifteen minutes before his watch on deck begins, it is in this way: "Eleven forty-five, sir, temperature sixty, weather squally."

The barometer is still considered almost as necessary to a ship's equipment as is the chronometer. Weather entries are made in the log as

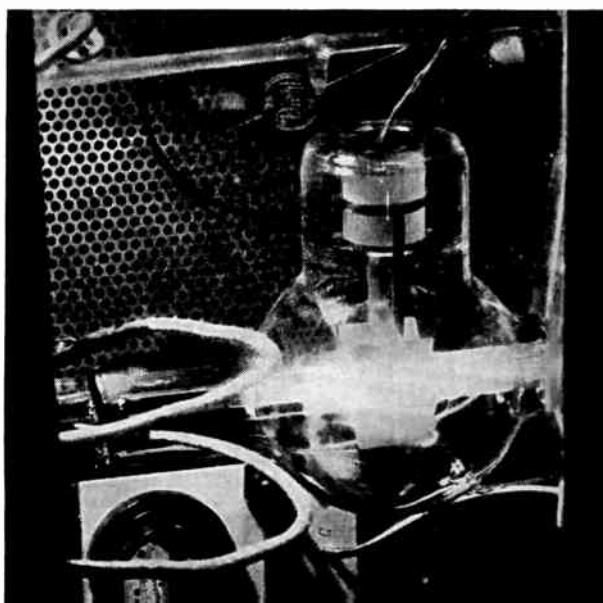
One of the newest air-cooled, high-frequency transmitting tubes

they were in the days of sail. When the captain wants careful vigil kept for a reported derelict or a certain light he says, "Keep a weather eye out for —— etc.," so we see that notwithstanding the great strides that man has made in the building of ships, their propulsion and their navigating, they are still the playthings of the storm, though better able to cope with it and, thanks to radio, can avoid much of its fury.

When, therefore, a practical radio weather service to ships at sea was established there was rejoicing among ships' officers who had been harassed for years by taking the weather where they found it. This weather service comes to the ship in the form of a weather map.

Now imagine a ship a thousand miles at sea. The captain is concerned about a hurricane that is raging to the south of him. He knows nothing of its course or probable duration. All the weather lore that he and his officers have accumulated during a lifetime at sea gives him but little to go by. Then the ship's radio operator sends him a printed weather map direct from the United States Weather Bureau at Washington, D. C.

It contains accurate information on weather conditions from ships at sea all over the area which the map covers. This information is arranged in map form so that it shows the isobars, the movement of the storm center and the prevailing winds, as well as other information in



When more power is drawn from tubes than they are intended to supply, their metal plates glow with a red-hot warning

a manner that would be impossible to send as a word message.

That map left New York but a few minutes previously and here it is on the bridge of the vessel being studied and measured by the captain and officers.

Almost a miracle! And one worth a little study. These weather maps are sent out by what is called the facsimile system. Through this marvel of science, a photograph, a blue print, a document, a sketch, or a manufacturer's statement can be sent, as well as a weather map.

It is surprising to note the rapid growth of this form of radio communication and its many applications to the requirements of modern life.

An example of the wonders of this facsimile service is the case of a young man who absconded from a New York bank with a satchelful of cash. It was an easy getaway, but not a complete one, for when he stepped on the gangplank at Southampton detectives, who not only had his photograph but his fingerprints, took him in. Both photograph and fingerprints had been radioed ahead of him.

The machine which performs this wonder is no larger than a typewriter and apparently less complicated. A film reproduction of the document, or picture, or weather map is placed on a revolving cylinder in the sending machine. As the cylinder revolves a pin point of intense light, no larger than the period at the end of this sentence, plays on the film. This light point moves slowly across the length of the revolving film so that it covers or scans its entire surface. As the details of the picture vary in density, the light point is reflected to a photo cell or electric eye with varying degrees of illumination. These light variations are converted by a photoelectric cell into radio impulses of varying power which are transmitted through space to a receiving instrument, where the radio impulses are converted into electric impulses which eject from a microscopically small nozzle a jet of ink which varies in volume exactly as the pin point of light varied in its reflected intensity.

