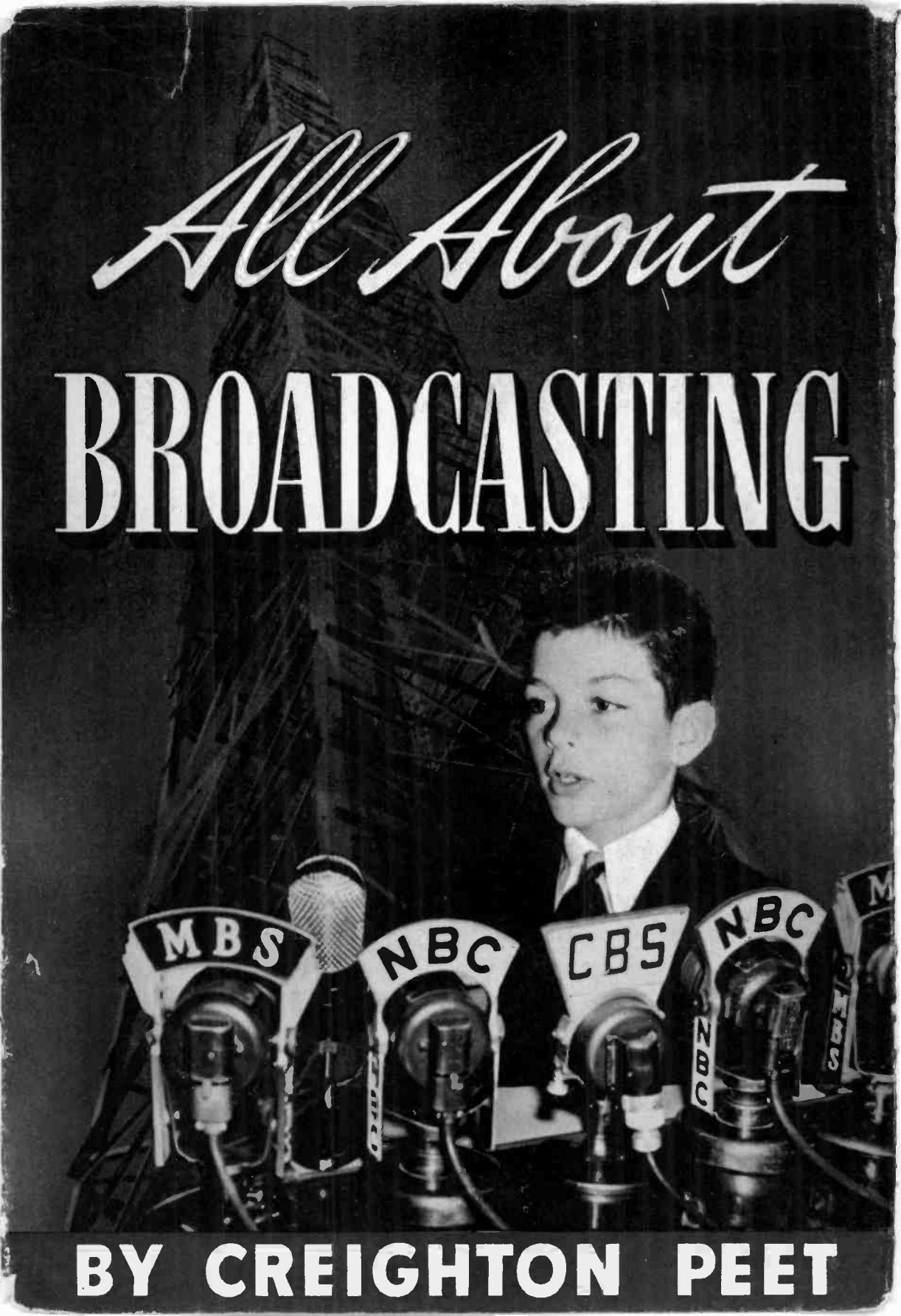
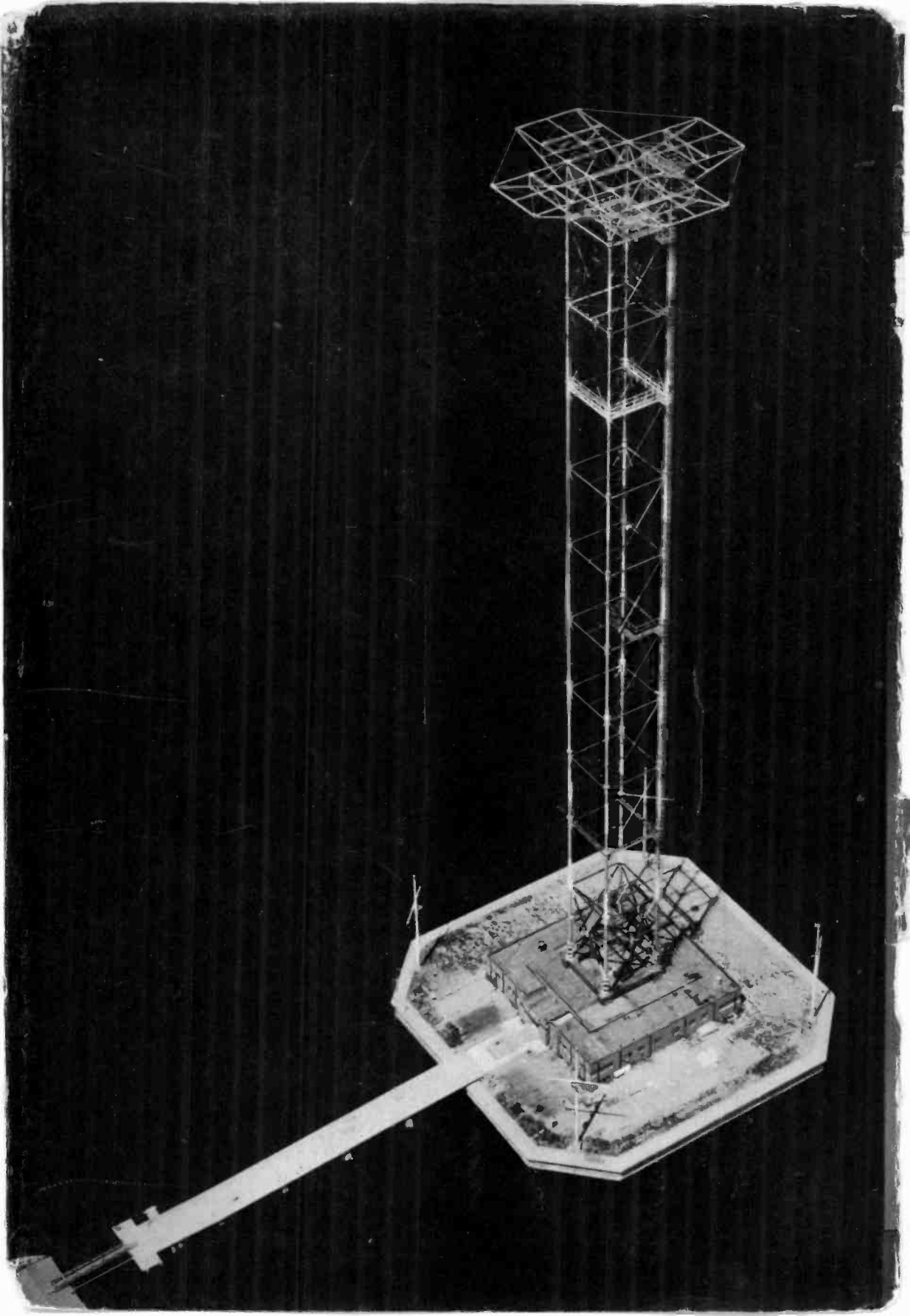
All About BROADCASTING



BY CREIGHTON PEET



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ALL ABOUT

BROADCASTING

by **CREIGHTON PEET**

How is it that radio programs can be picked up almost anywhere?

Hugh was quite sure that there was more to it than "people played music in the studio and then the waves came right into your radio" as one of his friends explained.

And he was determined to find out. So the next time his father went to New York he took Hugh along and they went to visit some engineers who did know all about radio.

From the translation of sound waves into electrical waves by a microphone, to the latest development in television, *All About Broadcasting* is a vivid, realistic presentation of one of the greatest achievements of modern science. It is made even more fascinating by the great number of excellent photographs which graphically interpret the text. All who enjoy listening to the radio will welcome this timely book.

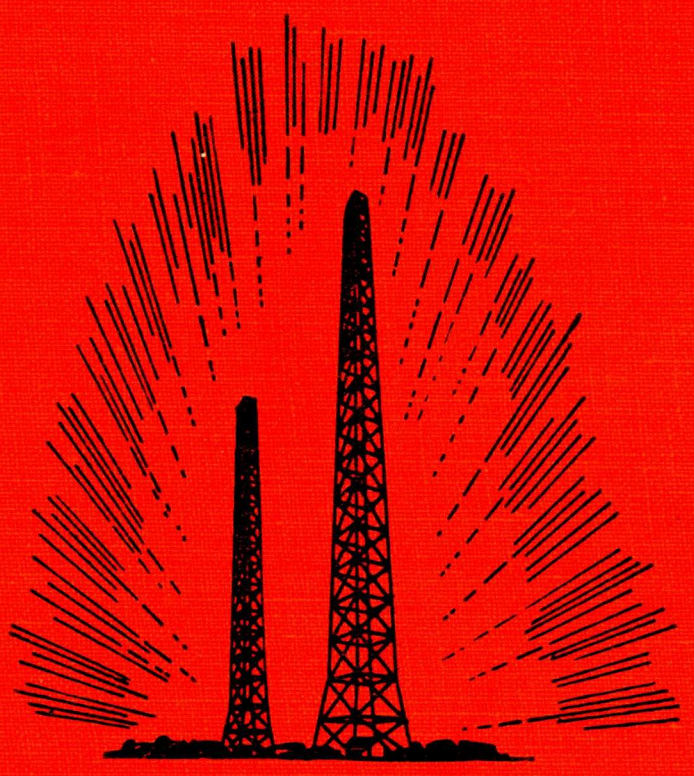
09014

CREIGHTON PEET

To judge from the number of countries in which he has lived, the long list of books he has written and the number of newspapers and magazines to which he has contributed, Creighton Peet should by all possible standards of computation be old and carewcrn. But hard work and an insatiable curiosity about life and "what makes the wheels go round" have kept him younger and more full of pep and enthusiasm than many men half his age.

He was born in New York City just at the turn of the century and though educated abroad and in various schools in this country he is a graduate of Columbia University. He began working as a reporter on the Philadelphia Evening Bulletin.

He is married, lives in New York City, and has a young son who promises to follow in his father's footsteps.



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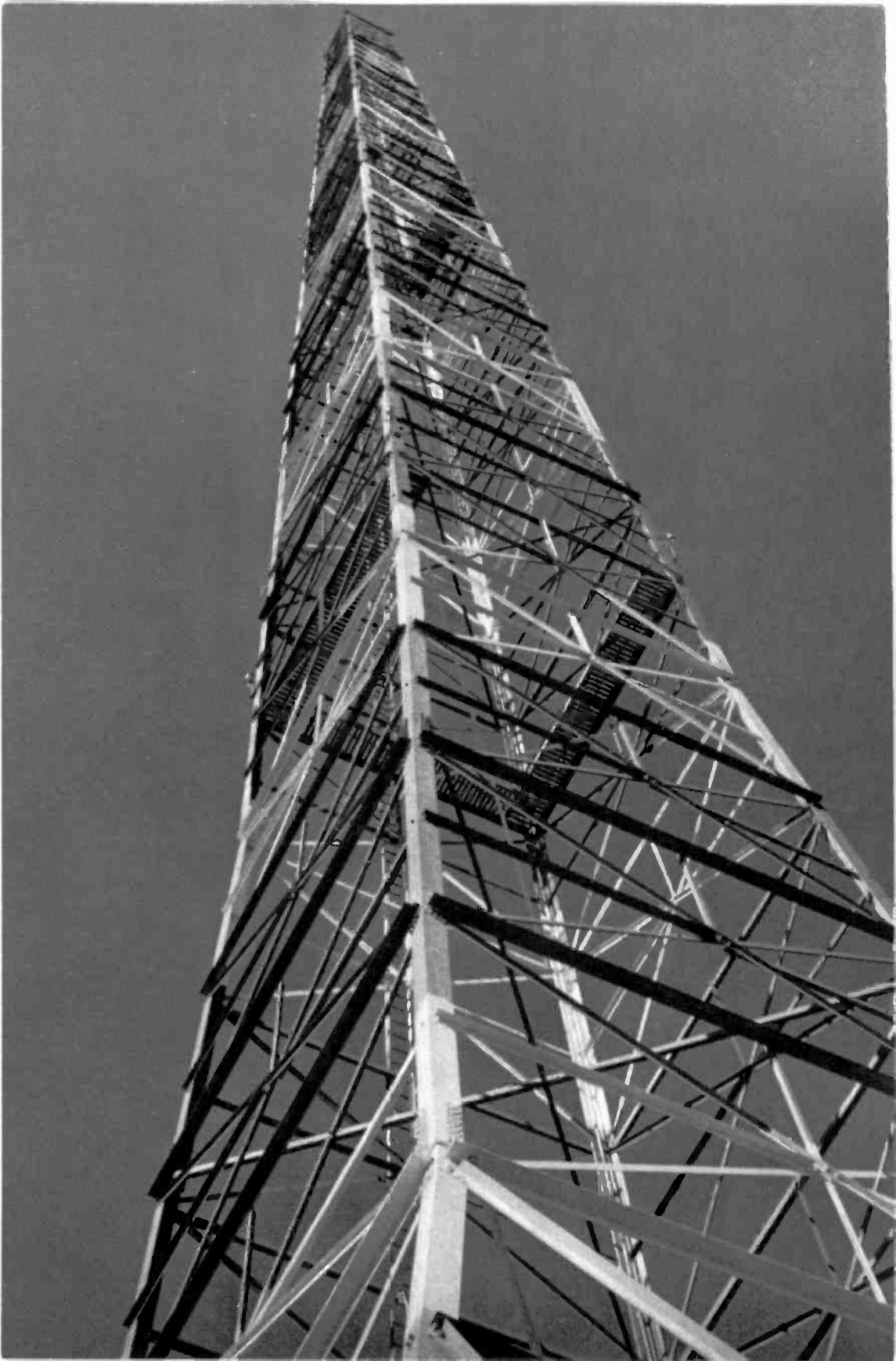

ALL ABOUT

BROADCASTING

BY

CREIGHTON PEET

[PHOTOGRAPHS BY THE AUTHOR]

ALFRED · A · KNOPF

NEW YORK


ALL ABOUT
BROADCASTING
NBC
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One afternoon Hugh and some of his friends were out on the lake listening to the radio. After a while one of the boys said he wondered how programs could be picked up almost anywhere.

Somebody said that was easy: people played music in the studio and then the waves came right into your radio.

Hugh said he didn't know much about it but he was sure there was a lot more to it than that. He said he was going to find out all he could.

That night when he went home he asked so many questions about the radio that his father and his mother and his brothers and his sisters and everybody else decided he had better go and find out about radio for himself.

[*p.* 2]

So the next time his father went to New York he took Hugh along, and they went to visit some engineers who did know all about radio.

First they learned that, although there are radio stations in hundreds of towns all over the United States, most of the big programs come from New York, Hollywood, or Chicago. These programs go out to the other stations over long-distance telephone wires. Most stations broadcast a combination of local programs and network programs.

There are four big networks in the United States: NBC, or the National Broadcasting Company; the Blue Network Company; CBS, or the Columbia Broadcasting System; and MBS, or the Mutual Broadcasting System.

Before going through the studios, Hugh and his father decided to find out something about how radio works—that is, how programs get on the air.

[*p.* 3]

The engineers told Hugh that if he wanted to find out about broadcasting, he should start where the programs do—with the microphones. They got out six kinds of microphones which are used for different types of broadcasts. The one on the stand at the left is for orchestras and dramatic shows, while those on the table are for speakers, news commentators, and sports announcers. The one hanging from the long arm at the right is a piano microphone, while the little one Hugh is holding in his hand is used when the speaker is walking around in the street, following a golf tournament, or interviewing people scattered over a big area.

