# The MIRACLE OF TELEVISION

Luther S. H. Gable, Ph.D., P. R. E.

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TELEVISION has spurted into popularity with such startling suddenness that few people have any understanding of the interesting story behind it. The scientists, inventors, and technicians who from the beginning have been "in the know" are only now finding time away from their laboratories and drafting boards to reveal what they have been up to. Their story, as revealed in THE MIRACLE OF TELEVISION, turns out to be one of the most exciting of modern times.

More than a mere history of television, this book tells in simple but stirring language the story of how this "miracle" came to be, how it works, what it does, what its future possibilities are—in fact, just about everything a reader would want to know.

Here you will read the incredible but true explanation of how a single beam of dancing electrons moves so swiftly across the television screen that the effect appears to the human eye as a complete picture. You will also learn how it will soon be possible to observe and hear, as though you were actually present, the fiery eruptions of a seething volcano thousands of miles away, or enjoy the wonders of our national parks without leaving your own home.

Whether or not you own a television set, you will want to know about this amazing invention which some people say is bound to work a greater revolution in our way of life than did the automobile and the motion picture.

*Wilcox & Follett Co.*

CHICAGO

NEW YORK TORONTO

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*Luther S. H. Gable,* PH.D., R.P.E.

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DEDICATED TO STUDENT YOUTH

*This living book is dedicated to all young people with vision. Its purpose is to inspire, to encourage, to promote a scientific habit of mind; to prepare for the development and operation of the greatest system of communication now on the trestle board of human endeavor* — WORLD-WIDE TELEVISION.

# CONTENTS

# 1

# *Darkness Before the Dawn*

TELEVISION MIGHT STILL BE only a scientist's dream if it had not rained in Paris one memorable night in 1896.

Returning home from the theater late in the evening, Professor and Madame Curie stopped at their laboratory to pick up an umbrella. As Madame Curie knew just where it had been left, she entered the laboratory without turning on the lights.

Suddenly she stopped in astonishment. From one of the many glass jars on the shelves came a strange white light, illuminating everything around it. She gazed upon this weird phenomenon with awe, feeling as Moses must have felt when he beheld the bush burning with fire, "and the bush was not consumed."

She reached out toward the glowing jar, but instinctively her hand stopped short. It seemed to be white-hot. Fearfully, gently, she touched it. To her further amazement she discovered that it was really stone-cold. Except for fireflies and glowworms, cold light had been unheard of until that moment. Apprehensively she took down the jar and turned it over in her hands. Great crystals as large as silver dollars clanked inside like a collection of dry bones. Deep within the jar the light seemed more intense, while the outside crystals remained in shadow, like the dark side of the moon.

At first she was alarmed, then stood very still, almost fearing the ghostly thing. She was face to face with a great discovery—radium, *the new wonder element,* which led later scientists to a knowledge of radioactivity, to dancing electrons, to the secrets of television, to atom bombs! And all because it rained one night in Paris.

The white light she had thus accidentally come upon was the unexpected outcome of an experiment that the Curies had been working on for about a year. The noted X-ray specialist, Antoine Henri Becquerel, had asked them to determine why a piece of pitchblende rock would fog a photographic plate if left near it for any length of time. They had tried again and again. The pitchblende rock was first powdered, or pulverized, and then dissolved in chemicals to filter out all the known values. A year of disappointing work followed, in which they had succeeded in reducing the pitchblende rock to barium—and apparently to nothing else.

Finally, much disheartened, Madame Curie had about concluded that further separation was impossible. Thoroughly discouraged, she gathered up the remaining crystals from the evaporating dish and dropped them hopelessly into a jar which she then sealed and placed upon a shelf with other discards. Maybe, she thought, she would try the experiment again some other time.

Then a month later came the memorable night of the rain.

As she stood transfixed in the darkness of the laboratory, she suddenly recalled that this ghostly light before her was emanating from the jar of barium crystals—all that had remained from the long pitchblende experiments which she had set away in discouragement a month before!

What actually had happened, as we now know, was that after the crystals had been confined for over thirty days, they had reached a point of maximum equilibrium of radioactivity. During the first few days of confinement, barium crystals in proximity to radium absorb radiant energy. Day after day the barium takes up more of these radiations until it reaches a point of maximum absorption. After a period of about thirty days, the barium begins to give off excess radiations; in other words, it loses radiant energy at the same rate that it is being charged by the radium still present with it. When this happens, millions of free, dancing electrons bombard the barium crystals violently, causing the barium to glow brilliantly white in the darkness.

When Madame Curie held that jar of radium barium salts, contemplating the awesome phenomenon, she did not know that it was burning her hands, that the nerves were being deadened by the terrific impact of the penetrating rays. Nor did she know that in this jar she possessed a priceless means to life or death, depending upon the hands that used it. How could she know that the dancing electrons she had discovered at play in that jar would cure cancer or grow better vegetation; would leap from our radar scanner to the moon and back; would bring the scenery and events of the world even to the bedside of the shut-in by television?

The cold white light proved to her only that her long and tedious work had really been successful after all. It explained why the pitchblende always spoiled photographic plates when left near it.

It was not until later that she learned that the light came from a new chemical substance which she had not succeeded in separating from the barium. She christened the new substance *radium* because the element radiated light in all directions.

When Madame Curie looked closely at the little dish of radium barium crystals in daylight, they seemed like ordinary salt. But in darkness the entire dish seemed to shimmer as if it were made of white-hot iron. When she observed it under a magnifying glass, the short, white flames resembled thousands of fireflies in a meadow, or a great meteoric shower.

This was the prime discovery, the dawn of a new day, that later led to the identification of alpha, beta, and gamma rays—and to the discovery of the dancing electron, without which television would have remained forever impossible.

## 2

## *Meet Mr. Electron*

BEFORE WE TELL YOU HOW to take an electronic moving picture of, let us say, the Mardi Gras at New Orleans and send it through the air to reproduce itself instantaneously on ten thousand television receiver sets all through the country, you should become better acquainted with Mr. Electron. Now that we have learned a little of how he was discovered, let us see where he lives and how he behaves at home. After all, he is the genie of television.

Mr. Electron has many widely scattered "country residences": floating cloud castles in the sky, from which he leaps with the lightning; aquatic sea gardens under the ocean, where he helps the electric eel shock or kill its enemies; and uranium ore beds, deep under the earth, where he slowly pounds the atoms apart to make new atoms of radium. Here he watches his chance to leap into the stream of a subterranean vein of water and ride out to the bubbling spring to bring health and happiness to sick and ailing people who drink of the "radioactive" waters of these "fountains of youth."

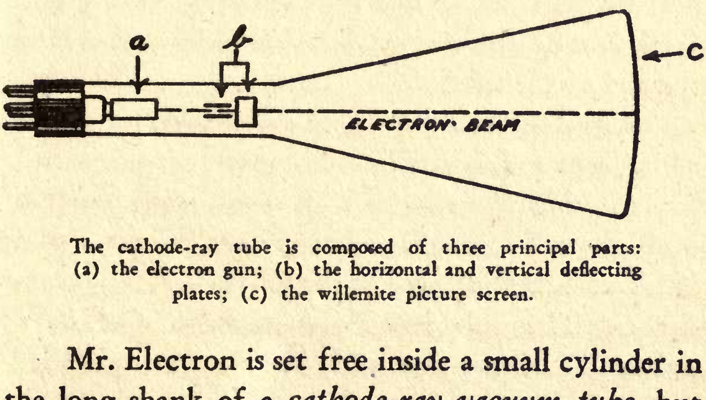
He seems to have a pretty good time roving around the earth by himself, giving life to good plants and animals and killing deadly fungi and destructive microbes which thrive in the dark.