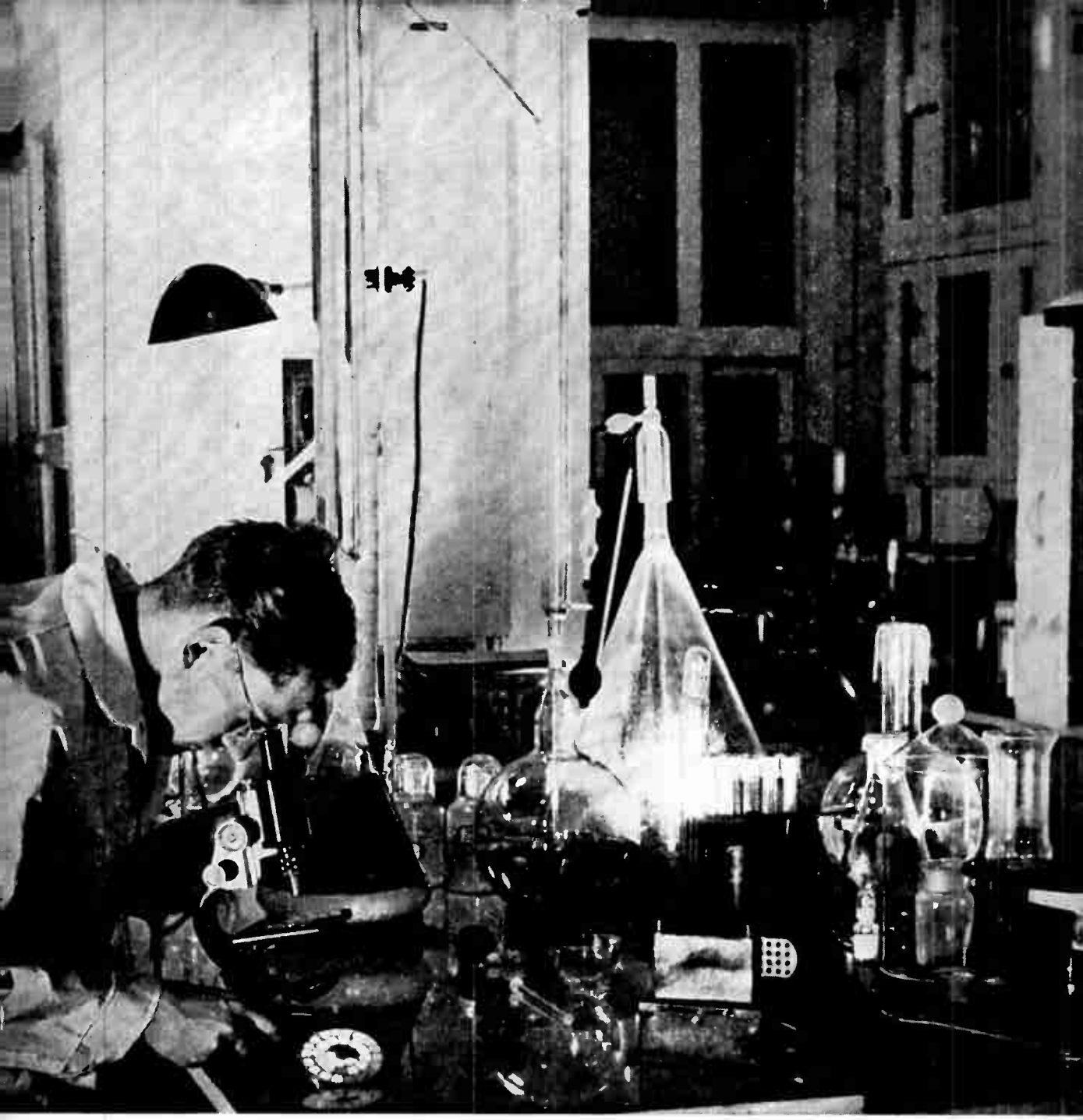
CHAPTER X

TELEVISION

The television image tube is here shown reproducing a picture invisible to the eye

NOW this transmitting of pictures through space must not be confused with television, which is in no way related to facsimile except in that radio is the messenger that bears them both. The relation of one to the other is that of the still photograph to the motion picture.