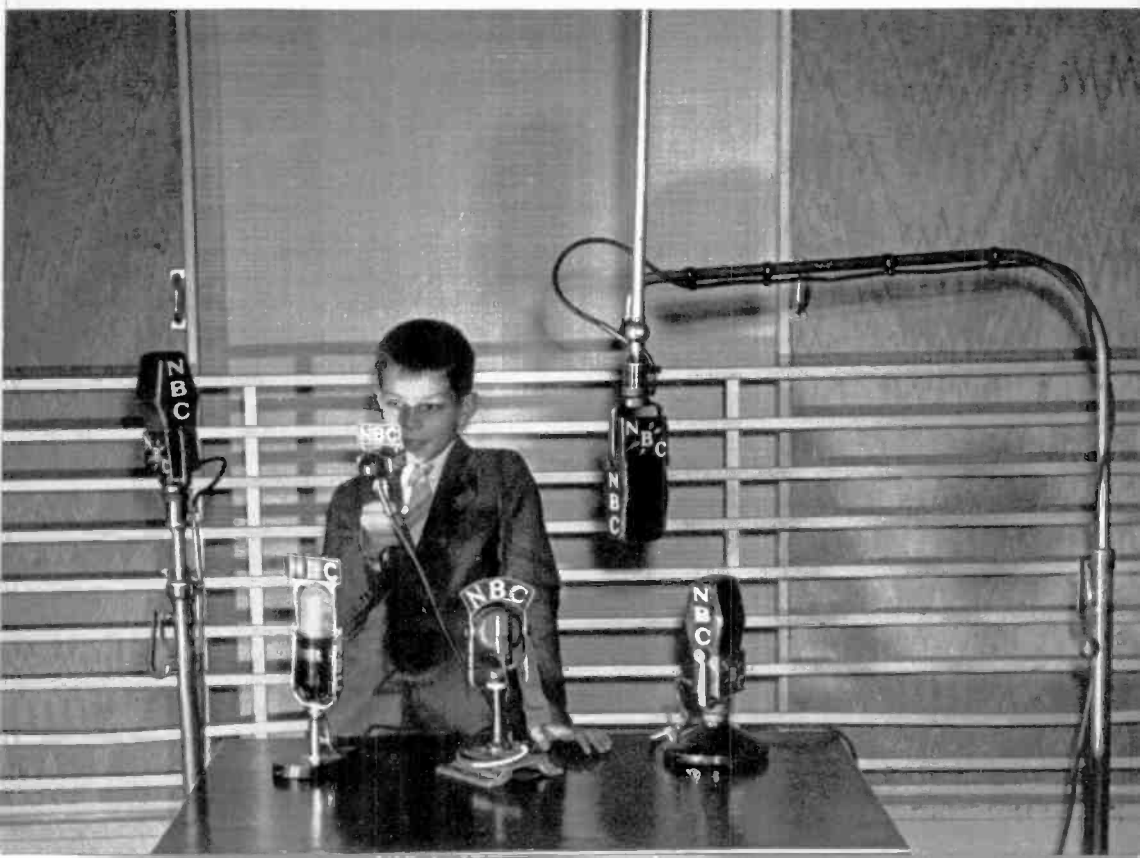
[*p.* 4]

Before anything can be broadcast, the engineers said, the sound waves, which are set in motion by voices and musical instruments, must be translated into electrical waves by a microphone.

Sound waves are vibrations of the air we breathe, and travel only about 1,100 feet, or the length of a city block, in a second. They are the waves which strike our ears when we hear anything. They are muffled, or even stopped completely, by walls, buildings or trees. Also, most sound waves can be heard only a few feet away, even when there is nothing between us and them.

Radio waves, which are electrical, travel with the same speed as light, or 186,000 miles a second, which is fast enough to go almost seven and a half times around the world in one second. Unlike sound waves, radio waves pass easily through, or around, or over buildings, forests, mountains, and other obstructions, and some have been picked up after actually going clear round the world.

[*p.* 5]



Both sound and electrical waves can be compared to the waves made when a stone is dropped in water. All three kinds of waves become fainter as they get farther and farther from their sources, but all stay the same length, even when they are very faint. The length of a wave is the distance from one crest, or top of the wave, to the next.

Every sound has a definite number of vibrations. If someone strikes middle *C* on the piano, for instance, he will send a sound of 256 vibrations per second into the air. Even if you are at the far end of a hall, and can barely hear the sound, it will still have 256 vibrations, and still be the same middle *C*. Another explanation is to say that this sound has a *frequency* of 256 cycles, or vibrations, per second. The same thing holds true with all sounds, no matter how many or how few their vibrations. People in radio usually talk about sound in terms of *frequencies.*

When actors speak or a band plays, a series of sound waves strikes the sensitive face of a microphone. These sound waves start an electric current flowing through the microphone which is identical in length to the sound waves. As it continues to "hear" [*p.* 6] sound waves, the microphone will faithfully translate into elec-

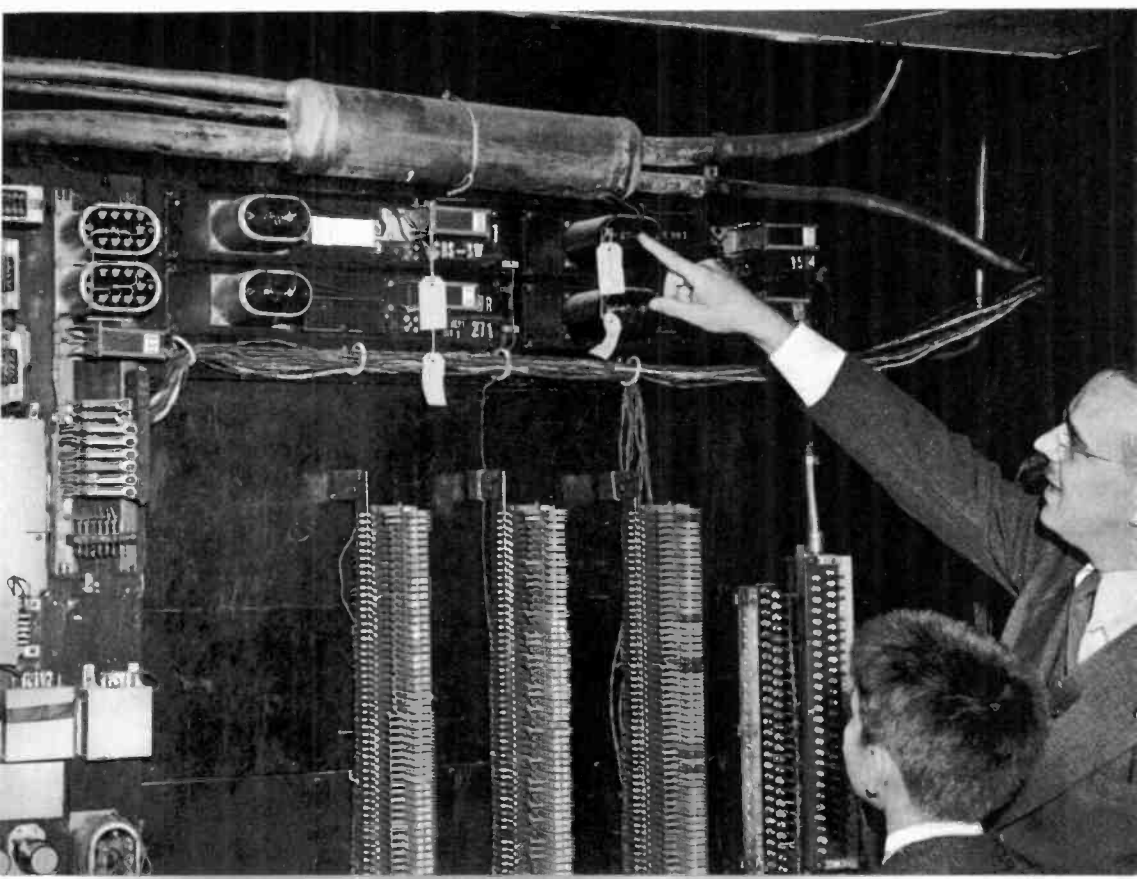
trical waves all the sounds and combinations of sounds which come to it.

After leaving the microphone, this current goes through a great many control points until it is sent out to the transmitter station to be broadcast.

So far the process has been exactly like that which goes on when you talk into a telephone, and most radio programs even go out from their studios over a telephone wire in a regular cable. In cities, this cable goes under the streets, and out in the country, on poles. Hugh saw the cable connections in one of the big studios.

Transmitters are usually several miles away from a city or town of any size, and in the middle of a big empty field, or on an island in a bay or a river. They are built in such places because a transmitter with any power at all "blankets" the area for miles around it. If a big transmitter were in the middle of a city, the people living there would have a great deal of trouble getting any other station on their radios.

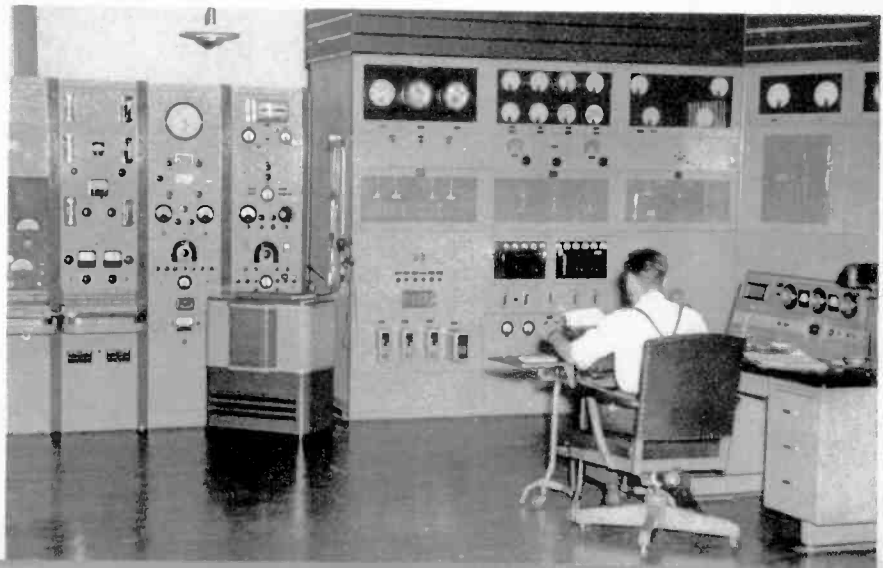
[p. 7]



Another reason why transmitters are usually placed in out of the way places, is that engineers have found that radio waves get a better start from a flat piece of ground than from one covered with tall buildings. The best "pathway" of all for radio waves is salt water. Two big radio stations spent thousands of dollars not long ago to move their transmitters to points from which their radio waves could reach New York City by a direct path over salt water. One station was moved only six miles.

The transmitter station Hugh visited was a little one-story building, not much bigger than an eight-room house. Even in the main control room everything ran so smoothly that no one seemed to have much to do.

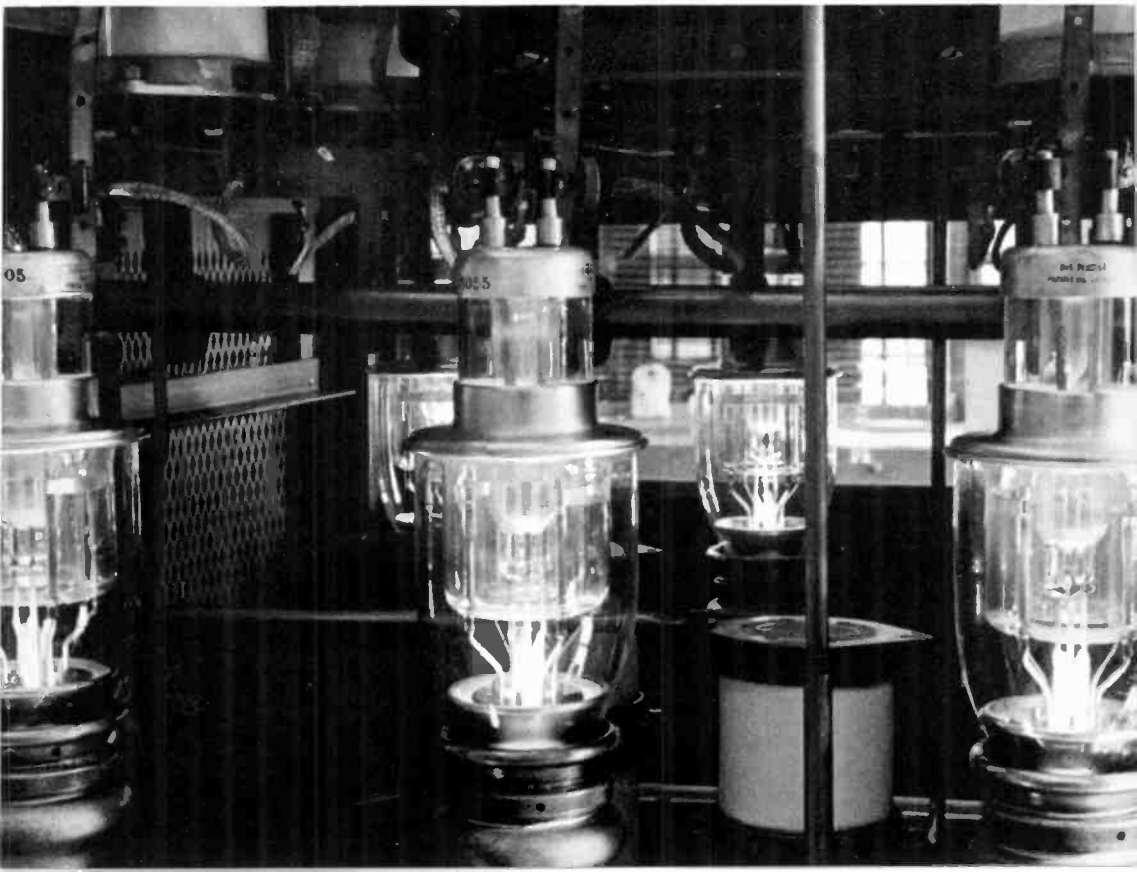
[*p.* 8]

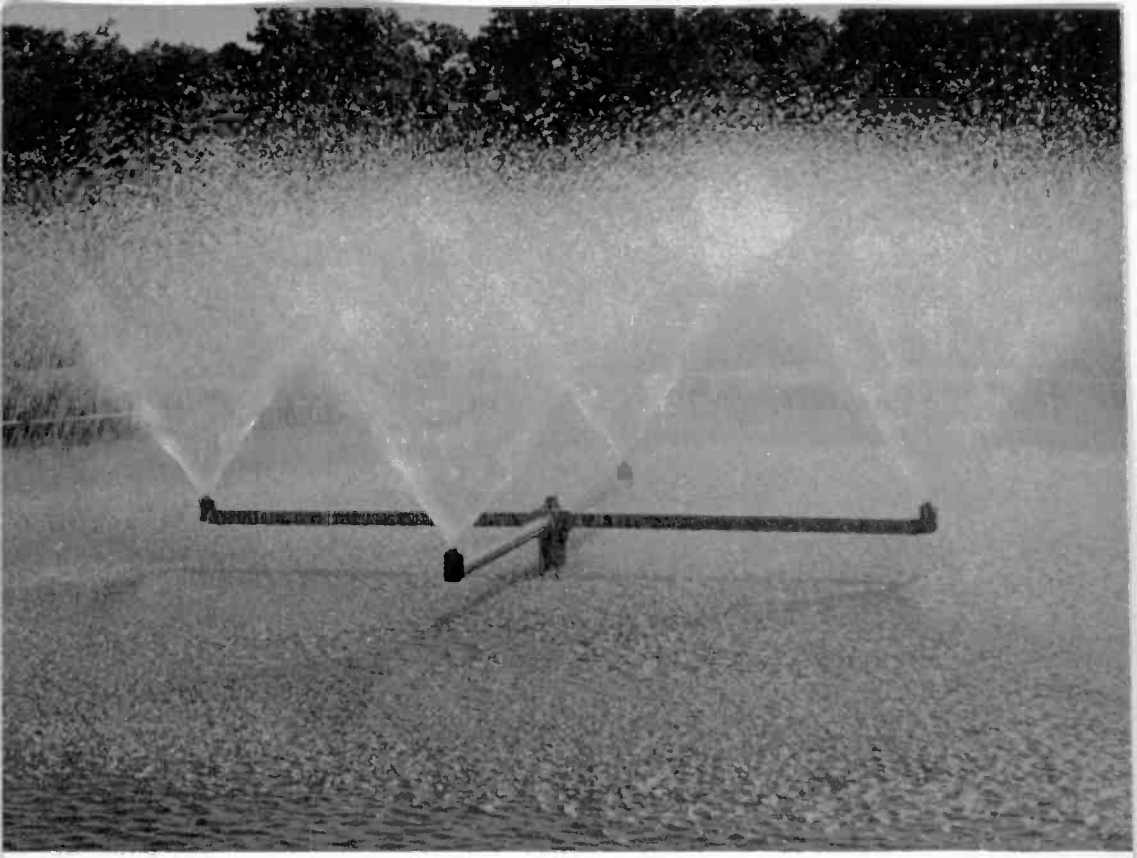


Although the current which starts at the microphone has been strengthened for its trip to the transmitter station, it is still much too feeble to take to the air when it reaches the station. Before it can be broadcast and picked up by thousands of receiving sets in the hundreds of square miles a station serves, such a current needs a tremendous boost.