For sport, Mr. Electron goes deeper into the earth to find a critical volume of critical elements in critical proximity and to set up a chain reaction by nuclear fission, releasing gases and steam with which he can lift a mountain, or blow its top off. He probably shakes with laughter as he watches a great volcanic eruption send strangely fluorescent dust into the air, some of the finest of which is nine years coming back, though more of it is attracted to the magnetic poles of the earth. Mr. Electron rides along to join his arctic brothers in the cosmic rays. There they stage a show starring the "dancing electrons" which illuminates the dark ice peaks of the arctic midnight with the beautiful colors of the aurora borealis. The dark arctic sky is the screen and the dancing electrons create highlights and shadows as they now do on the television screen.

Mr. Electron had a wonderful time all by himself until man pursued and chained him in his lair. Man found him first in the lodestone, then rubbed him out of amber, and finally made it so hot for Mr. Electron in a generator that he started out to go places. They harnessed him in a storage battery, making him work. They penned him in an electrolytic capacitor from which he attempts escape at every opportunity. He would ruthlessly kill or burn anyone who handled him carelessly. Yes, man taught him that. He is getting so unruly now that only electronic engineers who understand him can make him behave and work for us safely.

The harnessing of Mr. Electron to television is a triumph of man's ingenuity. Many devices had to be developed to make him travel a desired course. The wire path built for him to travel on is called a *circuit*, and his movement on a wire is called a *current*.

The push he exerts to go places is measured in *volts*. Barriers which hinder his flight in the circuit are known as *resistors*. Sometimes he gets caught in a trap—a *capacitor*. That delays him a little. Soon it is overcrowded in there. But he is ready to spring out and work at high speed when he is needed. He threads his way around and around a coil until he arrives at the end of the line. He finds himself in a *vacuum* *tube* perched on a *cathode*. He is extremely uncomfortable there. It is a hot seat. He discovers a heater under him and takes a flying leap across the space between the cathode and the plate facing him on the other side of the tube. He is in such a hurry to get across that space that he goes much faster than before. He travels so much faster that he hits harder when he lands on the plate. At normal speed, his landing would make a little tick or signal. But because he travels so swiftly and hits so hard, he produces a louder tick or signal. That vacuum tube is the secret of the loud speaker and constitutes the real secret of how a television picture is made.




The cathode-ray tube is composed of three principal parts: (a) the electron gun; (b) the horizontal and vertical deflecting plates; (c) the willemite picture screen.

Mr. Electron is set free inside a small cylinder in the long shank of a *cathode-ray vacuum tube*, but when he gets out, he is going faster and hitting harder. Now he is caught in another cylinder which speeds him up again. By the time he gets out of that and through a third cylinder, he is so anxious to escape that he is going at the rate of 46,500 miles per second. These little cylinder traps are called accelerating factors or electron guns. Suddenly, Mr. Electron finds that he is imprisoned between *two horizontal plates.* They change his mind about where he is going. They may direct him upward or downward vertically, depending upon the momentary charge of either plate, but he zips out between them without slowing down. Instantly he finds himself between *two vertical plates.* Again, they switch his direction, depending upon the momentary charge of either plate, but can only force him to the right or left horizontally. At last he is free! But he does not get far. He collides head on at the end of the tube.

Inside the tube, on the slightly rounded surface of its large end, is a white substance—powdered willemite. If he hits that at high speed, with plenty of push, the willemite will glow in a dazzling white spot; if his push is weak, the spot will be slightly gray or darker. The difference between these shadows of light and dark will be exactly like the lights and shadows in the pictured image he is trying to make.

Now Mr. Electron really swings into his dance. We cannot call it a square dance, because he outlines almost every figure except a square. He pirouettes in repeated cycles so rapidly that the small dot seems to create a streak of white on the screen. It may appear as a figure eight; a thousand rolling hoops; a twirling basket; a country fence; or a gigantic wave on an ocean. We call these figures "lazy Joe figures," but their correct name is *Lissajous figures* or *curves*, after Jules A. Lissajous, a French scientist. Until now, Mr. Electron has been playing, but when the television transmitter goes on the air, the horizontal and vertical plates direct a stream of high-speed electrons against the willemite in predetermined order. They will travel over all the lines across that willemite. In every line, they will hit with varied impulses that produce high or low lights, or shadows, exactly in the order of the lights and shadows of the object televised by the television camera at the broadcasting station.

Actually they travel over five hundred and twenty-five and one-half lines across the willemite, but since the beam of electrons hurries over all of them in one thirtieth of a second, that half line is not of much consequence. Then, too, the rectangular framing set in front of the round face of the receiver tube shuts off a few of these lines. The flattest part of the tube will really show only four hundred and eighty-four lines in most cases. It is variously stated by different receiver manufacturers that there are anywhere between four hundred and eighty-four and five hundred and twenty-five lines per frame, or picture size, depending on their use of the figure as theoretical, factual, or practical. At any rate, there are as many lines on an iconoscope (camera) plate, which is only about three inches wide. This is a marvel of compactness, considering that there are four hundred separate cells on each line, and that each one is capable of being charged by a beam of light and of releasing that charge with greater or lesser "push" to change the even impulses of a broadcasting wave to uneven impulses—thus creating the lights and shadows that go to make a television picture.

In every line of the screen, then, Mr. Electron will stop four hundred times, to leave a high light or a shadow. After traversing all the lines, he is returned by the horizontal and vertical plates to repeat the journey. When he has again rested four hundred times on each of the lines, the horizontal and vertical plates send him back to do so again, and again, and again! And each time he does so, the high lights and shadows combine to make a picture, and Mr. Electron makes a picture thirty times a second. By the flashing speed with which so many pictures appear on the screen each second, any flickering effect is eliminated, and each picture, changing slightly as the televised object moves, gives one the illusion of a moving picture.

At the rate of four million to six million hops per second Mr. Electron dances on the mosaic of cells. The speed with which he appears and reappears is of course too rapid for your eye to follow, but because of a certain "persistence of vision," you believe that the picture he paints is always before you, and because it comes before you with variations you believe you are seeing a moving picture.

### MR. ELECTRON AT THE BROADCASTING STUDIO

Now that we have seen the course on which Mr. Electron moves in the television process, let us visit him before he leaves his new home—the broadcasting studio. The first broadcasting studios were a blaze of lights. In fact, so much light was needed to impress a clear image on the receiving plate that the heat of these lights became extremely unpleasant. The light had to be intense enough to impress a clear picture on the three-by-four-inch rectangular plate. The cells on the plate each become charged with electric energy, though not all with the same intensity, for the cells in a light area receive a relatively higher charge than those in a shaded or dark area. Then a beam of electrons sweeps over the plate and discharges all cells consecutively; the discharge from each cell causes an electrical impulse to be broadcast on the air—the light spots emitting a high impulse, the shaded and darker cells emitting lower impulses—all of which are picked up by your receiving antennae.

There they go through the cathode-ray tube in the same order in which they left the broadcasting studio. They are joined, side-by-side, in such rapid succession that they re-form the same picture which appeared originally on the receiving plate at the studio, and, once in your receiver, operate in exact unison, but not line by line. They select each alternate line, then return to repeat, using this time the line they had skipped over the first time; and doing so in order to complete the reproduction of a single picture known as a "frame."