Of all the science marvels with which the average person is familiar, less has been written on television than on any other. It has been shrouded in the mysterious twilight of the laboratory. It is so thoroughly intermingled with pure science that unlike its parent, radio, it is far beyond the amateur. Unlike radio, also, it is an expensive subject in which to dabble, as highly complex and expensive equipment is necessary to it.



Examining the crystalline structure of luminescent materials in "the cleanest chemical laboratory in the world"

While television is no longer a theory and has passed beyond the laboratory stage, it has not yet reached a point in its development where it is commercially practical on a large scale. There are still many obstacles, some of them huge, which have to be overcome. It cannot, except under favorable conditions, be broadcast much more than twenty miles. Sending it over the present wire systems is also a long way off, as the existing wires used in these systems are unsuited to the transmission of television as it now stands.

Up to date the size at which television can be shown with reasonably good results is quite small—about the size of half a page of this book—so that the broadcasting of baseball games or football games to large assemblages is still in the future.

Perhaps its greatest handicap is going to be that people will compare its pictorial quality with that of motion pictures. As a matter of fact they bear no relation to each other, as the motion picture is a manufactured article that can be sold at so much a foot and be shipped and stored like shoes or sealing wax, whereas television is but a view of *life* at a distance at the moment it is viewed.

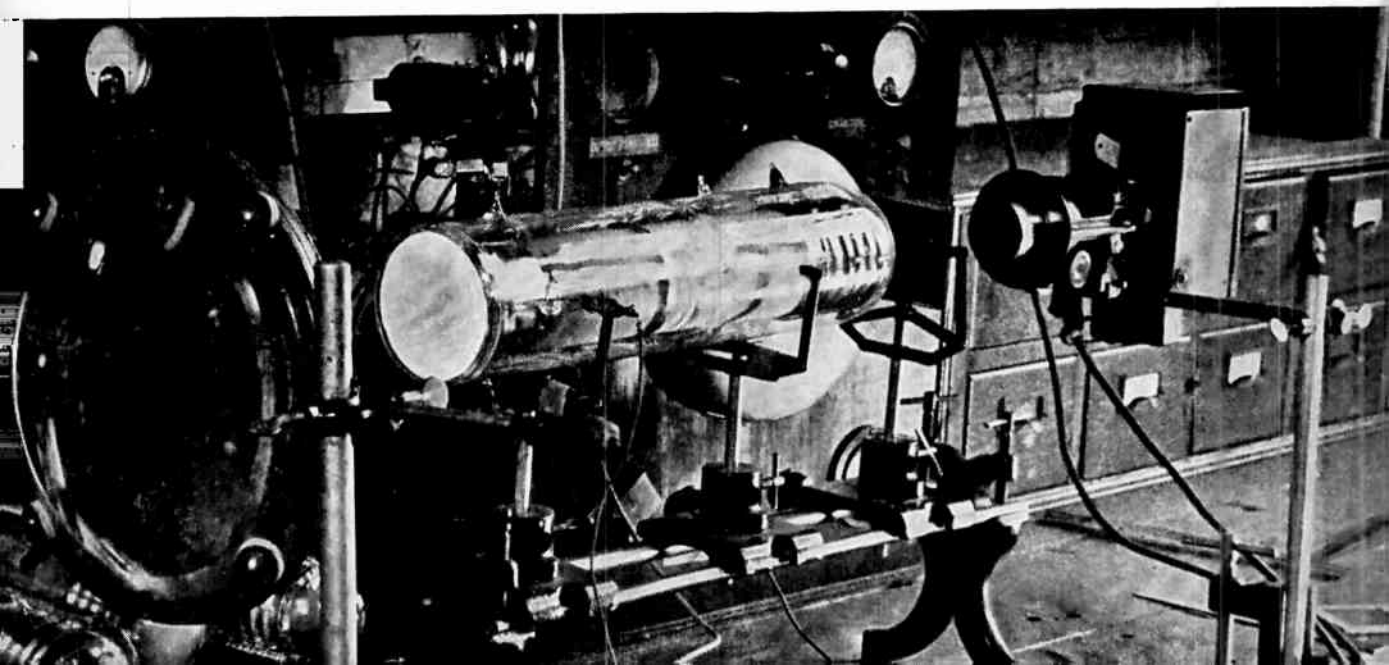
In television there is no negative, no positive, no print. There are no chemicals or developing processes, nothing that can be felt or seen. Nothing goes into the television "camera" but light and electricity, and

A corner in the chemical laboratory

what comes out nobody knows. It cannot be compared with motion pictures any more than radio can be compared with a phonograph record.