Just how much of a boost it gets depends, of course, on the power of the station in question. A 50,000-watt station, the largest regular commercial type now approved by our F.C.C., or Federal Communications Commission, makes a good illustration, since nearly every large city is served by several such stations. A 50,000-watt transmitter can be heard about fifty to a hundred miles in the daytime, and many more miles at night.

At the transmitter station the little current from the microphone is passed first through a series of tubes, starting with little ones much like those in your radio set, and ending up with giant amplifying tubes each about two feet high, carrying 20,000 volts, and costing about $500 each. [p. 9]

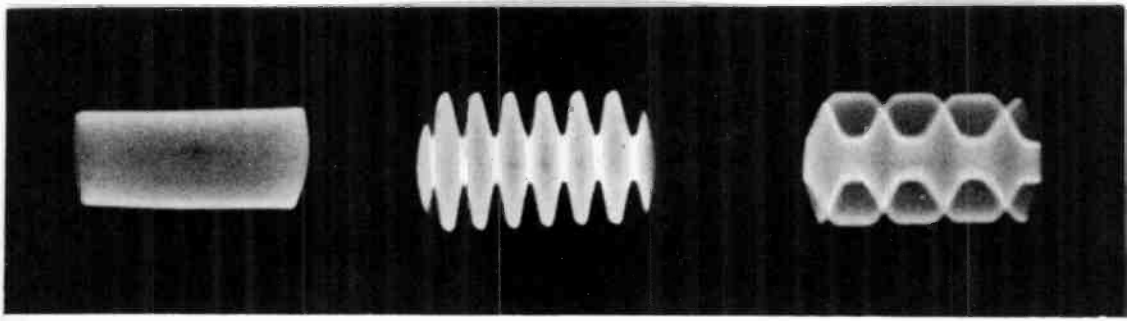




In front of many transmission stations there are pools with sprays like this one. It is not just a fountain, but a part of a cooling system to keep these big tubes running properly.

The lower part of each tube, which goes way down in a socket, must be cooled constantly by flowing water, like the engine of a car. This water is then pumped out of doors and forced through a spray. At the same time cool water from the bottom of the pond is pumped back into the tube cooling system.

The current starting at the microphone is now amplified, but is still not strong enough to go on the air, so the engineers take 225,000 watts of ordinary electric energy—enough to keep a good-sized town going—and create a powerful "carrier" wave. This carrier wave has a permanently fixed rate of vibration, which was assigned to it by the F.C.C. No other station in the same [*p.* 10] part of the country can use this wave length, so that its broad-



casts can be picked up without interference from any other stations.

The amplified wave from the microphone is now *superimposed* on this powerful carrier wave. It modifies the carrier wave without changing its *rate* of vibration. That is to say, the waves all stay the same distance apart, but differ greatly in size.

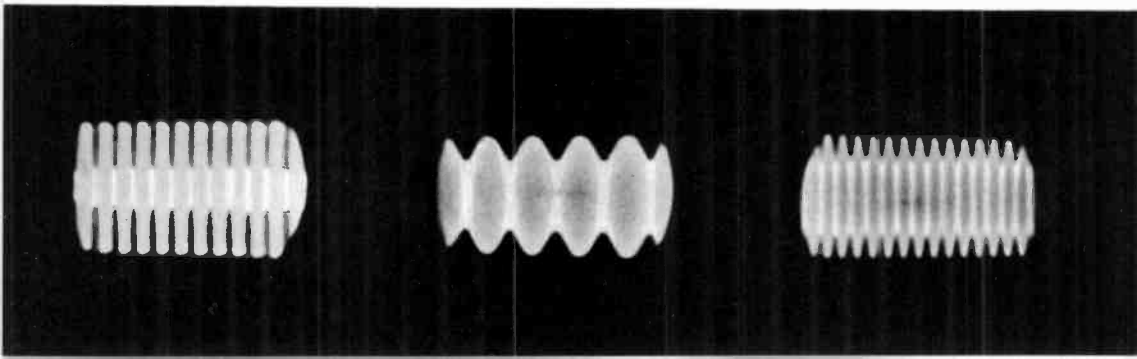
One engineer explained it this way: you might think of the carrier wave as a bolt of cloth reaching from the transmitter right down into your receiving set. Then think of the sound waves as patterns which slide along this cloth at the rate of 186,000 miles a second! As these patterns speed by, they change the shape of the cloth. Sometimes they stretch it to double its width. At other times they squeeze it to a fraction of its usual size. The instant the patterns have passed, the cloth is again even and smooth.

In a laboratory Hugh saw what radio waves really looked like in an instrument called an oscillograph. From the outside the oscillograph seemed to be a box with a round glass window in one end.

In the upper left-hand corner you can see a carrier wave all by itself. It is so even and steady that it looks like a solid band of light.

In the other pictures this same carrier wave has been modified by different sounds. Every time Hugh whistled a different note, the wave picture in the oscillograph changed.

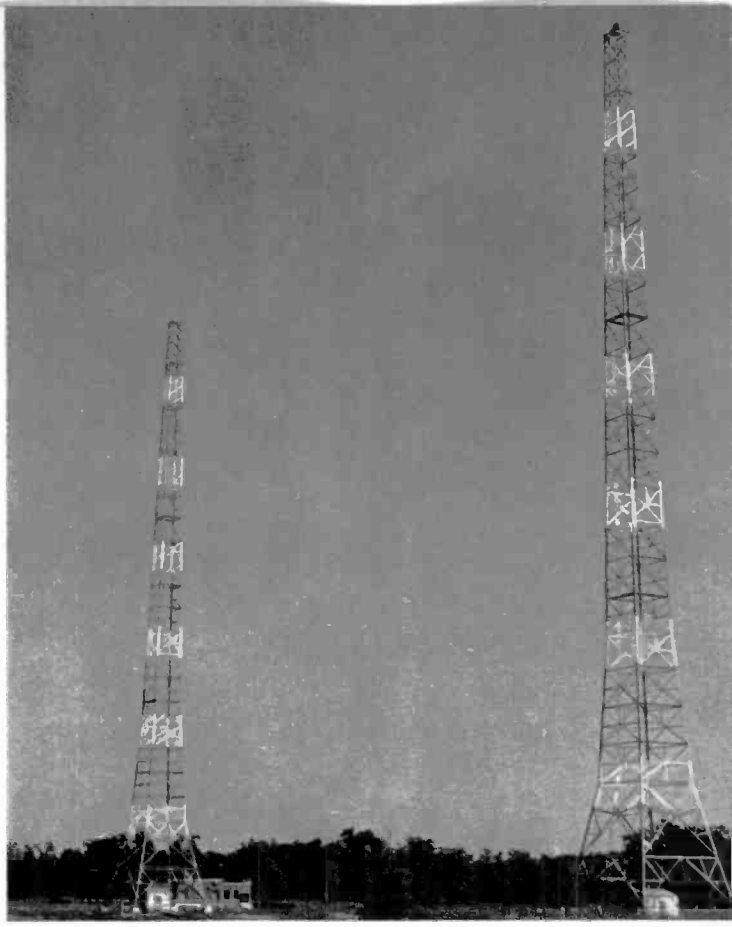
[*p.* 11]



After making several sounds by themselves, the engineer turned on a regular radio program of orchestra music, but this time the oscillograph showed so many flashing streaks of light that it was impossible to make out any patterns. The engineer told Hugh it was because so many different sounds were all making patterns at once that only a jumble could be seen.

After the combined sound and carrier waves have gone through a final amplfication, so that the sound wave has about 50,000,000,000 times as much power as it had at the microphone, they are led out to the transmitter's towers, or radiators as the engineers call them. The conductor which takes this powerful current out to the radiators is often covered, as this one is, with very special insulation which includes a layer of heavy tiles.

[*p.* 12]



A transmitter may have one, two, three or even more towers depending on the location and type of service. Some towers are insulated from the ground, others are not. As you can see, there are no wires in the air between these towers. The radio waves go out from the metal structure of the tower itself. The wires you sometimes see fastened to radio masts are usually cables to keep them steady in a wind storm, and have nothing to do with broadcasting.

Hugh noticed that the towers were painted in alternate stripes of red and white. The engineers told him that all radio towers must be painted exactly this way so that airplane pilots will be sure to see them. At night a red light shines from the top of each tower.

[*p.* 13]

The engineers also said that the transmitter was grounded through a series of copper ribbons, each about 600 feet long, which had been plowed into the ground nearby. They went out from the transmitter like the spokes of a wheel.

When you tune in your radio set you are fixing it so that it will receive a particular carrier wave. Suppose you turn your dial to 830 kc, or kilocycles. Since a kilocycle is a thousand cycles, you are setting your set to receive a carrier wave with 830,000 cycles, or vibrations, per second.

A city full of radio sets tuning in is much like an orchestra in which all the instruments are being put in tune with a piano, or some other instrument.

After your receiving set is tuned in to the carrier wave of the station you want, the set itself then reverses the whole process of broadcasting so far as it has gone.

First, the set separates the wave coming from the microphone from the carrier wave.

Then it amplifies, or strengthens, this wave, and finally it changes these electrical vibrations back into sound waves in the air—which your ears can understand.

To get a different station you simply put your set in tune with a carrier of another frequency.

There are many kinds of carrier waves but those with which we are most familiar are the "long" waves used in most local broadcasting, and the short waves which travel vast distances and are used chiefly to send news bulletins from one continent to another.

When engineers say that your local radio station sends out long waves, they mean that the crests of the waves are far apart, not that the waves reach a long way. Generally speaking there may be about three to ten long waves to the mile.

In the United States local broadcasting stations use wave lengths between 550 and 1,600 kilocycles, or 550,000 to 1,600,-
[*p.* 14] 000 cycles per second. On your radio dial this is usually short-

ened to 55 and 160.

The government assigns frequencies to commercial broadcasting stations in units of ten kilocycles. That is, there is one radio channel at 550, another at 560, another at 570, and so on up to 1600. This is called our local broadcast band, and you can see it gives us only 106 radio channels.

Yet there are over 885 radio stations in this country. This is possible because several stations may use the same wave length if these stations are sufficiently far apart, or so placed that their programs won't interfere with each other.

Powerful stations in the same city or area are usually at least fifty kilocycles apart. Before you can operate a radio station you must prove to the F.C.C. that you will not interfere with the broadcasts of any station already on the air. Radio waves often do surprising things, so there are few hard and fast rules as to when and where you can build a transmitter.

There are three kinds of radio channels:

1. Clear channels—which are reserved for single stations, usually operating on 50,000 watts.

2. Regional channels—one of which can operate in each region. These are usually at least 300 to 400 miles apart.

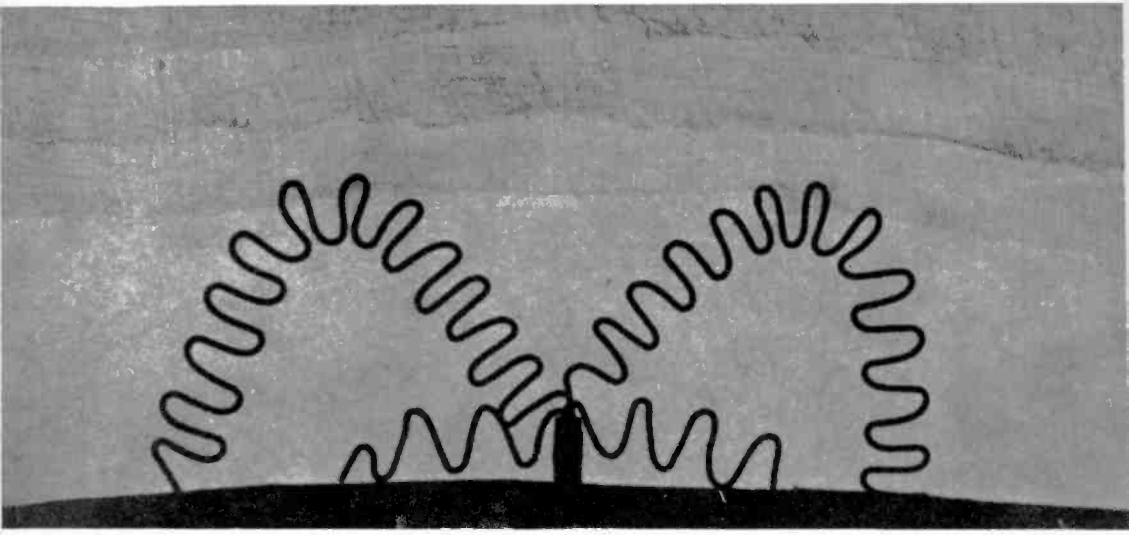
3. Local channels—on whose wave lengths there may be as many as a dozen stations, in different parts of the country.

Usually stations with the same wave length have very little power, but WPTF of Raleigh, North Carolina, and KPO of San Francisco, California, for instance, both 50,000-watt stations, operate on the same wave length, 680 kilocycles. These two stations are 2,400 miles apart.

Sometimes stations using the same wave length interfere with each other in very surprising ways. Both WNYC, New York City's municipal broadcasting station, and WCCO, a Columbia network station in Minneapolis, use the 830 kilocycle wave length, or channel. During the daytime both stations get along without any trouble, but when the sun sets in Minneapolis, the

western station can suddenly be heard in New York, causing a good deal of noisy interference. For this reason WNYC, which is a regional station, gives up and goes off the air when the sun sets in Minneapolis. This varies from about six o'clock in the afternoon, New York time, in December, to around ten o'clock at night in July and August.