If Mr. Electron traveled on each line consecutively, the time lag between his completion of a frame and the beginning of another would be so great that the eye would detect the interval, and the picture would appear to flicker. By sending first only half of the picture, and following it in quick succession by the other interlaced half, we eliminate any flickering. All this is the story of just one frame! This requires one thirtieth of a second, for Mr. Electron dances merrily on to complete thirty frames every second, bringing to you, perhaps, the Mardi Gras in all its colorful gaiety, or perhaps a thrilling auto race that is taking place a hundred miles away.

# 3

# *Prime Factors in Television*

TELEVISION IS A MAGIC WORD, but the story behind it is more intriguing than that of Aladdin and his wonderful lamp. When you see the action in a television frame, it is not because some genie has taken a flat picture and sent it through the air to your receiving set. Sending an entire picture at once is still impossible.

## INTERLACED SCANNING

As we have seen, all that we really send is a stream of electrons. Imagine those little electrons bouncing over hills and valleys, sand dunes and creeks, water towers and church steeples. There are a thousand visible hurdles which might conceivably jumble the little electrons so badly that they would never get anywhere.

Not an entire picture is sent at once, but one tiny piece of it at a time, a piece so tiny that it is only about one five-millionth of a whole picture. The impulse leaves the transmitter in an ever-widening circle, followed by the other 4,999,999 impulses in quick succession. All this in just one thirtieth of one second.

This system is the prime invention which made television possible. It was the idea of a man named Nipkow, who conceived the plan in 1884 in order to send pictures by telegraph. He would use dots and dashes to produce a silhouette of the picture to be sent, using dots for the light background and dashes for the contour of the dark area. These dots and dashes would be sent in closely spaced lines. The system can be illustrated very nicely on your typewriter.

To do this, use a small x for the background and a capital X at the point where the picture should begin. A capital X indicates the darker areas; when the proper width is reached, finish the line with a small x. Each successive line made with your typewriter will lengthen the shadow area until the silhouette picture is completed.

If you have used one space between the lines, roll the paper back to the top of the picture again; then loosen the paper and pull it up just half a space so that the next line you write will be between the first and second lines. Proceed as before—line by line, one space apart—using a small x for the background and a capital X for the shadows. When this is finished, roll the paper back again to the top of the picture and place a capital O on top of every capital X. (See illustration.)

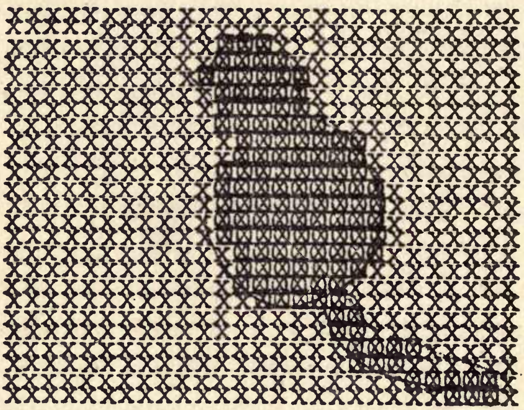


Illustration of lights and shadows by segments made on a typewriter to suggest how television pictures are sent one impulse at a time.

The preceding example illustrates exactly the principle used in television; it is known as *interlaced scanning*. Instead of using x's, however, high-speed, hard-hitting electrons are broadcast from the camera in the studio to your receiver at home in the same order and speed but in different intensities. Every shadow and high light will be duplicated on your receiver just as the camera plate received it.

Mr. Nipkow expected to use dots and dashes in close line formation instead of x's. You will understand this system very plainly if you will examine any photograph as now reproduced in a modern newspaper. Place a good magnifying glass over such a printed picture and you will see that the high lights and shadows are reproduced by thousands of small light dots, with heavier dots for the darker area.

You will find that there are usually fifty-five lines to the inch in each direction, vertically and horizontally. Better "half-tones," as printed in books, are usually made up of one hundred and twenty or one hundred thirty-three lines to the inch. Television pictures are sent to you by electrical impulses covering four to five hundred lines to each "frame" or picture, whether the picture is one inch or ten inches high. That is why small pictures are brighter and clearer than when they are so large that the electrical dots are farther apart.

In just the same way that the printed dots in the newspaper picture present a result far superior to the first telegraph results with the dots and dashes, so television presents lifelike, animated pictures because of the smaller electrical dots and impulses and the high speed with which they are sent. This is because the lines of dots in the top rows do not die out of the vision (due to the time lag of our persistence of vision) until the scanning beam of electrons have finished the picture at the bottom and have returned to the top again. This requires but one sixtieth of a second. That is sufficiently fast to give the illusion of a continuous picture, as the eye is too slow to notice any flicker. This principle is a combination of the earlier discoveries and uses of electricity, telegraph, radio, and radar impulses, so television had to wait until these other things had been developed.

## PERSISTENCE OF VISION

The optical illusion which enables us to see a picture where there are only a continuous stream of dots is made possible by the fact that the human eye reacts slowly enough to see the dots only after they have composed a complete picture; and it retains that image until the succeeding bombardment of dots has created another picture, and so on.

You can detect this persistence of vision in yourself by performing some simple tests. Some twilight, just after sunset, look toward the western horizon, where trees and buildings make a silhouette against the glowing sky. Select a tall tree and gaze steadily at its tip for fifteen seconds. Then suddenly lift your eyes to about twenty feet above the same treetop. You will see that the entire contour of the horizon will also seem to rise twenty feet, not in black silhouette, but in bright clarity. The time required for that part of your retina to return to its normal reception of images is the time-lag measure of your *persistence of vision.*

Or try another experiment: Stand for a time in a brightly lighted room. Then suddenly switch off all the lights. For the first moment or two you will be sure that the room is absolutely dark. But if you wait for a few moments, the objects in the room may become visible, and you may find that the room is not dark at all. As long as the retina retains the impact of the bright light, or higher frequency, it cannot perceive the faint light, or lower frequency. This *time lag* again measures your "persistence of vision."

Now, look at the television screen. There is really only one little bright spot to see. It moves rather swiftly, however, changing its position along a predetermined path. Sometimes this spot is brighter, sometimes darker, giving the illusion of high lights and shadows. But that little spot changes its degree of brightness and point of impact about 6,300,000 times every second. Naturally, you become confused as to where the spot is now; where it was; or where it is going.

That time lag in your vision permits the overall formation of lights and shadows in a definitely outlined silhouette which we call a television picture. It is a nice optical illusion!

Actually billions of electrons are emitted from the distant transmitter and strike the face of your receiver tube in the same order that they started. Some produce a white spot; some, only a gray spot; some, a comparatively darker one. They come in rapidly, striking the face of the tube between four and six million times a second. Your eye cannot change its impressions that fast. You become confused. The rapid impressions remain on your retina just long enough, owing to your persistence of vision, for the high-speed spot to paint a complete picture and then continue piling new impressions on your retina so quickly that you think you see a moving picture. All that really happened was that—one after another—billions of dancing electrons hit the fluorescent screen with different intensities, at different places, millions of times every second. It was the persistence of vision in your eye that made the picture.

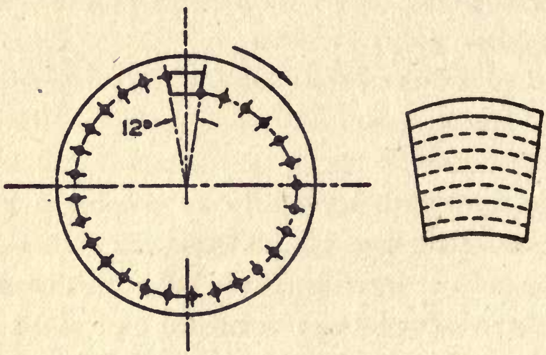
4

# *Perfecting Television Transmission*

CONSIDERING THE NECESSITY of sending a great many separate impulses out on the air, in consecutive order, the early experimenters worked with a beam of light. Since this could not be turned on and off fast enough, in quick continuity, they decided to break the beam. This was done by a revolving disk with holes around the edge, through which the light could shine intermittently.