The first step forward in television was made in 1873 by Dr. May, who discovered that the element silenium had the property of varying its electrical resistance when subjected to light rays of varying intensity. Although this was before the days of radio the good doctor proceeded to build a device that would, he believed, transmit pictures electrically through the medium of a silenium plate upon which a picture was projected. He was disappointed. The machine never worked. Two years later a scientist named Carey, taking Dr. May's experience as a guide, conceived the idea of using a screen or plate composed of a large number of silenium cells, each of which was energized by an individual electrical circuit. This, too, was a failure although he established the fact that a picture or subject must be divided into a great number of component parts, each one of which had to be transmitted separately to a receiving device that would put them together again. Just as if you sent a jigsaw puzzle piecemeal to a friend who assembled it as he received each piece.

This disassembling, sending, and putting together again was then



Above, an "iconoscope" tube in an early stage. This tube is the "eye" of the television camera

An experimental image tube. It enables man to see through the dark when scenes or images are illuminated with "black light" which may consist of either infra-red or ultra-violet rays

attempted by another method known as the Nipkow disc. This scanning disc method, as it was called, was only moderately successful, for while it did actually transmit pictures they were so flickery and so vague in outline and detail that they were of no real value, so the scanner was abandoned.

It was now quite plain that if television were to be an accomplished fact an entirely new method would have to be adopted. The nearest approach to true television is the human eye, which picks up an impression of an object or scene on the retina from which it is transmitted along a group of nerves to a light sensitive spot on the brain where it is converted into sight. With this analogy in mind science set to work.

Putting the finishing touches on a powerful ultra-high-frequency radio transmitter at the television laboratories

Within ten years Dr. Vladimir Zworykin of the R.C.A. laboratories developed an electric eye which he calls the iconoscope, which is the first device to give practical television results. Beside this iconoscope many of the great marvels of science fade into simple, almost elementary, devices. Although it is in appearance a rather simple-looking affair the miracles that take place within it are unbelievable.

Laboratory model of the television camera. The iconoscope tube is contained in the compartment

It looks like a large spherical bottle with a very long neck. A rectangular plate is suspended within the body and a few electrical gadgets, including a cathode, are placed within the neck close to the stopper.

Now this iconoscope is placed within the television camera in such a way that the image of the subject, a baseball player let us say, is thrown on the rectangular plate. This plate, while it looks very simple, is made up of 70,000 light sensitive cells. As the image is projected on these cells a stream of electrons is played upon it from the heated cathode in the neck of the bottle. These electrons bombard the plate at the speed of light, and are directed at it so that the stream travels from side to side in a series of close lines. As the entire plate is scanned thirty times a second you can imagine the speed of the operation. Each time the plate

An early television test room. A laboratory model of the television camera is in the center foreground

Experimental cathode ray tubes waiting to receive their electron guns. The tube at lower right shows the fluorescent material on the flat end

is scanned its cells send forth an impulse along the scanning beam that varies with the light values of the image which the lens throws on it. These electrical impulses are then converted into radio waves and are transmitted to the receiving instrument which may be miles away. These radio signals come in as conventional waves but are at once set to do a job that is altogether different from what they do in your radio receiving set. In the television receiving instrument there is also a bottle-like "tube." This one, however, is shaped like a Florence flask and is called the kinescope. It is conical in shape, with a short neck and a flat bottom. It is on the bottom of the flask, which is placed horizontally, that you see the image of the ballplayer when from the cathode in the

Inside this door the engineers remove their shoes and change clothing before going into succeeding rooms, where every precaution is taken against dust