If you could see a local, or long-wave radio program leaving the radiator of a transmitter station, the waves would probably look something like these, except, of course, that instead of the



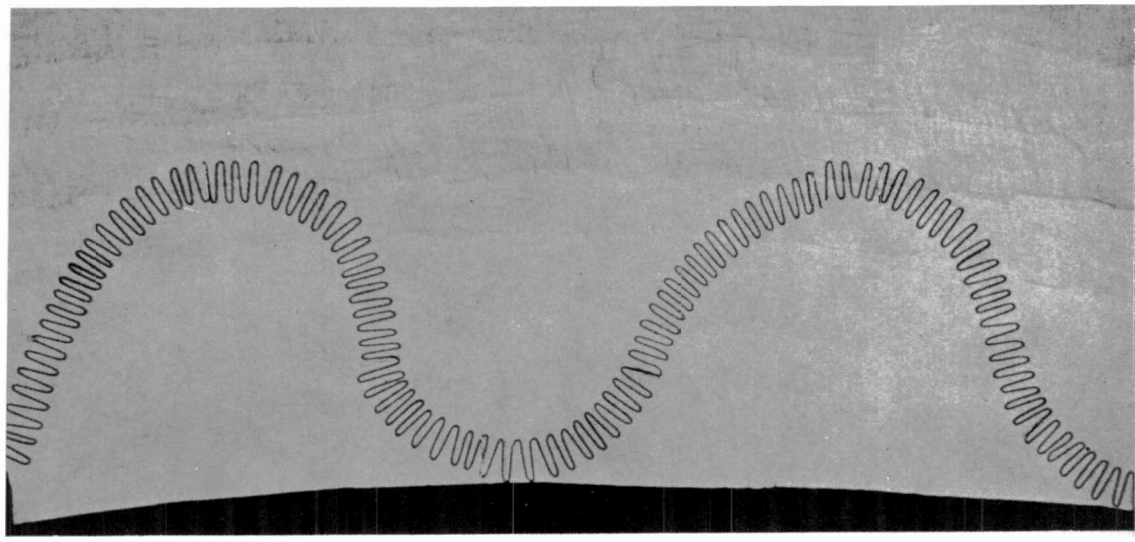
few waves in the picture there are billions of them, completely covering the area around the tower.

Most of the long waves go out pretty straight from the tower in all directions. Some are "ground waves" and follow the general contour of the land. They flow over and around and through buildings and mountains. After traveling a certain distance, however, these ground waves become too weak to be heard, so that listeners a hundred miles or so away get their programs from another kind of wave.

[*p.* 16]

These are "sky waves," which go shooting off into space after leaving the radio tower. After these sky waves go up a "short" distance above the earth—actually about eighty-five miles—a very surprising thing happens. They seem to strike something which makes them bounce back to the earth again, so that they can be picked up in receiving sets.

The thing they bounce against is an area called the ionosphere, or the Kennelly-Heaviside Layer, a pretty fancy name for something nobody has ever seen, felt, tasted, or heard.



The ionosphere is a sort of electrical sounding board suspended in space above the earth, which prevents radio waves from going off and never returning. This ionosphere surrounds the whole world, so that our earth is like an immense tennis ball inside a still bigger one.

We know very little about the ionosphere, except that it refracts, or deflects, radio waves, that it is affected by sunspots, and that it is much nearer to the earth at night than it is in the daytime.

Scientists believe that darkness and the heat of the sun have something to do with this change. Probably the ionosphere or some of its many layers come within fifty miles of the earth after dark. Anyway, that is why you sometimes get better radio reception at night. The waves don't have to go up so high before they bounce, so that they are still quite strong at a considerable distance.

We also know that the ionosphere is affected by sunspots, northern lights and other electrical storms, so that for hours at a time it is of no value at all as a ceiling against which radio waves can bounce. One thing is certain about the ionosphere. Without it no radio of any kind could be heard more than a hundred miles or so from its transmission station.

Local stations usually broadcast with equal force in all directions, but sometimes the engineers direct the waves so that they concentrate on the most thickly populated areas. The transmission towers of New York's radio stations, for instance, send their strongest waves over the city, and as little as possible to the east, as there is no use wasting power on the Atlantic Ocean. Likewise, in San Francisco the strongest signals are sent inland, rather than westward over the Pacific Ocean.

In short-wave broadcasting the wave lengths run from about 6,000 kilocycles to 25,000. They are called short because their crests are sometimes only about a hundred feet apart. As you can see from the model of the single one in the illustration, the waves all shoot upward from the transmitter at very sharp angles, and if they didn't hit the ionosphere and bounce back, they would keep right on going and never be picked up at all.

But unlike the long waves which bounce very little against the earth once they have been deflected by the ionosphere, the short waves also bounce just as well against the earth as against the ionosphere. Moreover, they keep on bouncing between the earth and the ionosphere for thousands and thousands of miles.

[*p.* 18] This is why short-wave programs, which often can not be picked

up at all near the transmitter, can be heard across oceans and continents, and even coming back from around the world, about a seventh of a second later.

A short-wave broadcast from London to New York might bounce against the ionosphere from one to a dozen times depending on the time of day and atmospheric conditions.

Broadcasting with short wave is a good deal like using a garden hose. The beam, as the signal is called, is generally directional—that is, it is aimed squarely at that part of the world to which the broadcast is directed. Of course, by the time the beam has traveled five or six thousand miles it has fanned out and covers a large area, but it still takes a good many separate beams to reach different parts of the world.

The result is that a short-wave transmitting station must have a whole system of antennae, each one aimed at a different part of the world. We use two separate beams to reach South America, for example, and a third for Central America. Two carry programs in Spanish, while the eastern beam directed at Brazil has programs in Portuguese.

[*p.* 19]

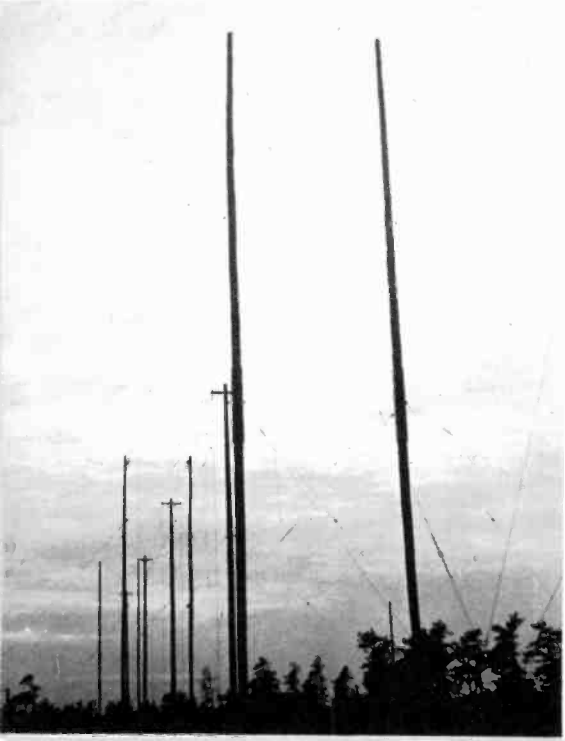
One afternoon Hugh went out to see the CBS short-wave transmitter. It was way out on a lonely section of seacoast, far from any main roads or buildings. Short-wave sending stations are always located in out-of-the way places because they need so much land. It would be too expensive to build one near a city.

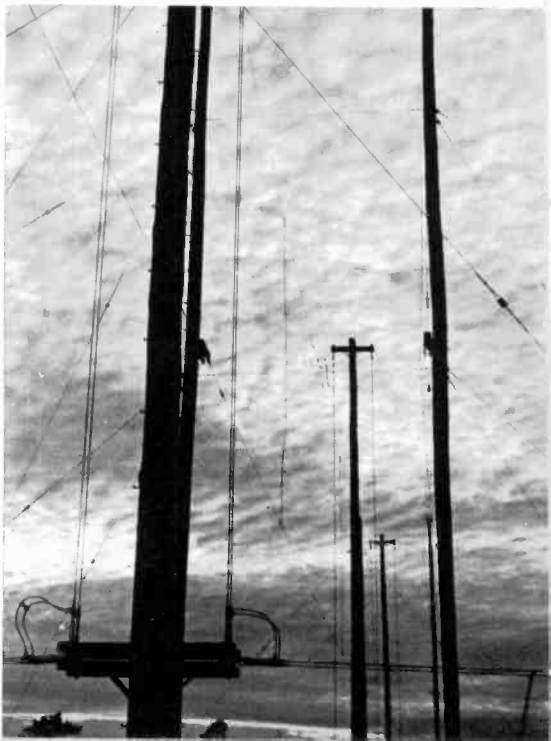
At first all Hugh could see was a jumble of poles and a strange arrangement of wires. The engineers told him they had a good many antenna systems that covered several acres. This picture shows the poles and wires needed for one antenna.

The wires from which the short waves come are called the "curtain." This particular curtain is directed at Mexico. To make a short-wave beam work properly, however, a second set of wires, called the "reflector," must be hung right behind the first. If this were not done, two beams instead of one would go out, in opposite directions. The result would be that short-wave listeners would seem to hear an "echo." They would receive everything twice, as it came at them from around the world in both directions at once.

Short-wave radio is sometimes blacked out entirely for hours at a time by sunspots. Usually sunspots run in a regular twenty-eight day cycle and can be predicted by astronomers, but others come suddenly and blot out a broadcast without warning.

[*p.* 20]





Another kind of broadcasting which is a great improvement, but which will have to wait until after the war for further development, is frequency modulation, or F.M. It is used for local broadcasting, but operates on ultra-short waves very similar to those used in television. F.M. has two advantages. It is not bothered by static, thunderstorms, or electric machinery such as vacuum cleaners, electric razors or elevators. Also, it has a greater range of sound than ordinary radio.

F.M. reproduces sounds which have between 30 and 15,000 cycles, or vibrations. Ordinary radio only reproduces sounds between 30 and 5,000 cycles.

A piano, for instance, has a range of from 68 to 7,000 cycles. A violin produces sounds with from 192 to 17,000 cycles. A man's voice is from 120 to 7,000.

Since F.M. cannot be received on an ordinary radio set, and can neither be sent from the transmitters we have now, or over ordinary telephone lines, it will probably be some time before it is used generally.

By this time Hugh thought he knew enough about radio waves, so one evening he and his father went out to visit the studios. A few of these are in special buildings, while others are in office buildings, or regular Broadway theaters. As they watched

[p. 21]

people going in and out, Hugh thought he recognized some movie stars and a famous comedian, but it was hard to tell because the people going in and out of the studios were always in such a hurry. A lot of the men were carrying musical instrument cases.

In one studio a singer and her pianist were rehearsing, and every minute or two a director would come out and talk to her. Single performers aren't usually put in studios as big as this one when they go on the air, but rehearsals are held wherever there is room.

Radio actors rehearse very little as compared with stage actors, who work weeks over a play, or movie actors, who often spend all day making two or three short scenes.

Even the longest radio shows, which last an hour, are never rehearsed more than six or eight hours. For a fifteen-minute morning serial program, or "soap opera" as they are called, radio actors seldom rehearse more than an hour. They never memorize
[*p.* 22] their parts but always read from typewritten scripts.

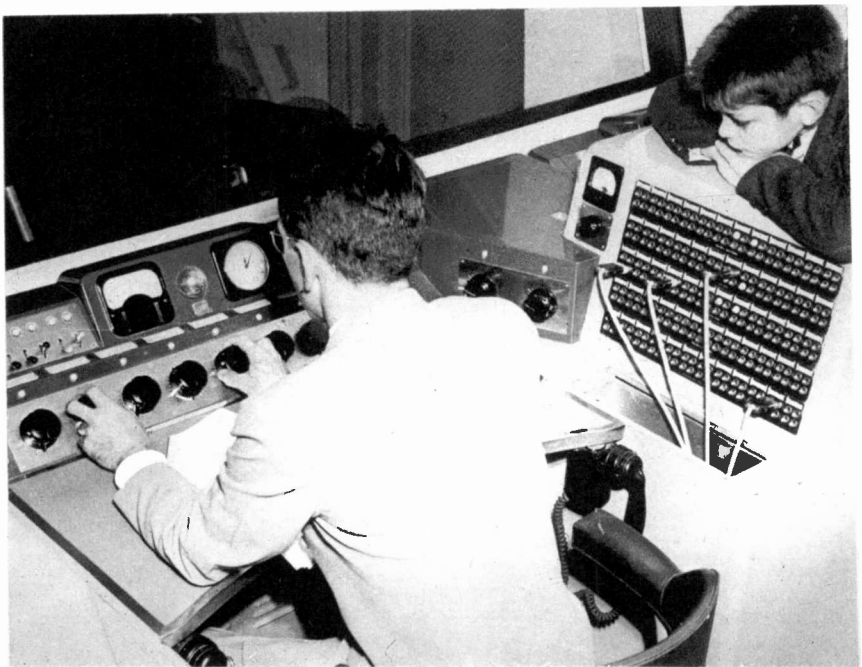
The next afternoon Hugh and his father went to a big Broadway theater where a show was being rehearsed. Hugh noticed that before the comedian came in most of the men in the orchestra got up and went home. The guide told him this was because even the most important radio shows never have a complete rehearsal. The musicians work up their numbers all by themselves, and so do the singers. Somewhere else, perhaps in Chicago or Hollywood or any other city, the comedian and his gag men work up the script, carefully rehearsing it so that it will fit into the program and not take a single second more or less than the time allowed.

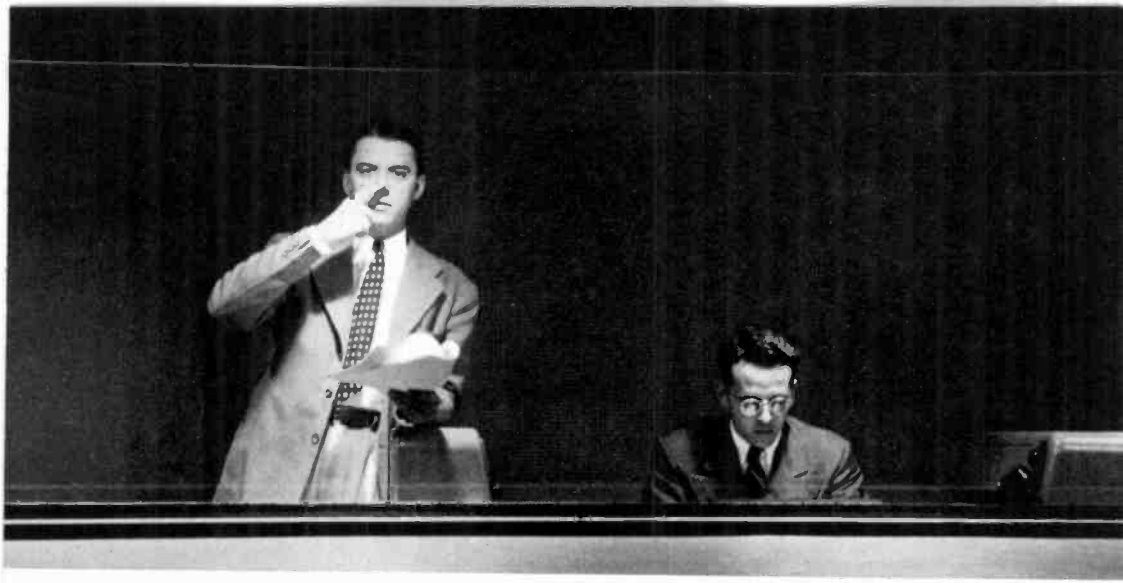
In order to find out how their jokes sound, comedians sometimes have records made during rehearsals, which they play over to themselves. If a wisecrack seems pretty funny they make it longer—but if it doesn't seem right they throw it out. When most big radio shows go on the air they have large invited audiences, so that the actors will be encouraged by their reactions and so that the radio listeners will hear their laughter and applause. [*p.* 23]

Hugh noticed that every studio had two little rooms beside it, from which people could look out through heavy plate glass windows, like those in an aquarium tank. He found out that one of these little rooms is called the "client's booth," and is reserved for the advertising and business executives of the manufacturing company which is sponsoring, or paying for, the program. The other little room is a control booth for the engineers who are monitoring the program as it goes out on the air. Hugh went up into a control booth to see what went on there. The engineer showed him that the eight big black knobs on the desk controlled the microphones down in the studio in front of him. Most programs use at least two or three microphones, others many more. In one show a singer might use one, a comedian another, some actors in a sketch a third, an orchestra two more, and a sound-effects man still another one. The sound-effects men are always put way over in a corner, out of the way of the actors.

Monitoring a program consists in keeping actors, musicians and sound effects in their proper places with regard to the amount of sound each produces. If the orchestra is too loud for the singers, the man in the control booth turns the knob connected with the microphones placed in the orchestra. If the sound effects are too loud, or not loud enough, he turns that microphone up or down.