This beam of light would be directed to a photo-electric cell. There the light would cause a very small stream of electricity to be released. Cutting the beam of light on and off would cause successive charges of electricity to follow one another in quick succession.

The more light the greater the impulse. To cut this beam of light, a metal disk four feet in diameter was caused to revolve by an electric motor. Starting near the outer edge of this disk a row of pin-point perforations about an inch apart was cut in a "concentric circle," meaning a circle constantly drawing closer to the center of the disk and ending directly under the first perforation, but a few inches below it.




Revolving scanning disk of early period (1924).

As the light would shine through these holes, on a rectangular area, it could only strike within the confines of that area while the light was perpendicular to it; but as the disk revolved and the concentric circle drew closer to the center, the light would sweep from the top to the bottom of the picture. This picture area would be just as high as the length of the distance between the two ends of the concentric circle.

From this you will see the area of the picture would be swept by thousands of light dots in lines, moving from the top to the bottom of the picture area with each revolution of the disk, in the same fashion that dots comprise a printed picture.

With the application of the principle of the photoelectric cell, each dot would broadcast an impulse of high or low intensity to reproduce the high lights and shadows of the subject being televised.

The principle seemed sound, but the application was beset with immediate major difficulties. First, the little perforations permitted the light beam to spread before contacting the photoelectric cell; this had to be overcome by inserting a lens in each perforation to focus the beam. Small lenses did not permit the passage of sufficient light. Stronger lights were then invented and larger lenses were used. Next, the speed had to be increased; by this time, a heavy four-foot steel disk carrying nearly a hundred two-and-one-half- to three-inch lenses had to be revolved at the rate of two miles per minute. By the time it was going that fast, however, the pull of centrifugal force was so great that the lenses would fly out like shrapnel from a bursting shell, sometimes cutting holes in the walls and ceiling of a room.

A steel channel iron was then bent around the disk to prevent casualty or destruction. The size of the motor had been so increased to insure smooth running that this first television receiver set now weighed a total of fifteen hundred pounds! On one occasion when this was being exhibited in a theater in Chicago the anxious audience who had crowded in to see the first television picture were astounded by a splintering crash as the heavy high-speed receiver broke through the floor of the stage and crashed into the basement! Obviously this was not a practical parlor television receiver set.

It soon became evident that for best results both the transmitter motor and the receiver motor would have to be synchronized; meaning that the same portion of the concentric circle would have to be used on both instruments at the same time and operate at the same speed in order to prevent bisecting and inverting the object or person being televised.

After years of wrestling with such heartbreaking difficulties, a high-frequency stream of electrons was developed by the use of a small electron gun. Thus was born the first "cathode-ray tube" for television, but the picture received was tiny. This was a major achievement; though far from satisfactory and very dim, it was hailed as a great invention because it eliminated the use of the whirling disks, flying lenses, and heavy motors. It required but a few more steps to develop that tiny electronic picture to its present size through the use of larger and still larger tubes.

### MAKING RECEIVER TUBES

The first television tubes were very small. The "moving picture" created by a stream of electrons on the face or end of the tube was no larger than a postage stamp. The entire tube was built in a metal case, with electrical terminals at one end and open at the other. The flat end of the glass tube was nearly flush with the open end of the metal casing. The picture was so dim that it was necessary to have the viewer wait for several minutes until his eyes became accustomed to the darkness before he could make out the picture.

Even so, the creation of the first electronic pictures was considered almost a miracle and public exhibitions were made of the tiny tube. The lecturer would hold his audience in a dark auditorium for about fifteen minutes, then invite each one to step up front and peer into the little tube.

Invariably, the expressions of wonder and amazement would be followed by the innocent criticism that "the picture flickers." That one expression always made the designing engineer's heart ache. For he surely knew it flickered, and just as surely he did not know how to correct it.

As the tubes were made larger and stronger, the metal case was eliminated. The shank was lengthened to accommodate the insertion of a metallic "electron gun" to speed up the electrons. This tube was about ten inches long and had a three-inch face end. Two sets of electronically controlled deflecting plates were inserted to direct the beam of high-speed electrons so as to sweep the end of the tube in predetermined lines.

Inside the tube the front end was coated with fluorescent willemite, and the picture was considered good. However folks wanted it larger and still larger, until the face of the tube measured seven inches in diameter. This was considered a safe maximum size due to the extreme risk of "crushing."

These tubes, it must be remembered, are produced with as near a perfect vacuum as possible. Obviously, any flat surface on the end would have a tendency to cave in or crush inward, due to the great air pressure on the outside. Because of the vacuum, there would—of course—be no equal pressure on both sides; and with all pressure removed from the inside, there would be more than 500 pounds of air pressing on the thin glass end of the seven-inch tube. Obviously, the face end had to be made slightly convex so that the great pressure would be distributed in all directions toward the shoulders of the tube.

Experiments continued until television receivers were made with a face twenty inches in diameter. The danger of breakage however increased with the size. Breakage was not alone due to natural air pressure and accidental violence. A tube could be painstakingly finished and laid away, a proud example of the glass-blower's and engineer's art; then suddenly it would explode with a violent roar! Surely nothing had touched it. The mystery baffled every one. Out of a dozen finished tubes, less than a third would remain intact after a few weeks. The force of an explosion often filled the laboratory air with powdered glass dust and drove the tube terminal into the wall. One day, when there were only three workers in a laboratory, a twenty-inch tube exploded! In the closed room, it sounded in their ears like a heavy artillery piece in action, in the field. For fifteen minutes, the men were dazed. No one spoke and no one could have been heard if he had spoken.

This danger was finally overcome by the use of special glass and critical inspection before finishing the tube. The great number of discards raised the price of these seven-inch tubes to seventy-five dollars.

Today, ten- and twelve-inch receiver tubes are being safely and successfully made with flat face ends. The glass is especially strong, is preinspected for flaws, and the face plate is made over one half inch thick. The sides and shank are about one quarter inch thick. This achievement is a credit to the high art of glass blowing and molding.

The final shape of the tubes is the result of operations in a machine lathe equipped with a score of gas jets which may be turned on or off, creating high flame or low heat, by one hand of the expert operator, while with the other he shapes the melting, bending, red-hot glass with a piece of apple wood or a spatula.

So great is the demand for these television tubes today that production has been speeded up. A horizontal turntable holding twelve tubes, vertically, twirls them around through the searing hot gas flames while the operator literally blows them into shape through a tube from his mouth. They are later finished to perfection on the gas lathe.

Coating the inside of the face end of the tube requires another type of precision art. The powdered willemite, or other fluorescent coating, must be sprayed or washed on with the utmost care so that the result is very even and not thick or thin in spots; for this coating is the real foundation of the television picture. The observation of the unaided human eye cannot be trusted to judge an even coat, and the best white or artificial light will hardly reveal the accuracy of the result.

For this task, one of the newly discovered black lights is used. Each tube is taken into a dark corner of the laboratory, after the coating has been completed, to be inspected. Here, an invisible beam from the so-called black light (in the short ultraviolet range) is directed through the clear siding of the tube, against the inside surface of the coating. Instantly, the entire coated surface on the face of that tube will glow brilliantly. If there are any irregularities in the thickness of the coating, they will show up as dark or light areas.