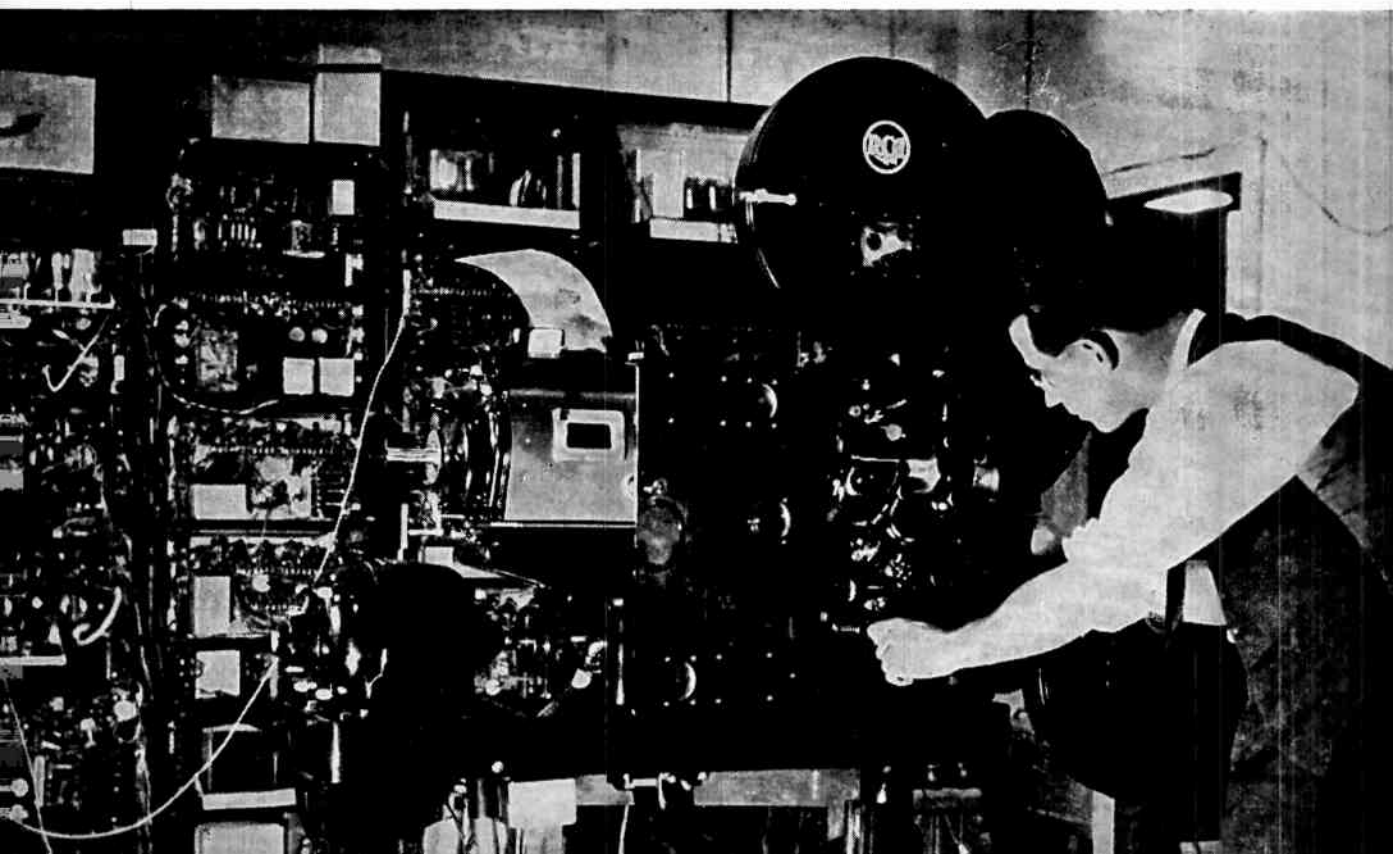
neck comes a spray of electrons which makes the prepared "bottom" fluorescent.

The scientists are still at work on television and are making rapid progress in securing an enlarged image.

The size of their task may be imagined when you consider that they are working with and studying the behavior of electrons which are so small that if a drop of water were enlarged to the size of the earth an electron would be in comparison the size of a grain of sand on the beach. They are as speedy in their movements as is light. When an electron jumps from one spot to another it goes at the speed of 186,000 miles a second.