[*p.* 24]





But the engineer is not the only person in the control booth, Hugh discovered. Often the director of the show goes up there to keep an eye on his actors and singers. He can hear them through a loud-speaker, but they can't hear him through the heavy double glass. He couldn't talk to them, anyway, because his voice would go out on the air along with the program, so he directs them through a set of hand signals.

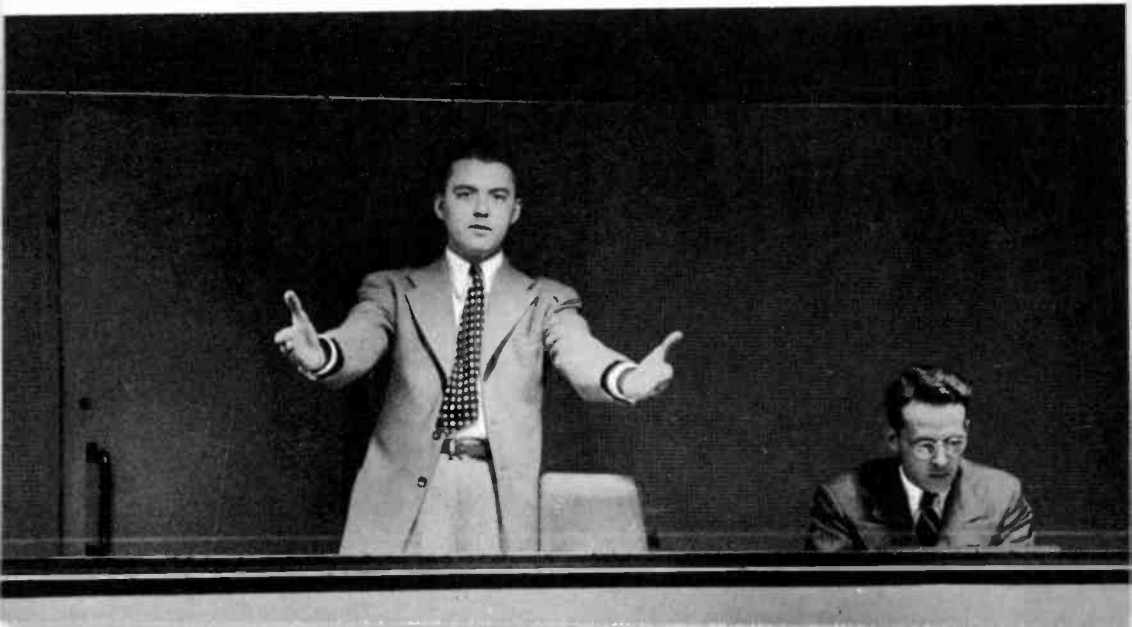
In the top picture he is telling the performers that they are hitting it "on the nose"—that is, that they are going at just the right pace, neither too fast nor too slow. Timing is extremely important in radio. In the picture below, the director is telling the actors that they are "OK"—that is, that everything is going on the air smoothly.

[*p.* 25]

Above, the director is signalling to the actors or musicians that they are too loud, and should tone down their performance. In the lower picture, he is indicating that they are not loud enough, or perhaps if there are many people in a scene, he wants them to talk, yell, laugh, or cry more loudly.

On the opposite page, he is giving an actor a cue, "throwing a cue" as they say, to make sure he will be ready when his time comes. When they are not actually talking into a microphone, the actors in a radio show often step back and sit down some distance away from the microphone, coming up only when they are needed.

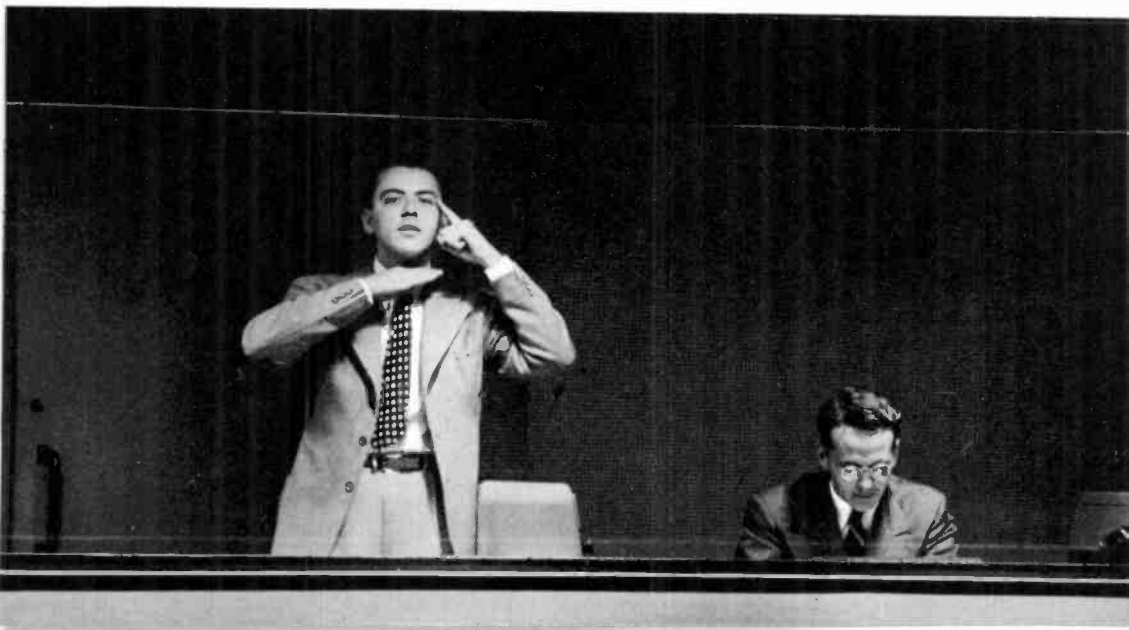
[*p.* 26]



In the bottom picture, the director is running his finger across his throat, which is a signal for "cut it short," meaning that some song or piece of business is lasting too long and should be cut short or the show will run overtime.

All radio programs are carefully planned so that every second is accounted for—the program itself, the commercial announcements, the station identification, and sometimes a network identification. In many cases there is a twenty-second interval of "silence" on a network between programs, but this "time" is often sold to advertisers for ten-second commercial announcements called "hitch-hikers."

[*p.* 27]



In another studio Hugh saw some actors rehearsing a current-events program in which they took the parts of senators, generals and other important people. Since it was a first rehearsal, they all followed their scripts very closely.

Hugh noticed some odd-looking screens in one of the walls and asked about them.

The guide showed him that they were wall vanes, which could be opened or closed by touching buttons in the control booth. When an orchestra or band is playing, he said, the vanes are closed so as to form a smooth, hard surface. This produces what engineers call a "live" studio, which gives brilliance to musical tones.

[*p.* 28]

But when a studio is being used for a dramatic show, the vanes are opened to expose an inner wall covered with a felt, sound-absorbing material. This produces a "dead" studio which gives a better effect when the only sounds are human voices.

Although a single radio show seldom lasts more than an hour, some radio actors make a lot of money by appearing on several programs the same week, the same day, and even at the same time! Most of the big radio stations in New York are within a few blocks of each other, and if an actor is only appearing in the first few minutes of one show he or she can have an elevator waiting, go down to the street, jump in a taxi, and arrive at a different studio to play another character all within the same fifteen minutes. Popular actors often go on the air as many as

[*p.* 29]

a dozen times a week. This is especially true of the morning and afternoon serials which require almost no rehearsal, particularly after an actor has been playing Uncle Joe or Cousin Bessie every day for some months.

A big musical comedy program with a famous star, a first-rate band, and a couple of singers lasting an hour will cost a manufacturer about $20,000. Half of this money will go to the broadcasting company for the network time, and half to the performers. The star may get about $5,000, while the singers, stooges and other minor performers will be paid from $300 to $800 each. The rest will go to the orchestra, the script writers, and music composers.

[*p.* 30]

Except for very special shows, radio actors wear any old clothes they happen to have on, and pay very little attention to the studio audiences, often turning their backs on them to get into a better position before the microphone.

Since most programs call for several sound effects, every studio has a big storeroom filled with all sorts of odds and ends, and special pieces of apparatus. In Radio City, Hugh found a very realistic jail door which made a loud "clang" when he closed it, and a sort of little wooden cradle. This was half-filled with water, and when you rocked it back and forth it sounded just like the river slapping against the piers of the bridge back home. Pieces of apparatus such as these are carried from one studio to another as needed.

In one studio some actors were doing a program which took place in an old-time sailing ship during a heavy storm at sea. First some men wheeled in a big box called a turntable, which had places on which to play three phonograph records at once. With this machine, the sound from one record after another, or two at once, could be used without wasting any time changing records. For the sea scene the sound-effects man started two

[*p.* 31]

records, one of wind howling in a ship's rigging, and another of rumbling, crashing thunder. Then, with his right hand, he turned a little paddle wheel in a canvas bucket half-filled with water. This made a splash-splash, slop-slop sound of waves striking against the ship. Still keeping his eye on the director in the control booth, he produced a very realistic sound of creaking timbers by working a little squeak-gadget with his left hand. This gadget consisted of a wooden peg fitted tightly in a piece of board.

The actors who were playing in this scene were in another part of the studio, and used a different microphone. The orchestra which was playing the "bridges," as they call the music between the scenes, was off in still another corner, using a third microphone.

As you can see in this picture, some radio shows, particularly serials, keep two sound-effects men busy all the time. Usually the crowded corner where they work looks like a junk shop.

[*p.* 32]

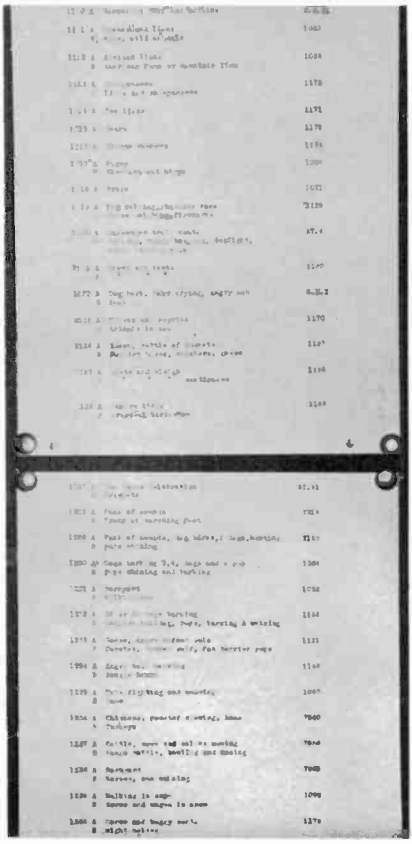
Notice that they never let their scripts get very far away. These men are making a few of the clinks, plops, squeaks, crashes and crunches in a typical serial, "The Shadow." The man with the hatchet is cutting off a head (a wet hand towel rolled up tightly). Also visible are sound effects for walking on gravel, walking on cement, rattling a doorknob, turning a key, a squeaky hinge, and a dial phone. Other properties used in this show were several old orange crates (for sounds of breaking down doors), and boxes of broken glass as well as many recorded sound effects, and a large organ to produce horrifying rumbles and moans.

A good many sound effects can be taken from records, and every station has a big collection of these. The catalog is usually posted on a wall, so that a director can find, in a few seconds, a record of a crowd cheering at a football game, the traffic in Times

[p. 33]

Square, or the bellowing of cattle crowding into a corral.

While Hugh was in the storeroom a director came in and tried out eight different records of trains running over railroad tracks before he found just what he wanted.



Some small sound effects are filed away alphabetically in a big cabinet like this, which holds everything from knives and forks to Chinese flutes.

Sometimes when the heroine is trapped in a mine shaft, a dungeon, or a cave the engineers "feed her voice," as they say, through an echo chamber. This is a low, narrow corridor of the sub-basement of the studio building. When its only door is [*p.* 34] closed, it is a pretty dismal spot. At one end is a loud-speaker

connected with the heroine's microphone up in the studio. At the other end of the corridor is a microphone which picks up her cries for help and takes them back to the studio, properly muffled and with a distinct echo. When she escapes from her dungeon

or mine shaft, the echo chamber circuit is turned off, and listeners again hear her voice directly from the studio.

Broadcasting companies often make recordings of their programs to send to advertisers as sales arguments, or for rebroadcasting at a later hour. In addition to these recordings, the National Broadcasting Company also makes permanent recordings of speeches, news events, and important musical programs, which may some day be valuable to people writing history. [*p.* 35]

Radio people watch their mail very carefully, as it is their most direct contact with their listeners. Millions of letters and packages are sent in to studios every year. Some fans advise the characters in their favorite serials what to do next. Others write letters of praise, flattery, or criticism. Many ask for cash, old clothes, or autographed pictures. Sometimes listeners tell actors whom they should marry, what kind of clothes they should wear, and such intimate things. Others write in to say they are praying for them, send them home-baked pies, pieces of needlework, poems, scrapbooks of clippings, jewelry, pictures of themselves, and almost anything else. The big mail, however, comes the day after somebody on the radio has offered something free, or in return for old box tops.

A radio broadcast may start anywhere in the world; high up in a plane, in a mine, in the White House, in a submarine, in China, or in a crowded street. If the engineers can lay their hands [*p.* 36] on an ordinary telephone line, the rest is easy. The program goes

right into the radio station, out to its transmitter and out over the air, or onto the network.

However, since it is not always convenient or possible to have a direct connection with a telephone line, radio engineers have something called a pack transmitter, very much like the "walkie-talkie" radio used in the army. Here is a radio program coming from the back of an elephant as he walks through a big zoo. You can see the pack transmitter with a little buggy-whip aerial on the back of one of the men. The third man on the elephant is an engineer who is listening to the program through earphones, as he picks it up, coming out from the station's transmitter, over a small radio he is carrying.

This little transmitter is not very strong and can be heard only four or five miles. Therefore, in a broadcast of this kind, the radio engineers set up a small receiving set in some near-by building, which takes the program from the little transmitter and puts it on a telephone line connected with the radio station. [*p.* 37]

In the above picture, there is an even smaller portable transmitter with which a radio reporter is getting an account of a flood from a boy.

In the lower picture a reporter, looking out of the window [*p.* 38] of a plane, is describing the war games going on below him.

Above, a couple of radio reporters from CBS are having a pretty crowded time of it at a political convention, while below, Ed Tomlinson goes in for solitude (except for the llamas) at the top of Mount Meiggs in the Andes mountains in Peru, the highest railway point in the world.

[*p.* 39]

Radio stations and networks now cover some kinds of news almost as thoroughly as newspapers. Many of them subscribe to the AP (Associated Press), the UP (United Press), the INS (International News Service) and other services, which send them bulletins all day long over electric teletypewriters, much like this battery of them at NBC.

Commentators are kept busy editing these thousands of [*p.* 40] words into short bulletins which are broadcast every hour or so

during the day. Hugh noticed a little box on the table near the microphone and asked about it. The engineer said it was called a "cough meter," but that it was really a disconnecting switch with which a speaker could cut himself off the air for a few seconds, while he cleared his throat.

By evening, when people have come home from work and have more time, the commentators, military authorities, and other special speakers go on the air with longer news reports and opinions. Here at CBS, William Shirer and others are on the air with their evening news-analysis.

While the radio newsmen rely on the regular wire services for many things, they also use items from the short-wave broadcasts which they pick up from all over the world. From these they often get bulletins before the newspapers do. Sometimes they give these to the papers to help them out.