A poorly prepared coating will be very blotchy. The slightest impurity or foreign matter present in the material will show up as a black speck. Since specks or blotches would be disastrous to the smooth perfection of an electronic television picture, it is obvious that this basic background must be perfect.

The stream of electrons from the short-wave ultraviolet black light is also used as a floodlight to illuminate the entire television screen at one time, making it very easy to pick out the imperfections on it. This is very similar to the controlled "spot stream" of electrons which eventually present a television picture on this same screen. Any tube which cannot be considered perfect is returned to the laboratory for correction or remake.

After the glass tube and its coating have been inspected for perfection, the integrated "electron gun" is inserted in the shank of the tube and connected with the terminal end, which later will be plugged into a multiple female terminal of the system. After the vacuum is drawn and the tip sealed shut, the tube is ready for the final electronic test. Only perfect units are used.

## THE CATHODE-RAY TUBE

Out of such highly skilled artistry devoted to the critical design and structure of the tube was developed the cathode-ray tube for X ray and the modern cathode-ray tube for television. Never in his wildest dreams could Professor Wm. K. Roentgen have imagined the world-wide applications and implications of his principle when he invented the first X-ray tube and deflected a stream of electrons. In one form or another that principle is used in radar, sonar, and television.

The cathode-ray tube may be made of glass, quartz, or fused quartz, depending upon the use for which the tube is intended. It is a long vacuum tube with a cathode at one end and a plate at the other, and is made in scores of different shapes. The position of the plate varies with the specific uses of the tube.

In X ray the high-frequency electrons are bent toward the side of the tube, which they then easily penetrate because the wave length is so short that they readily pass through the spaces between the molecules of so-called opaque matter. In radar the electron stream is directed into the ether at a different frequency and with a great deal of "push," which carries them off into space.

Rays which strike the earth are absorbed, but those which cross the horizon go on and on, so great is their velocity and speed. When something in the outer space intercepts them they will return or come back, like an echo. On this principle, they have been used to locate airplanes in the sky. Some have reached the moon and returned to report this astral body on the radar receiver. Sonar sends these same impulses through the water to measure the bottom of the sea or to search for derelicts or sunken reefs.

Television uses this same electron stream in different frequencies to write its impact on a fluorescent screen, while the scanning radar uses the phosphorescent screen in the same type of tube. The difference is very interesting.

With one sweep around the tube the scanning radar paints a picture which glows and remains glowing long enough for the operator to detect the location of islands, water, ships, mountains, or towns. When the tube is used for television, however, it must glow brilliantly, but for only a small fraction of a second. This we call *fluorescence.*

Since we are concerned with television and its proper operation, we shall consider at length one use of this tube which makes it possible for service men and television engineers to locate trouble easily in a television circuit. This instrument is called the *oscilloscope* and its function is to create pictures or *oscillographs* of the characteristics of the current at any point in the television circuit.

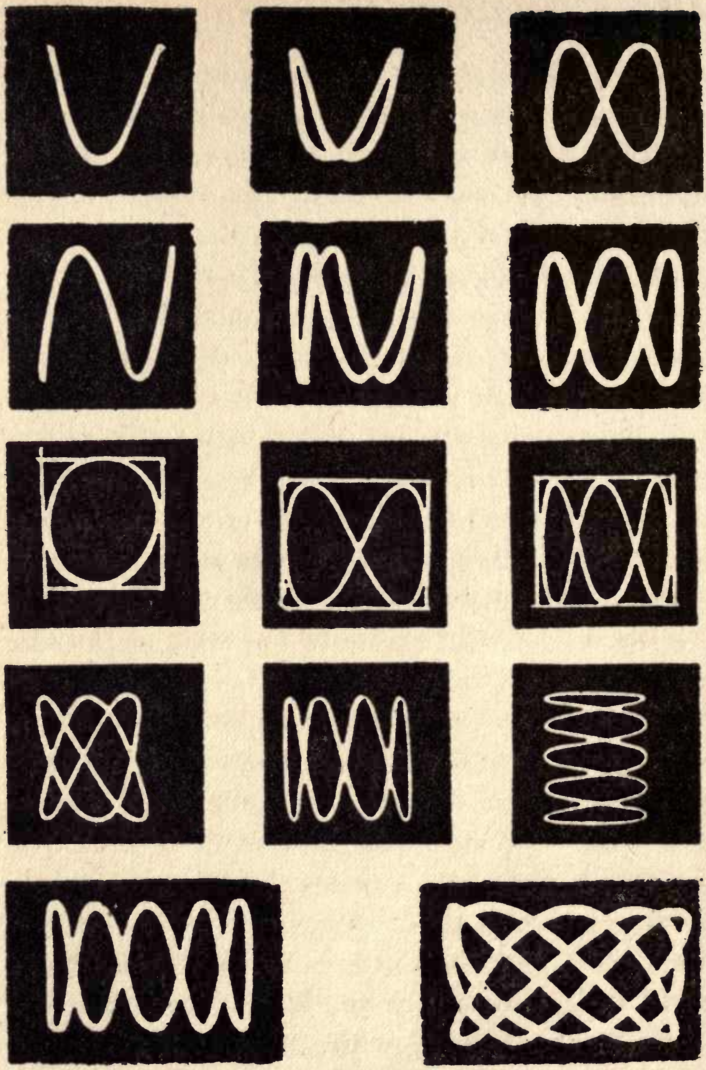
As the electrons enter the cathode-ray tube at the terminal end, they are speeded up through an electron gun. This stream of electrons then passes between two sets of plates. One set is called the horizontal sweep and the other is called the vertical sweep.

When the parts of the circuit being tested are normal, a circle will appear upon the face of the tube. If in the circuit being tested any point pushes or pulls against another point, this circle will change its shape to an oblong, a figure eight, or very many other different shapes; this will instantly tell the mathematically trained electronic engineer just exactly how many degrees "out of phase" one point is from another and exactly what he has to do to correct this.

These figures or patterns may take on any one of thousands of weird, fantastical shapes. They may seem to stand still, or they may revolve in any of four directions as the vertical or horizontal plates are more or less charged by the probes finding their mark while hunting trouble in the circuit.

You can conduct a very interesting experiment at home which will demonstrate these same patterns and illustrate how different degrees of push or restraint, when acting upon each other, will conform to the same scientific pattern under the same forces.

Suspend a small bucket of fine white sand from the center top of an open doorway, using a cord about four feet long. Twelve inches on either side of the first suspended line, attach a second cord of the same length, and bring it down to the handle of the bucket. Draw this cord tight, so that both cords form a V with the bucket hanging at its point. Put a small hole in the bottom of the bucket, just large enough for the sand to trickle out of it in a small stream. Set a small table, upon which you have placed something dark, about a foot below the bucket. Now you are ready for the experiment.



Lissajous figures ("lazy Joe" patterns).

Attempt to swing the bucket in a circle and then let go. When it comes to rest, push it in some other direction and let it go. The two cords, acting against each other, will make identically the same movement until the bucket comes to rest. Many varieties of these "lazy Joe" patterns can be produced by the different ways in which you swing the bucket, but they will make definite patterns. Altering the distance more or less between the two ropes at the top will initiate a different set of beautiful geometric figures.

The figures you obtain in the above experiment will be strangely similar to those recorded by the oscillograph when two currents oppose each other, each pulling a different way, as did the cords in your experiment.