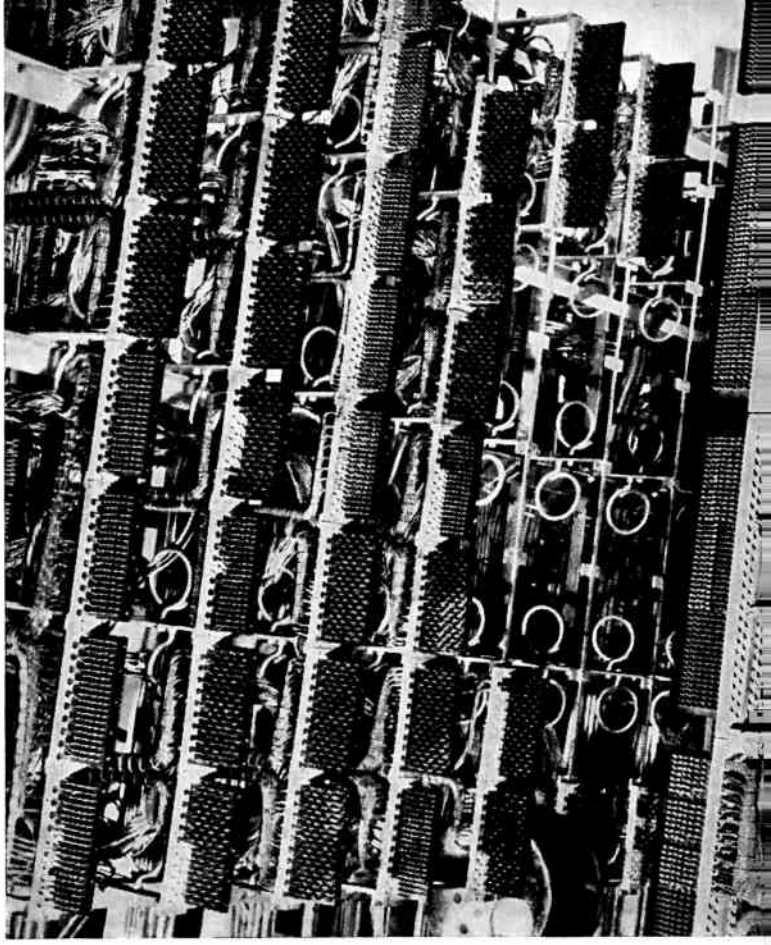
While television is today an accomplished fact, in that we can actually see events that are happening miles away from us, we are still far from the day when it can be considered comparable in coverage and service to the present system of sound broadcasting.