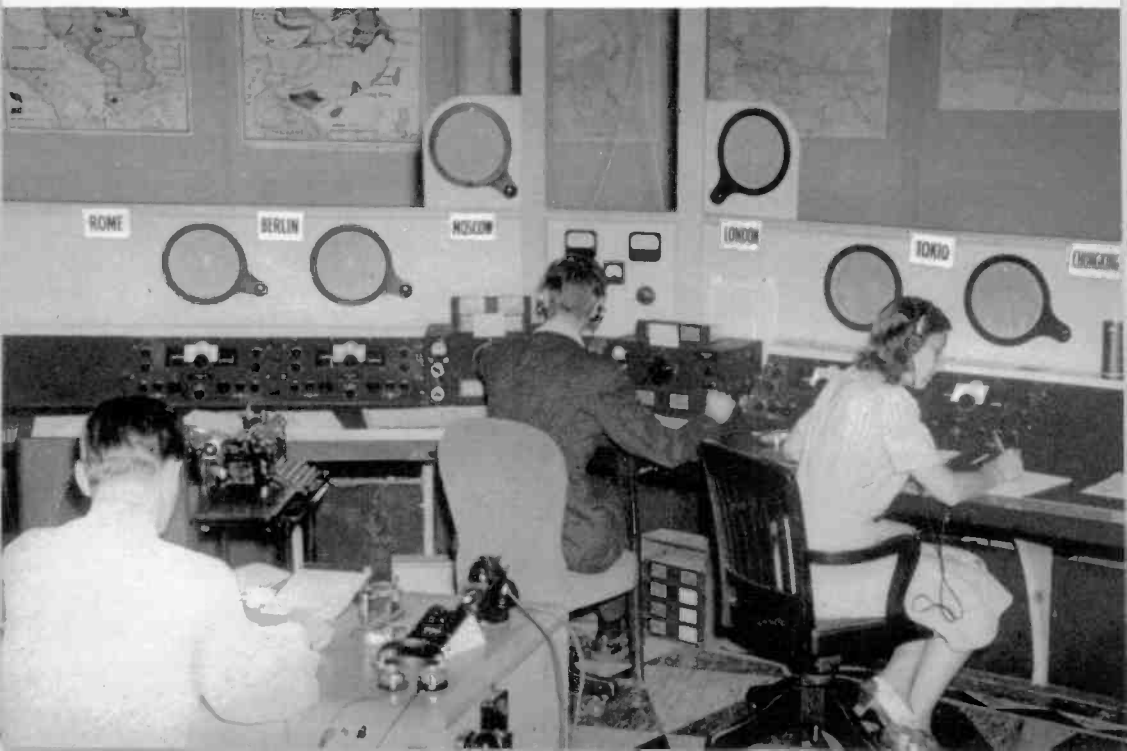
Of course anyone can pick up a short-wave broadcast now and then if he has the right sort of radio, but there are times when reception is difficult or impossible with a small set. To make sure that they hear every short-wave broadcast of any importance anywhere in the world, the big networks have powerful listening posts in different parts of the country where they can check up on almost everything said in any language.

[*p.* 41]

When Hugh got out to the NBC listening post on Long Island, New York, he found it looked more like a cottage at the beach than anything else. There were two aerials. Each one consisted of a single wire strung between four poles.

His guide told him that this post was on duty twenty-four hours a day, with twelve monitors to do the actual listening, and as many more engineers to keep everything running. The busiest time is at night when reception is best and there are more news broadcasts. Of course the monitors have worked out a schedule of regular news broadcasts, but every now and then they pick up special and surprising voices as they listen in all over the world during the day and night. Sometimes these are unsched-

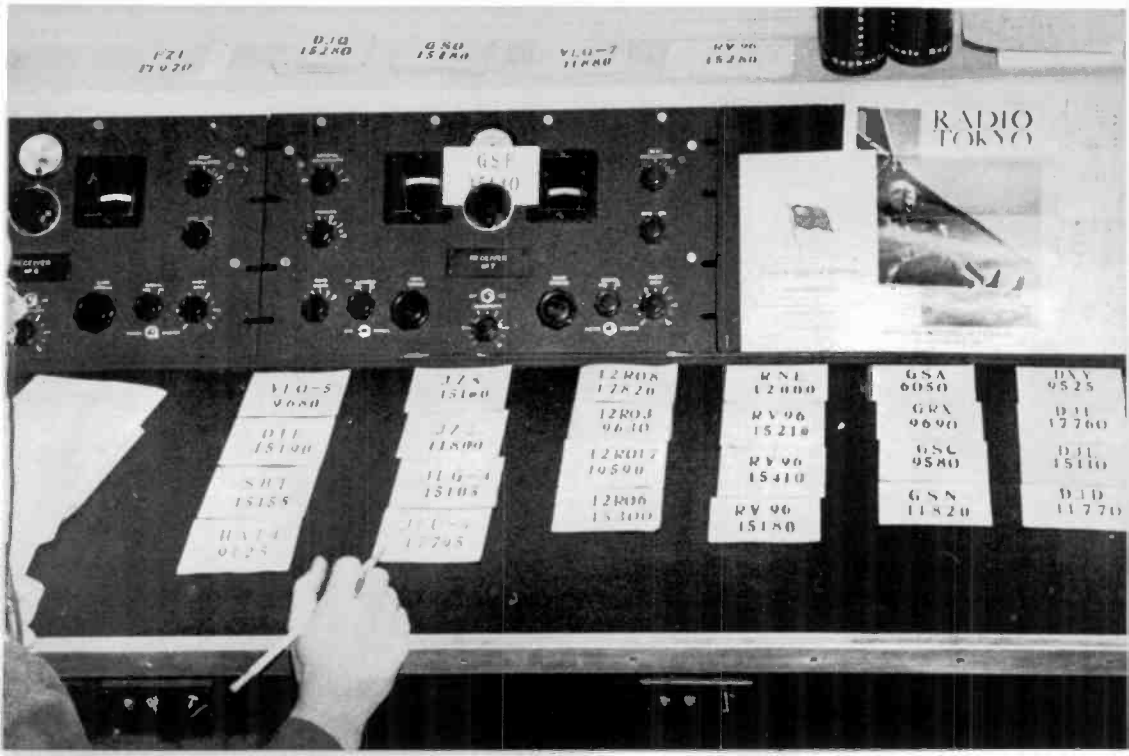
[*p.* 42]



uled news bulletins, and sometimes they are mysterious "pirate stations" which sneak in on some regular station's wave length for a short time. There are anti-Nazi transmitters sending short-wave messages from Germany, France, and Italy. Many of these are probably mounted on trucks, as their position is constantly changing. The monitors said there was one in Germany which came on the air pretty regularly at seven minutes to the hour.

The chief monitor at the listening post said there were so many short-wave stations which they picked up regularly that they couldn't begin to have a receiving set for each one. To avoid confusion, they had made a hundred or more little cards, one of which was stuck over a tuning knob when a set was picking up a particular station. For instance, the set in this picture is tuned in to GSF = 15140, which is London broadcasting over the Daventry transmitter on a wave length of 15140 kilocycles, or 15.14 megacycles, as we usually say in this country.

The monitor laid out a few of the other cards on the desk and explained what they meant. Most important short-wave stations have several wave lengths which they can use regularly. After taking into consideration the time of year, the weather, the time of day, sunspots, and other meteorological conditions, [*p.* 43]



the engineers decide which wave length to use for each particular broadcast. Here is a list of the stations represented by the cards on the desk:

VLQ-5
9680 is Sydney, Australia.

OIE
15190 is Lahti, Finland.

SBT
15155 is Motala, Sweden.

HAT4
9125 is Budapest, Hungary.

JZK
15160 and the three cards below it are all wave lengths for Tokyo.

12RO8
17820 and those below it are all wave lengths used by Rome. (The second one is used mostly at night.)

RNE
12000 and those below it are wave lengths used by Moscow.

GSA
6050 and those below it are wave lengths used by London.

DXY
9525 and those below it are wave lengths used by Berlin.

To get a job as a monitor at this listening post, the applicant must be a college graduate, know at least four languages fluently, be good at dialects, and be familiar with the geography and economics of every country in the world.

News bulletins are taken down in shorthand, or on dictaphone cylinders if too many things start coming in at once. Anything of importance is sent to the newsroom at NBC in Radio

[*p.* 44]

City either by telephone or teletypewriter. Important speeches, which American listeners might want to hear for themselves, can be switched into a regular coast-to-coast network by pushing a button on the panel board. Arrangements for such rebroadcasts are usually made hours in advance, of course. If these speeches come at an hour when most people in this country are asleep, they are recorded and then rebroadcast at some later time.

After his trip to the listening post, Hugh thought he had seen about everything there was to see about radio, but the engineers told him he still hadn't found out about networks.

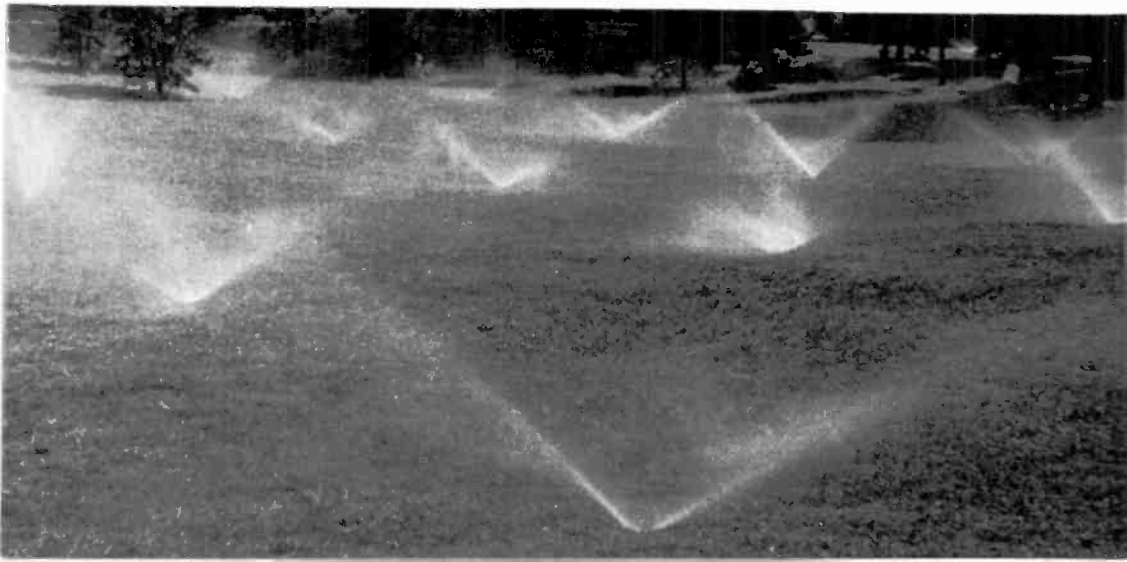
"How do you suppose programs go all over the country when even the biggest radio long-wave station can only be heard for about a hundred miles?" an engineer asked him.

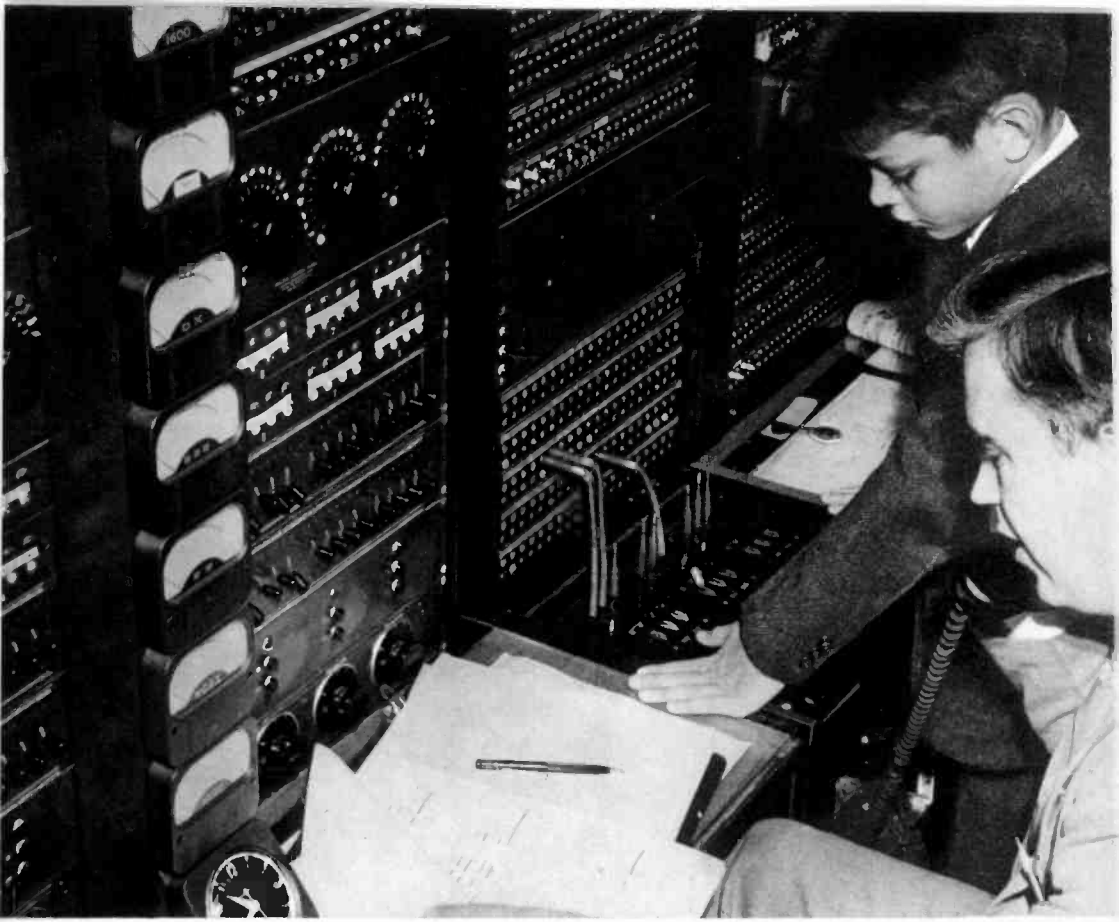
When Hugh said he he hadn't thought of that, they went back to the big broadcasting stations and the engineers showed him about networks. They said there were four big networks in this country and about twenty smaller ones.

A radio network operates much the same as a set of lawn sprinklers, only instead of pipes set in the lawn, the radio people use telephone wires to carry programs from one station to another. Each station in a network broadcasts locally only, just as each spray waters only its own patch of grass.

Of course, in each area or city, listeners can receive broadcasts from *several* network transmitters, as well as from a number of independent stations. It is as though each patch of lawn was watered by many sprays.

[*p.* 45]





Here is the main control office of the Columbia Broadcasting System's main office. Over 127 stations are monitored here, as it is the largest single network in the world. The engineer showed Hugh the row of dials at the left which told how programs were going out over the "round robins." A round robin is a sort of sub-network, or group of stations within a big network.

Since not all sections of the country take the same programs all the time, even though they may all be members of the same network, there are "split networks." Some advertisers want to sell plows or pills or gasoline in one part of the country more than they do in another. Often a network may be split four or five different ways for a short time.

[*p.* 46]

Next, Hugh visited the master control room at NBC in Radio City where both NBC and the Blue Network are monitored on one board. NBC has about seventy-five stations, and the Blue about 109, while another fifty-eight stations use programs from both NBC and the Blue Network.

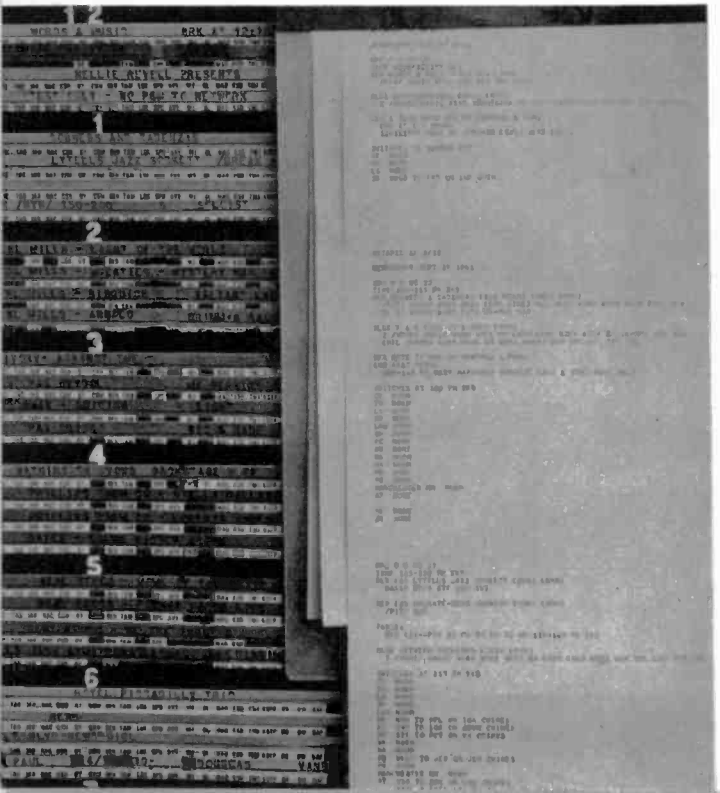
The engineer in charge showed Hugh that each one of the forty-eight little groups of lights up on the board indicated one studio. From these light he could tell which ones were on the air, and which ones were being used for rehearsals.