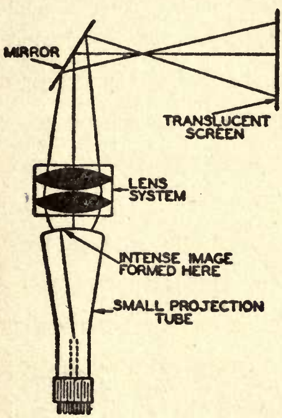
This same cathode-ray tube has found a most remarkable use in determining the resonance or quality of a human voice. When used as an oscilloscope it is connected through an amplifier with a microphone. Before anyone speaks into the microphone the electrons are beamed against the inner face of the tube in a rapid, horizontal sweep, producing a straight, even line. When someone speaks into the microphone, this straight line will instantly indicate the quality of the voice by showing peaks across the top of the line.

If the same word is repeated, the same peaks will occur each time.

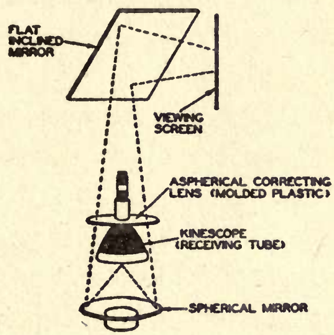
With a deep resonant voice, these peaks will jump an inch or more above the line; but if the voice is weak and without vibrant quality, the peaks may be barely perceptible. Should the speaker count "one, two, three, four, five," the number "four" will give the highest peak with any quality of voice, because the word itself has resonance. A trained speaker will cultivate his voice so that every word will register. The use of the oscilloscope is very efficient in training a good voice, as the trainee can watch the shape every vowel and consonant takes until he attains a good, resonant voice.

So definite are the patterns formed on the oscilloscope for each spoken word that the instrument has been used successfully in teaching a deaf person to read those patterns accurately and to understand thus the spoken word.

We have earlier in this chapter explained the use of the cathode-ray tube for receiving pictures. This same tube is also used for projecting the pictures. This process enlarges the image received many times. One of the ways employed, for instance, is to take a cathode-ray tube with a seven-inch picture face. The glass of the sides is drawn in sharply within a very short distance from the face end of the tube. The shank is then finished in the same length with the same internal mechanism as before. At the base level is placed a saucer-shaped disk ten inches in diameter. Half a dozen incandescent white lights are placed on the rim just around the tube. With reflectors, these lights are beamed through the sharply bent-in sides of the tube, against the inside surface of the picture face.




A simple projection system using a magnifying lens unit.



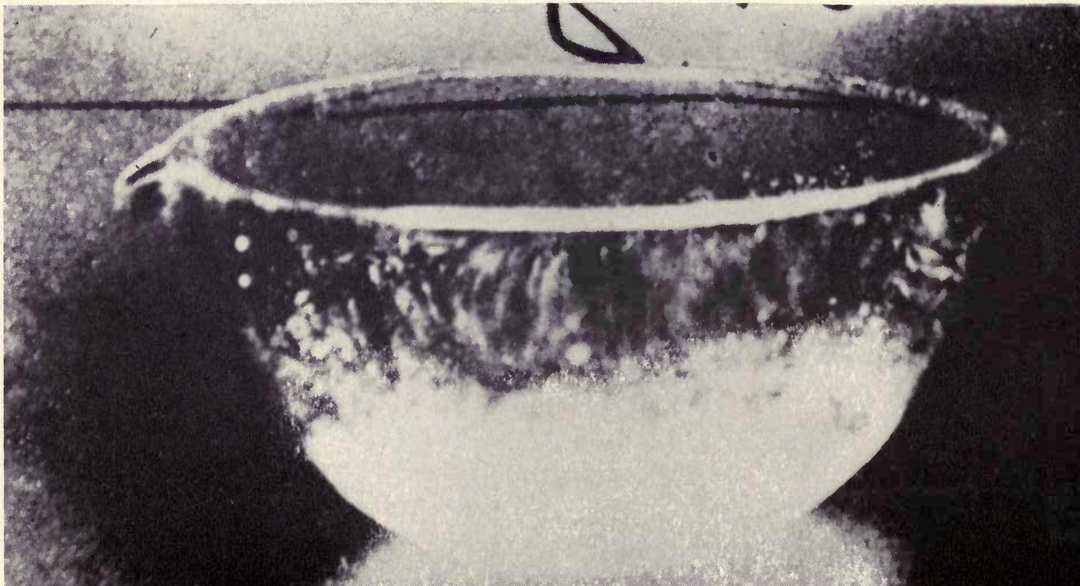

Application of the Schmidt system to television.

In the operation, the television picture is produced on the inside of the face tube, just as it is in any other cathode-ray receiver tube; but in this case, the lights from behind—and shining in through the sides of the tube—project that picture many times enlarged. A reflecting screen is placed some distance in front of it, in the same way that a lantern slide is projected upon a theater curtain.

Certainly we have come a long way from the days of the cumbersome whirling disks!

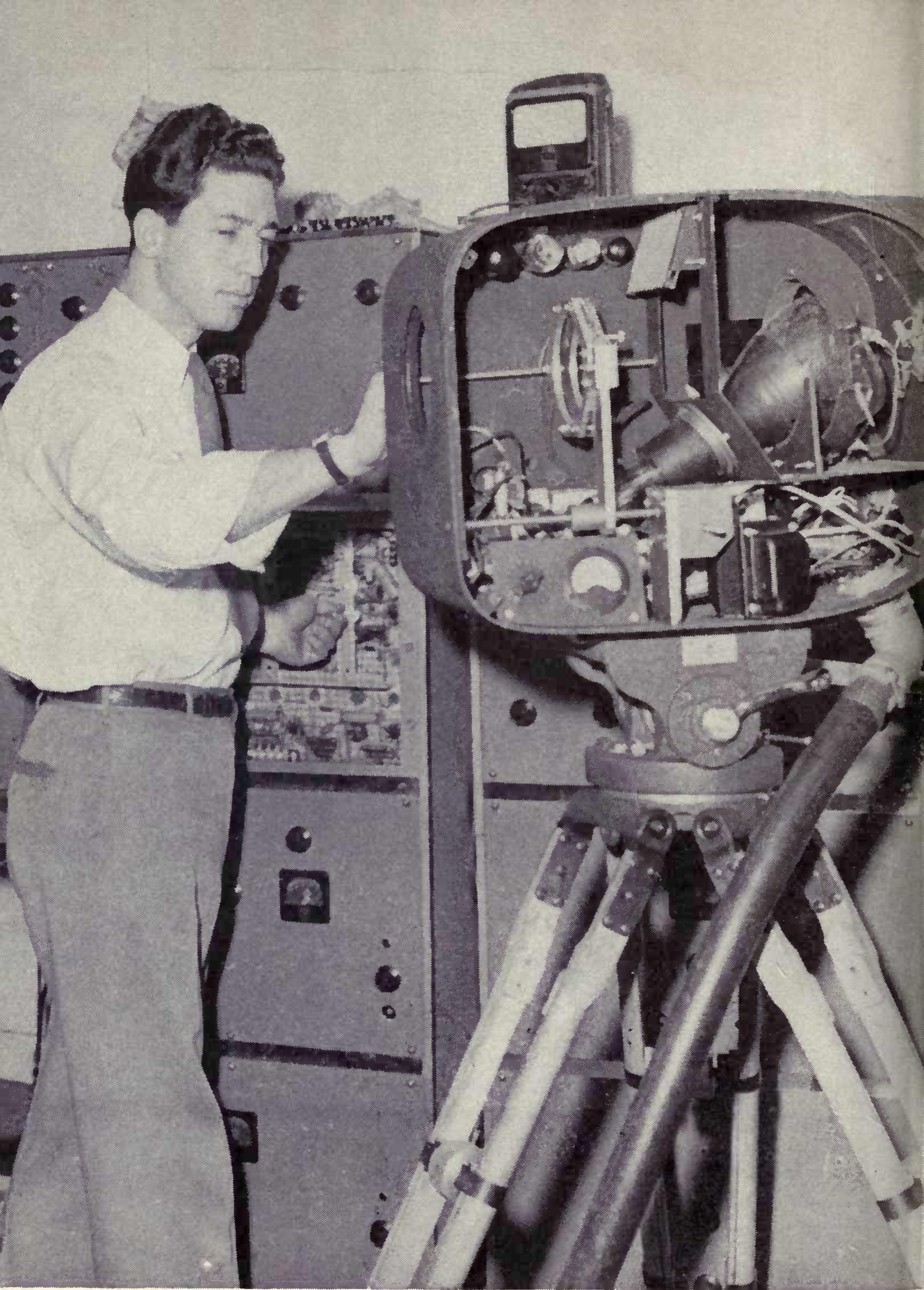
*Dr. Lee de Forest (left), known as the father of radio and the stepfather of television, is discussing recent developments in television with the author, Dr. Luther Gable. Within Dr. De Forest's lifetime all of the major discoveries and inventions leading to the development of television have been made.*