Motion-picture films can be transmitted by television as well as actual scenes



CHAPTER XI

AVIATION RADIO

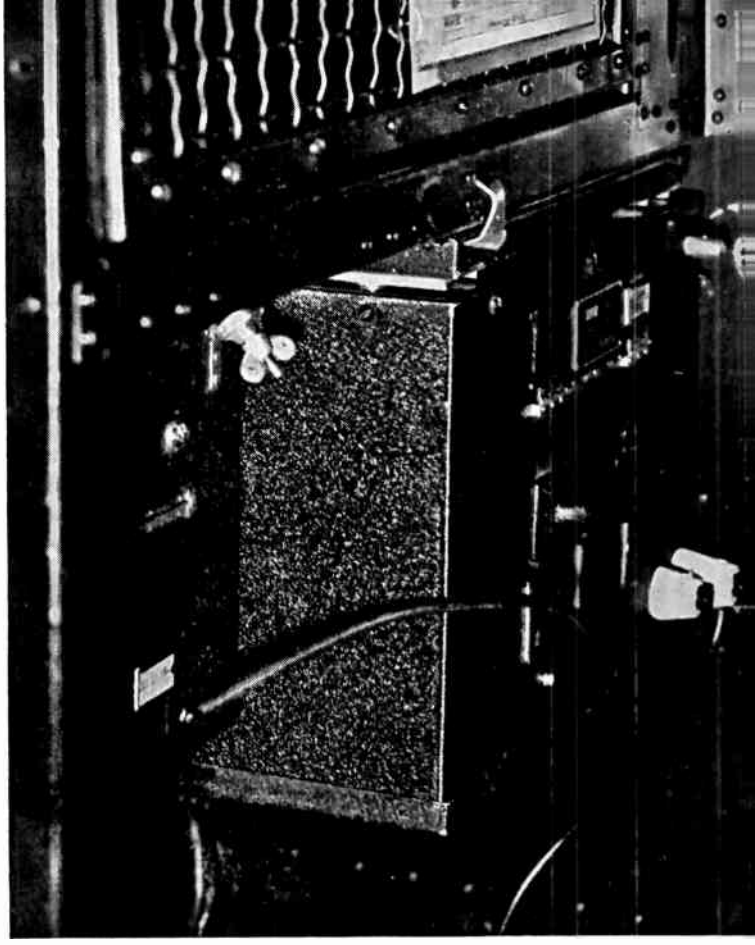


Master distributing frame, where millions of "wireless wires" terminate

THERE IS one more branch of radio communication that may very well be placed on the roster of science wonders, and that is aviation radio. Here we have it working hand in hand with an industry that is as young as itself, sharing its trials and its victories. Without radio, commercial aviation could not have developed to the point it has reached at present. The great airlines and their fleets of monster planes would be practically impotent without the guiding signal of the radio beacon. Pilots, no matter how competent, couldn't operate the huge passenger planes that wing across and up and down the country without the radio phone and the radio telegraph. In fact, it is no exaggeration to say that it was radio that made practical air transport possible.

Let us step aboard one of the transport planes and see how the radio beam works.

The pilot of a transport plane directs the course of his plane as much by sound as he does by sight, and in thick weather he steers entirely by sound. That is why he uses earphones as the captain of a steamship uses binoculars.



Simple transmitter on airliner

Along all airlines are placed at certain intervals a radio transmitter, called a radio beacon. The beacon sends out on the air during the day and night the two letters A and N which in the Morse code are dot dash for A and dash dot for N. Should the pilot deviate to the left of his course he hears dot dash, dot dash, dot dash, and if he strays to the right of it he hears dash dot, dash dot, dash dot, but if he is on his course the dash or long note at the end of A combines with the long note at the beginning of N and they both become a long musical note that indicates he is on the true course.

When he is "riding the beam" he does not have to worry about landmarks or signposts to guide him on his way. With his radio telephone the pilot can keep in touch with the airports on his course. He may speak with other planes and get information on weather and flying conditions.

He can call the airport for which he is headed and be informed on surface wind and be warned of obstructions if there are any. In fog he can be guided to the ground where frequently there is no ground to be seen.

Should his radio telephone foul he has his radio telegraph key to fall back on. Radio is at his command every minute to guide him on his course.