The little lights below have to do with the fourteen outgoing channels. Not all of these send programs on the air. Some are used to send special test, or audition, programs to advertisers by telephone line.

Keeping the programs being sent to all these stations straight [*p.* 47]

means a lot of bookkeeping. Near the master control in Radio City, NBC and the Blue Network have a "traffic room," with big boards on the wall for the different days of the week. Here the programs of both the NBC and the Blue Network, as well as of their split networks, are listed.

[*p.* 48] Here also, something else that is very important gets started.



Here are made up the teletypewriter messages, each about ten feet long, which tell the telephone company how to set the switches on its long-distance lines all over the United States. In this way, different stations can get the particular programs they want.

With this operation, all network radio programs, not only from NBC, but from the Blue Network, CBS, and Mutual, are turned over to the Long Lines department of the American Telephone and Telegraph Company, which "pipes" them, as radio men say, for thousands of miles over land lines.

[*p.* 49]

The set of switching orders on the long teletype message, which a network sends the telephone company during a day, tells the operators in the Long Lines department what switches are to be changed at fifteen-minute periods all day long.

As the special wires which carry radio programs are in the regular long-distance telephone cables, Hugh went down to the building where the telephone company handled its long-distance calls.

First, the telephone engineers showed him a teletype message coming from a network, telling the operators how to send programs around the country. Of course only a small amount of switching is done in New York. There are big offices in Chicago,

[*p.* 50] Kansas City, Louisville, Detroit, Minneapolis, Denver, Los

Angeles, and dozens of other cities. The New York office starts programs in the right directions, and the other offices see that they get to the right radio stations. All of these telephone offices talk to each other all day over teletypewriters, or by means of a special telegraph system. The engineers said they could talk faster and say more with a telegraph key than they could over the telephone! That is because they use so many tricky abbreviations. When Hugh tried to read the teletype message, he understood what they meant by abbreviations. This is what it looked like:

[*p.* 51]

```
RED (2) SKELLY OIL (COM CG) (CGM)
  IOA SOC WREN KMA KANS KSOO (SWT KC-OC) KOAM KGBX WKY WBR

BLUE BKFST CLUB (SUS CG) (CGM)
  /WBRE/ (BASIC EX WREN & KMA) WSAN WEEU WORK NH WTAR WSM (SWT
  OC-SA) BFL LOU TEX COL

NOTES TO NBC NY CNTL & PGM:
(NO AT&T OPRN)
  900-905AM SPICE OF LIFE (SUS) WEAF ONLY
  905-915AM HAPPY JACK (SUS CG) WEAF

  900-915AM WOMEN OF TOMORROW (COM) WJZ ONLY

ESTAB:
  RED (2)- HAMBURG ON IOA RETUN OM & KC 900-915AM
FABLE:
  RED (2)- HAMBURG-SHENANDOAH 900-915AM

SWITCHES AT 900AM EKD
CV  QUK TO IND ON CHIMES FM WTAM REG TRN LP & CON
TO  NORM
LS  NONE (WSM ON KY AS OF COB)
SB  NONE
LAG NORM
```

Hugh said the message didn't seem to make much sense, so one of the engineers translated some of it for him. The first few lines came out this way:

NBC (Red) is sending out a Skelly Oil commercial show. It comes from the Chicago studio (CG), and at the end of the program Chicago will ring its chimes (CGM).

This show is also to go out over the Iowa line (IOA), a group of stations which includes Chicago, Kansas, and Omaha.

It will also be put on the south-central wire (SOC) which feeds St. Louis, New Orleans, Birmingham, Atlanta, and other southern cities.

WREN, taken from the middle letters of Lawrence, Kansas, indicates it will also go to this station, not usually included in this setup.

KMA is the name of a radio station which is also to get the program. And KANS means Kansas, while KSOO stands for Sioux City, Iowa.

SWT meant that the program was also to go on the southwest line (Kansas City, Oklahoma City, and a particular group of stations).

By this time Hugh decided it would take him about a week to read one day's switching orders for one network, so they just gave him a few more translations picked at random.

LOU—a line going out from Chicago, down through St. Louis, to New Orleans, Atlanta, and other Gulf cities.

PGM—the announcer.

ESTAB—reroute a network via the office indicated.

HAMBERG—a small town which is an important switching point between Omaha and Kansas City.

EKD—Eastern daylight time.

EK—Eastern standard time.

CV—Cleveland, Ohio.

QUK—the Quaker leg, which includes territory from Cleveland to Pittsburgh to Washington.

FABLE—furnish a B line between such and such. This means a certain class of service.

As of COB—as of close of business—that is, as things were last night.

NORM—means that the line is to have its regular setup, or normal connections.

The chimes, used by NBC and the Blue Network, and word cues used by Columbia and Mutual are very important to engineers all over the country, as they indicate just when to make switchovers. While programs usually end pretty much on the dot, they sometimes run over, or even run short, in the case of sporting events. This means that the telephone technicians must be listening in all the time, waiting for the chimes or word cues, so that they will be sure to make the switchovers at the right time.

Hugh asked how radio stations got their names, or call letters, and found that these were granted by the F.C.C. In recent years stations west of the Mississippi have been required to start their call letters with K, while those east were required to start with W. There are several exceptions to this, but they are very old stations, which were established before the F.C.C. began regulating radio.

Sometimes stations have call letters which identify them. WORC is in Worcester, Massachusetts, and KSTP is in Saint Paul, Minnesota, WOOD is in Grand Rapids, where furniture is made, while WIOD, which stands for Wonderful Isle of Dreams, is a radio station near Miami, Florida, where people are always glad to see tourists.

Most of the long-distance telephone connections which carry radio programs stay the same from hour to hour and day to day, so that the engineers in the monitoring offices all over the country don't seem to have much to do. But the switchovers are so important that men must be on the job all day long to make them. The picture on the next page shows the main network control room in

[*p.* 53]

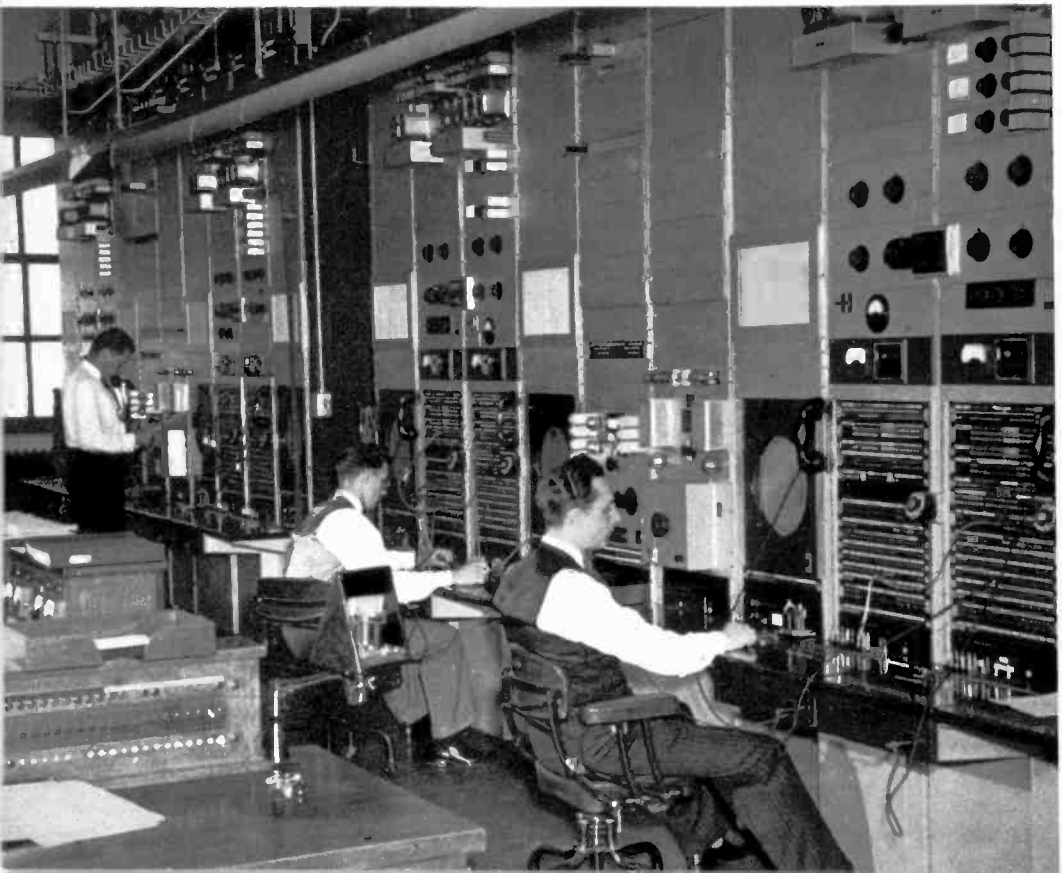
New York, the "NR" room, as it is called. The four "patching bays," or switchboards, here are the gates through which all the comedy shows, major football games, championship fights, operas, symphony concerts, presidential speeches, relays of short-wave broadcasts, and other important programs go out over the four major networks to all the millions of listeners in the United States.

Hugh noticed that there were only eight men in the room, but that everything was so efficient, and worked so smoothly, that even they didn't seem to have much to do.

The men explained to him that it was only when there were split networks—that is, when there were changes in the basic network system—that "patches," or switching changes, were necessary.

"Patches," they said, were temporary connections with short pieces of wire. Hugh saw several of these on the Columbia network's patching bay.

[*p.* 54] For its own convenience, the telephone company recognizes



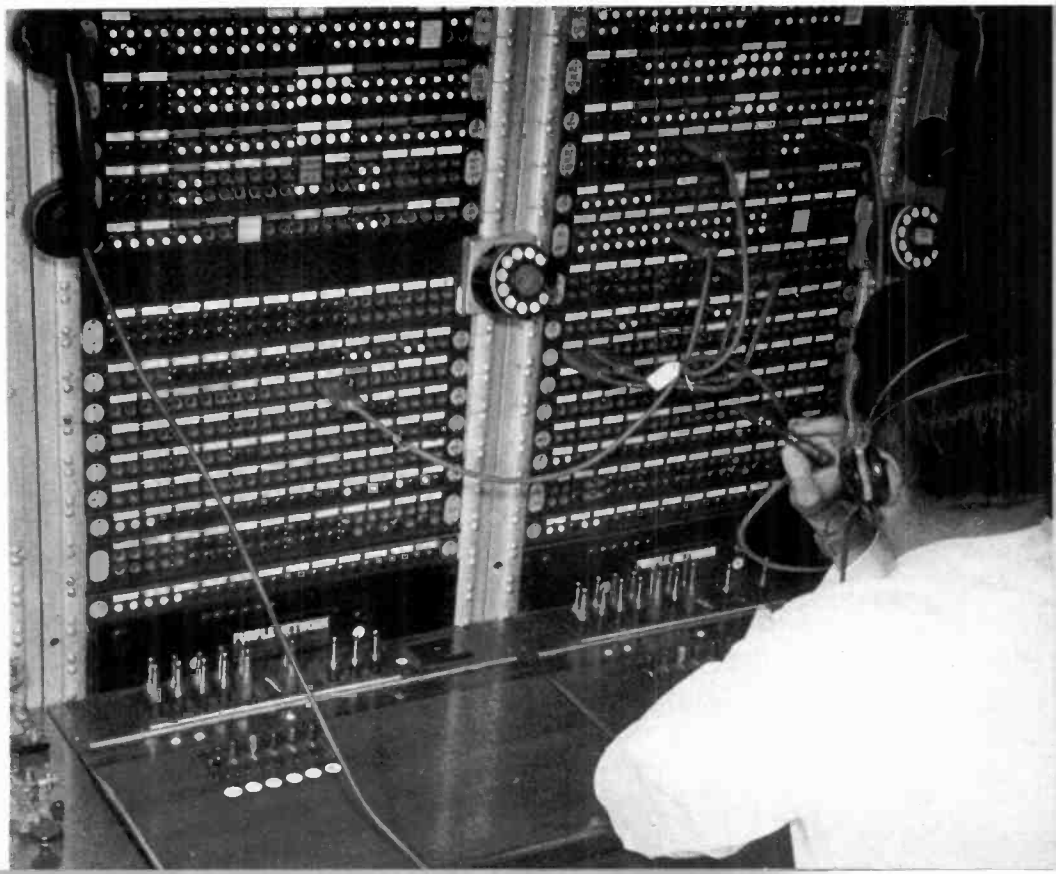
networks of more colors than there are in the rainbow. In addition to the Red (NBC) and the Blue network, there are the Purple network (Columbia), and the Gold network (Mutual). Smaller networks, some of them with but half a dozen stations, are the Amber, or Yankee, network of New England, the Pink network in the far northwest, and the Russet, Rose, Bronze, Slate, Peach, Salmon, Silver, Gray, Brown, and Black networks scattered all over the country.

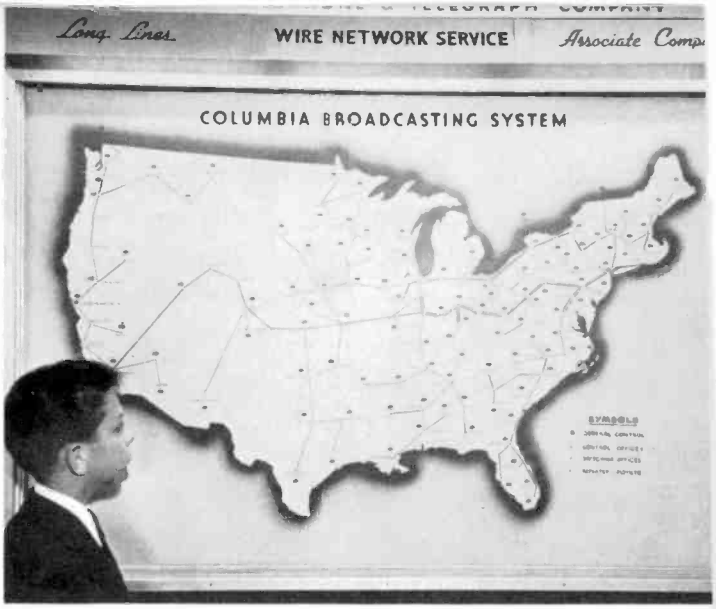
Finally, there is the Orange network, which is an experimental system operated by the telephone people to test new types of equipment. It never goes on the air.

These network colors are carried through, all over the country, on little typewritten labels such as those above the holes on this switchboard.

Through his earphones the man at the board can follow the program he is switching, so that he will make the necessary changes as soon as he gets the chimes or word cue.