*Acknowledgment is made for many of the illustrations (except as otherwise noted) by the courtesy of American Television Institute of Technology, Chicago, Ill.*

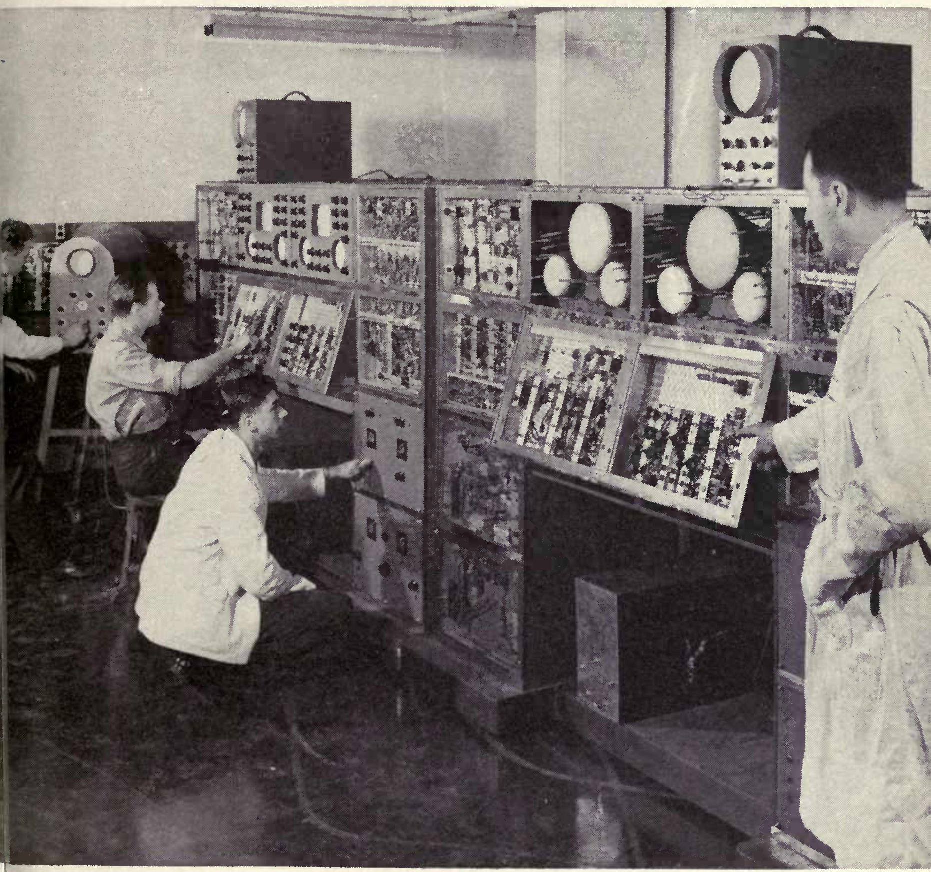


*Glowing rays like the ones emanating from the radium barium salts in this tiny bowl brought about the sequence of discoveries and inventions which made television possible. The photograph above was made with no light except that radiating from the bowl.*

*Every scene is a "take" in television, and every watcher is a critic. The cameras turn, and the performer is on her own. Her guardian angels are the director and the control operator.*



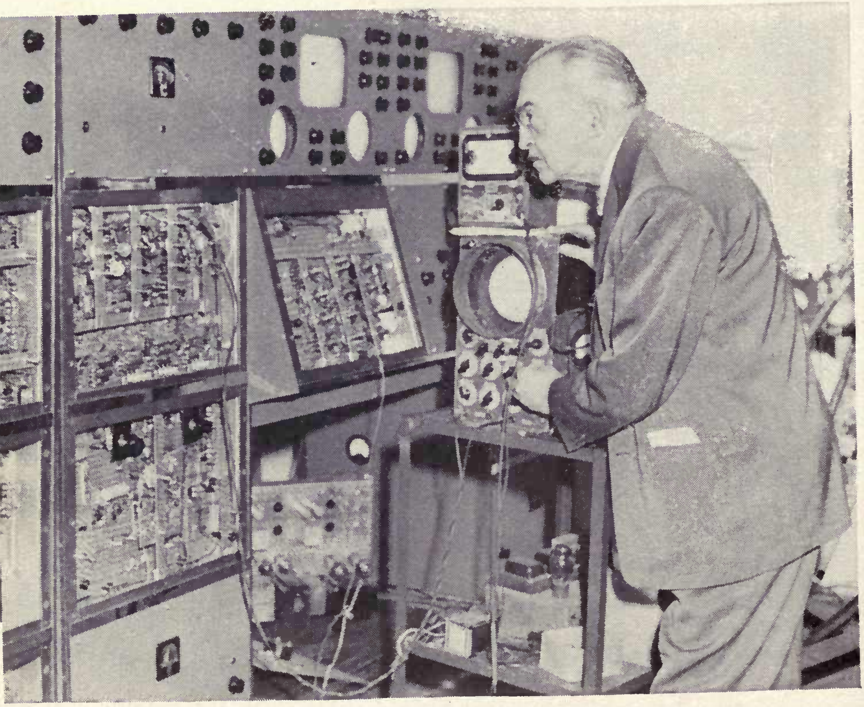
*We see here a television camera with the side removed so that we can learn a little about the maze of wires and strange tubes and lenses which make up its working parts. The large conduit leading from the front of the camera is a coaxial cable.*