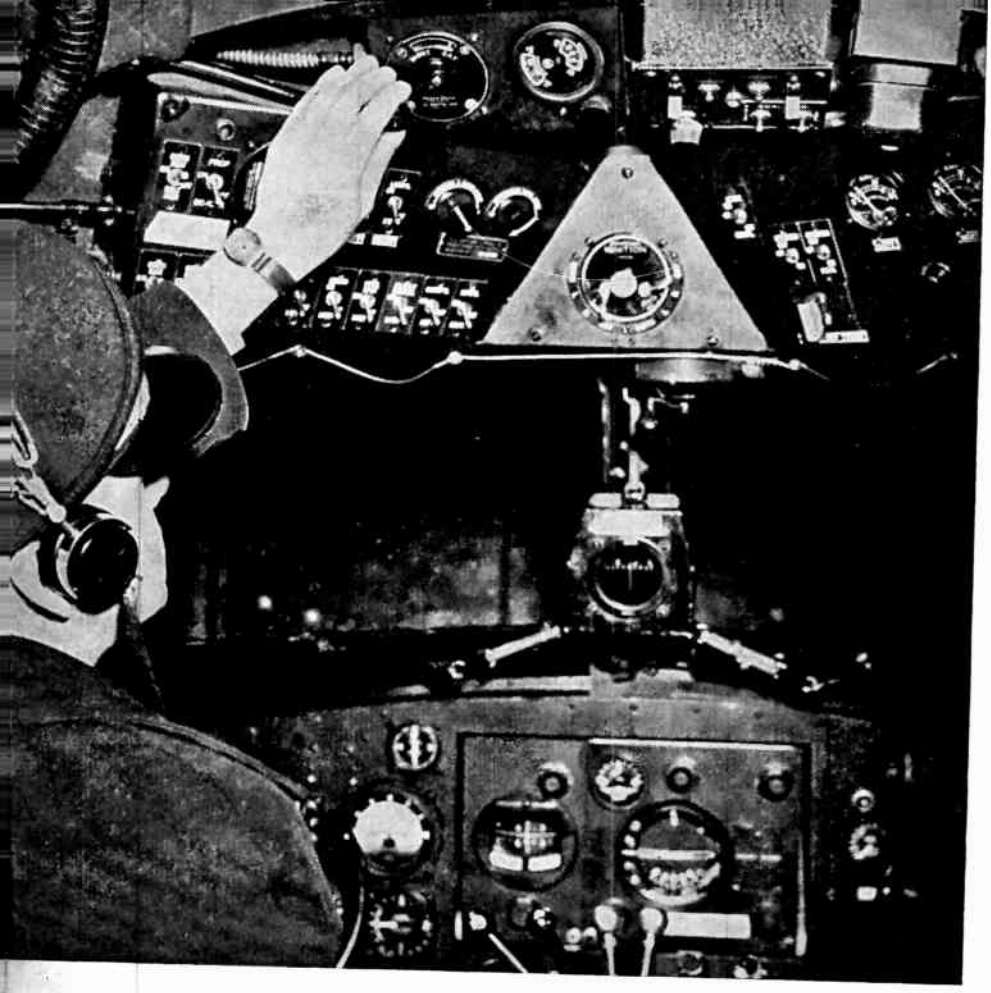
As this was written a pilot left the Pacific Coast in a plane, flew all the way across the country, and landed at the Atlantic Coast without having once caught a glimpse of the 3000 miles of territory over which he flew. His take-off and landing were perfect, and his navigation was accurate although he was enclosed in a cockpit that was so covered in that he had to depend entirely on the unerring radio for his guidance. This blind flying is doing much to remove the danger of fog, and it is believed that the time is not far distant when planes may come swooping in to perfect landings borne on the wings of radio even when the visibility is zero.

Of all the great industries which have grown up around us contributing to our pleasures, comforts, or physical needs, none has had the storybook career of radio.

Born of science, it thrived and grew from puny infancy to adolescence, and then to sturdy maturity under the paternal hand of the scientist. It was, is, and always shall be a child of the laboratory where research permeates every action and every thought.

Entering one of the great radio research laboratories is an experience never to be forgotten, for here one sees men and things that are not of this workaday world. One sees the forces of nature put through a third degree so that their secrets may be wrung from them.

The behaviorism of the electron is studied as if the invisible thing were a horse or a dog or even a human being. The great void of space is explored and measured and prospected as if it were a section of land on



Pilot listening in on "beam"

which oil or gold had been discovered. The mystery of light and sound is forever being probed. Waves and wave lengths are sorted and segregated and tied up in bundles like asparagus.

So broad is the scope of radio research that it may take two generations of ceaseless effort to bring to ultimate fruition some of the subjects being delved into today.

In no other place in industry will you find men engaged in such abstruse problems. Surrounded by all the physical equipment and material and skilled help they need, they pursue their fond dreams or pet phantoms without a worry as to the financial wherewithal or the security of their job—for job it is.

They may never actually catch up with their elusive will-o'-the-

wisp, but in the chase they are led into out-of-the-way places that sometimes prove to be storehouses of facts and findings that are valuable beyond price.

Of all the phenomena of the radio research laboratory none is more astonishing than the youth of its personnel.

There are no grizzled beards or heads bowed by the weight of years and knowledge. The figure you see peering into the microscope is broad shouldered, young, and vigorous. Among the thousands of strange chemicals, amid a forest of glass tubing and electrical wiring, there are no venerable octogenarians holding up test tubes in trembling fingers—not a bit of it. You see, instead, young men who must undoubtedly be good pitchers or catchers or first-base men.

Youngest of the industries, radio has attracted youth. It demands youth, in fact. In one of the large radio concerns the average age of the personnel in all its branches would be in the thirties. Virility and vitality are as necessary in its personnel as in its signals.

That is the story of radio as it stands today. What the future shall bring to it is hard to say. One thing is certain, however. As the world advances, radio keeps step with it in contributing to our safety, information, education, and pleasure—a pleasant outlook as we sign off.