[*p.* 55]

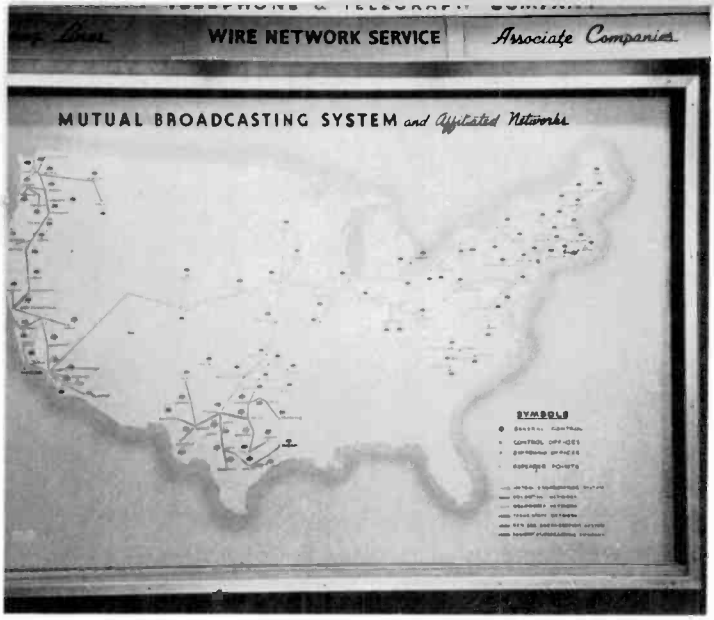




The number of stations in a network changes a little every year, as the super-salesmen in each network try to make theirs the biggest chain with the most listeners.

The engineer showed Hugh some maps of the long-distance telephone cables which carry radio programs around the country. Of course, if any of these lines are damaged by floods or storms, programs can be rerouted through other cables, so that there will be no interruption in service.

[p. 56] On the engineer's desk Hugh found a piece of standard long-



distance cable which had been cut open. Cables like this have 270 pairs of wires, six of which are for radio circuits. He could see that these wires were heavier than the others. Ever since 1926 all long-distance cables have included several pairs of such wires.

In the wire room on another floor Hugh saw how all the long-distance telephone and radio network lines met on tall racks reaching to the ceiling, and then were squeezed into a big lead-sheathed cable, which disappeared through a hole in the floor. [*p.* 57]

He had often seen these cables as he drove through the country, but never realized before that many of them carried radio programs.

These cables aren't always carried on poles. Often they are taken under rivers and harbors in cable conduits, and when they come to towns and cities they are carried down the telephone poles, as in the picture, and are buried under the streets. Recently, in the west, a trench was ploughed 1,600 miles long and a telephone cable buried which stretches all the way from Sacramento, California to Omaha, Nebraska. It goes straight across country, under wheat fields, farms, prairies and deserts. It is just deep enough to keep from being hurt by ordinary plowing in all states but Colorado. It is deeper there because the Colorado beet farmers must plow deeper than usual. In some parts of the country this cable also has gopher-proofing—a covering of material which these sharp-toothed little digging animals don't like.

The electric currents in the wires which carry the radio programs across the continent, over mountains and under rivers, must be boosted, or strengthened, every few miles or they will fade out and disappear. The "repeater stations" where this is done are about sixty miles apart, and are located in telephone buildings all over the country.

There are many important control offices in this system, but this one in Denver, Colorado, is important for a reason you might never suspect. It is the "center" of the United States from the point of view of broadcasting. In this Denver long-distance control room, the eastern and western sections of our networks meet. Many radio programs start in the east, others in the west. Some never go beyond Denver, but stay always east, or west, of it. Important programs used by most of the stations in a network are connected in Denver, to make what we call a "coast-to-coast hookup."

Certain kinds of broadcasts, such as those of grand opera, symphony music, and famous news commentators, come from the east, but so many of the best stage and movie actors are working and living in Hollywood, now, that the networks all have big studios out there. In this way the movie stars can take part in programs every few nights without interrupting their picture work.

At the top of the next page you can see KNX, the Columbia station in Hollywood. Below it is the inside of the main control room. On the facing page, top left, Gary Cooper and Bob Hope are broadcasting, while Zazu Pitts keeps an eye on her script for her cue to step up to the microphone. Beside them is a picture

[*p.* 59]

of Charlie McCarthy, Mortimer Snurd, and their godfather, Edgar Bergen.

The center strip opposite shows Arturo Toscanini conducting a performance of the NBC orchestra. The other two pictures, at the bottom, are of Ginger Rogers and Henry Aldrich & Co. Notice that the typewritten script Ginger Rogers is holding is stapled to a piece of cardboard. This is to keep it from rattling and making a noise which would be heard on the air. Henry Aldrich overcomes this trouble by placing his script on a stool.

[*p.* 60]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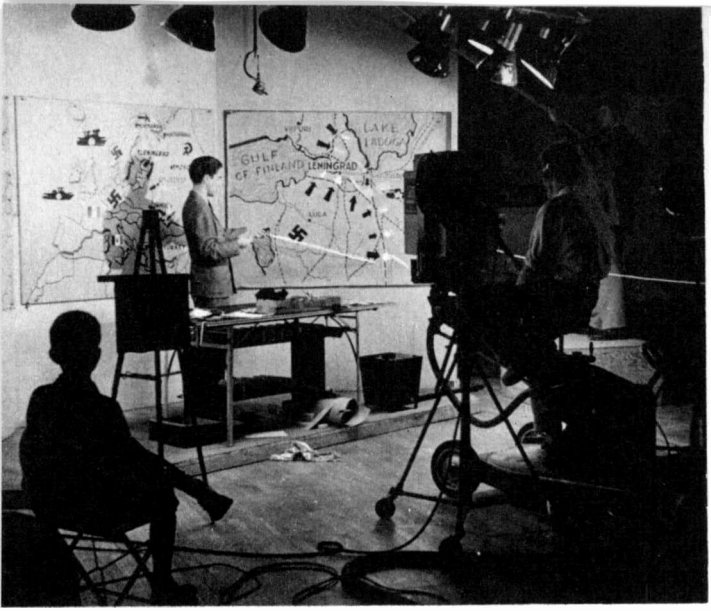
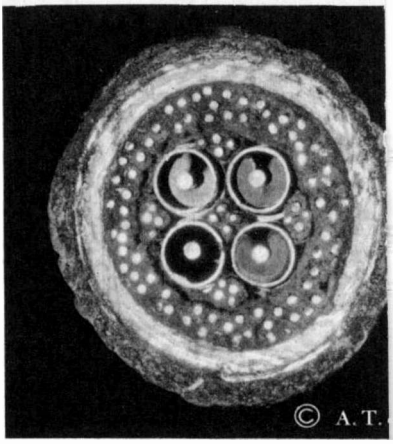




Hugh asked about television, and the engineers told him it was coming along fine, or rather would come along when the war was over and they could develop it further. They told him that several television stations went on the air every day for a few hours, just to keep their licenses from the F.C.C., but that there weren't enough receiving sets yet to give them very much of an audience.

Hugh went to see a news broadcast in which the commentator illustrated his talk with a series of maps on which he used a pointer, like the one the teacher used in school.

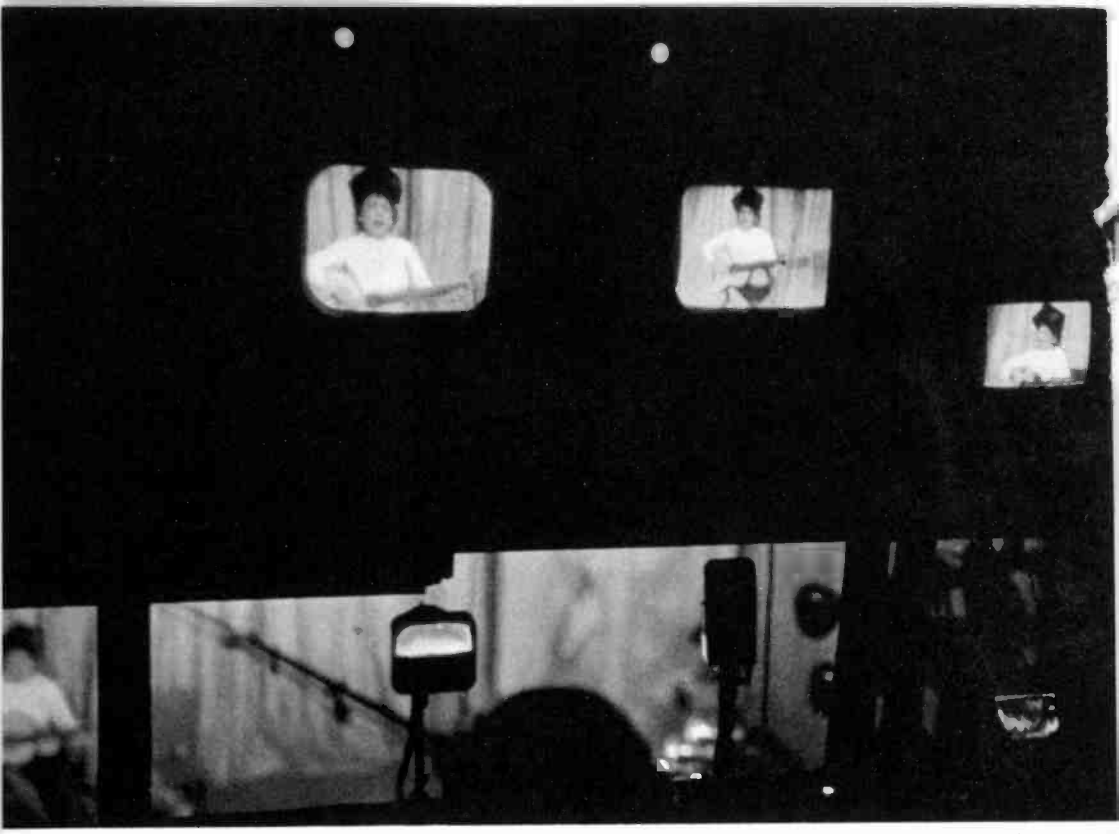
For many years the trouble with television was that radio people had discovered no way of sending a television broadcast more than about fifty miles from the broadcasting tower. This is because the ultra-short waves, which carry the signals for the pictures, usually glance off the edge of the earth as soon as it curves and don't bounce against the ionosphere in the same way as the regular short waves. There are now two ways to send television for some distance across the country. One is over a special conductor called a coaxial cable, and the other is by means of a series of automatic rebroadcasting towers, which look like ordinary water towers. At the right, above, is a cross

[*p.* 62]

section of the cable. There is only one long piece of coaxial cable built now. It is laid between New York and Philadelphia. It was an experiment which cost $500,000. Naturally, with the cable itself costing so much, it is not yet possible to carry television all over the country. The little towers, also experimental, work all right and are much cheaper for long jumps. Although fifty miles is usually considered the farthest a television broadcast can be sent, there have been occasions in which pictures from London have been picked up in New York, owing to freak electrical conditions.

In the television studio, Hugh also saw a story program for children in which a little girl listened while a story was read aloud, and watched while it was illustrated by a fast-working cartoonist. Hugh noticed that one camera was pointed at the little girl, and another at the cartoonist. He went up into the control booth and looked at the television image in the engineer's desk, which showed just how the picture would look as it went on the air.

Every minute or so, the engineer flipped a switch, so that the broadcast used first the picture from one camera, and then the other.



Here is what the engineer in a television control booth sees when they are using three cameras, each one covering the performer from a diffrent angle. By pushing switches, he can shift from a full face to a profile, or from a closeup to a long shot. Meanwhile he can talk to the cameramen, who have on earphones, and tell them which way to move the cameras for the next shot. The cameras are on big rubber tires and move very quietly. Through the glass window at the bottom, the engineer can watch everything that goes on in the studio. This window is of colored glass to protect the engineers' eyes from the glare. Individual performers are only on the air for a few minutes at a time, but the engineers may work many hours at a stretch.

Next, Hugh was taken to see a television broadcast of a talk by a man from the Metropolitan Museum of Art. While one camera was covering the speaker, another was turned on a small

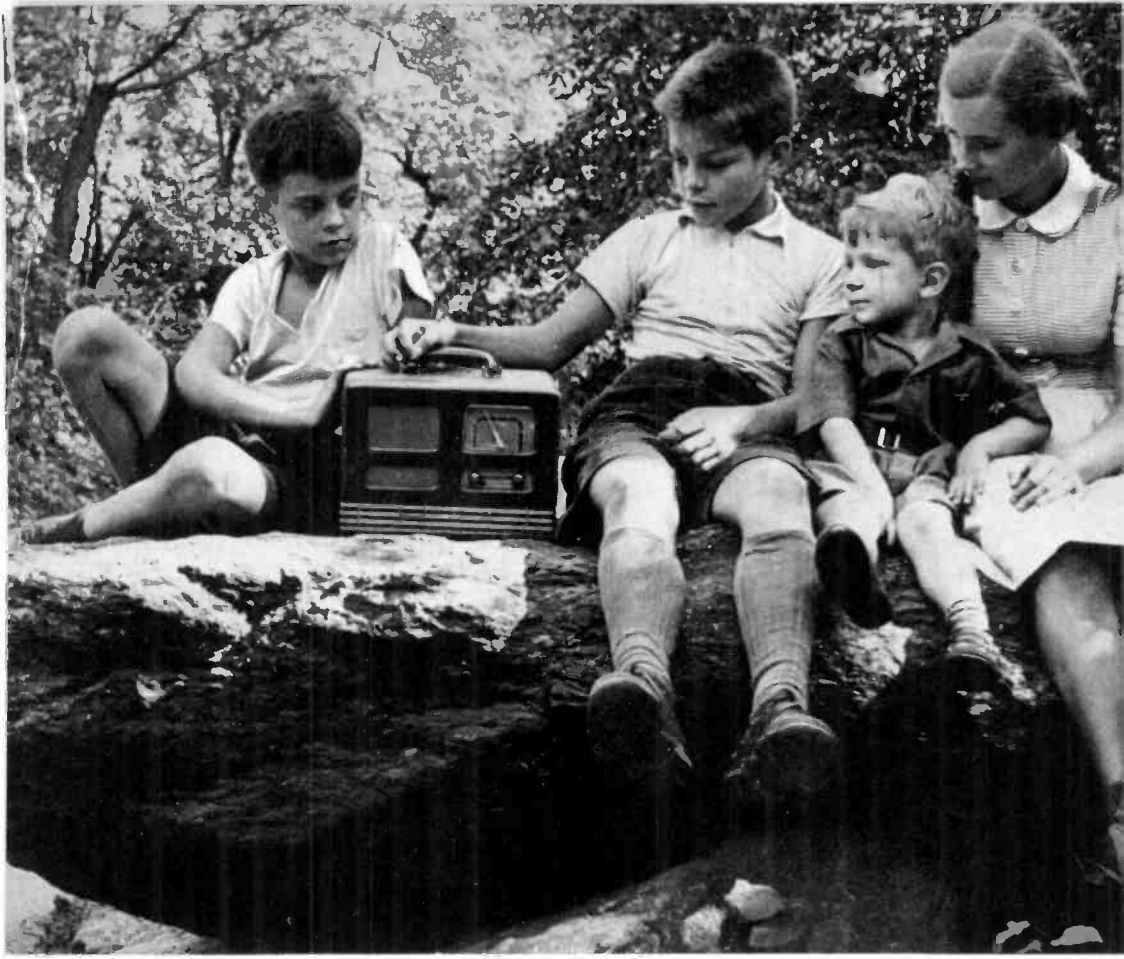
[*p.* 64]

map. Later the cameras shifted, so that there were close-ups of the china plates and silverware on the little stand at the right.

When radio covers a football game for television, the operators use two cameras, one of which has a wide-angle lens which takes in about one third of the field at once, and another for [*p.* 65]

close-ups. This close-up camera has a big telephoto lens, as you can see, so that it can follow the plays in detail. The cameraman uses the top lens in his camera to follow the action. He keeps in touch with the control booth through his earphones and a telephone mouthpiece built into the camera just below the sight.

Between halves Hugh looked out of a gangway in the stadium and saw this big truck, which was connected with the television cameras by thick cables. The engineers told him that the truck carried the control booth and the equipment with which the television pictures were broadcast to the broadcasting station. There the pictures were *rebroadcast* to the people with receiving sets. They also told him that the platform on top of the truck was fitted with slots to hold the cameras when they were [*p.* 66] covering parades or other outdoor events.



A few weeks later Hugh and his friends had the radio along when they went hiking in the woods, and this time Hugh could answer almost any question anybody could ask. Now he knew that thousands of people, some of them in remote parts of the world, were filling the air with a complicated system of all kinds of waves, so that almost anyone, anywhere, could listen in on what the world was saying, just by turning a knob.

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