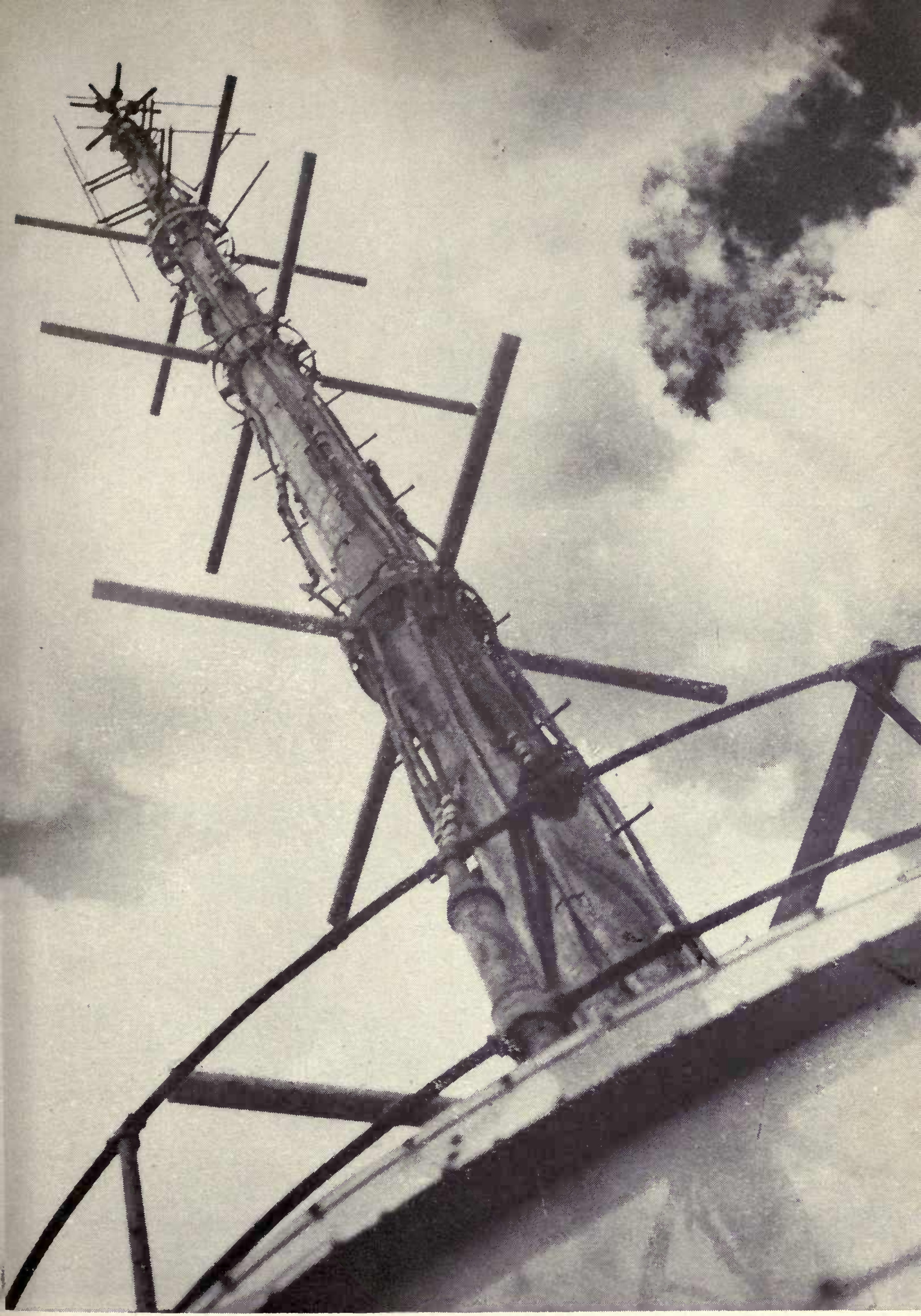
*The control room is a busy place, but no one rushes about. Each control operator must watch the screens to which he is assigned, and instantly select the scene which is best suited to be broadcast. A flick of a switch changes the broadcast from one screen to another.*

*Your favorite dance team, a melodrama, or a world-famous opera are brought to your living room and into the homes of thousands of families by television. Technicians are even now experimenting with color projection for television.*

*(Artist's conception, courtesy General Electric Co.)*



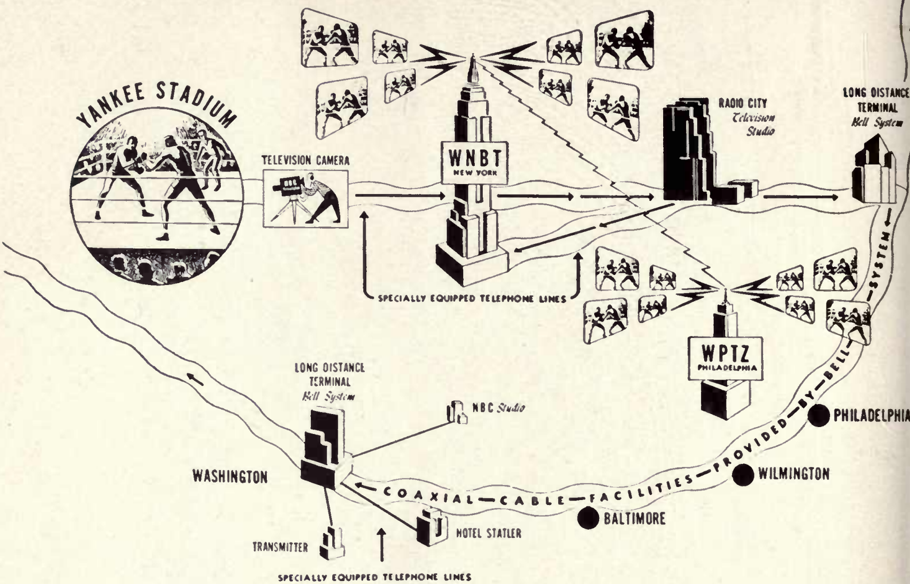
*Here the author uses an oscilloscope for testing a circuit. The "lazy Joe" patterns which appear indicate to television experts where in the "bird's nest" the trouble is.*

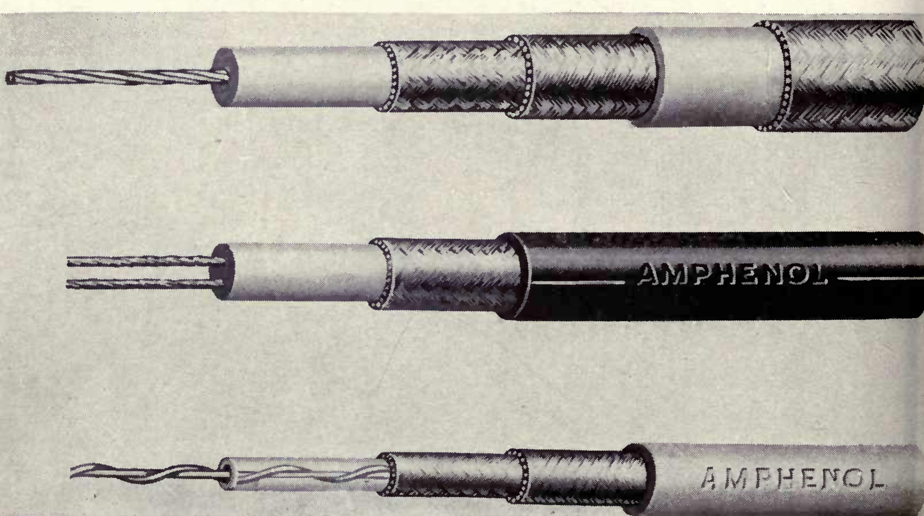


*The highest man-made structure in the world, the NBC antenna atop the Empire State Building in New York City, greatly extends the area for transmission of television broadcasts.*

*(NBC photo)*

# Boxing Match is Telecast




*The coaxial cables carry television broadcasts over areas where relay stations are not feasible. Pictured are peeled-back sections of three types of coaxial cables.*

*(American Phenolic Corp. and NBC photos)*

# 5

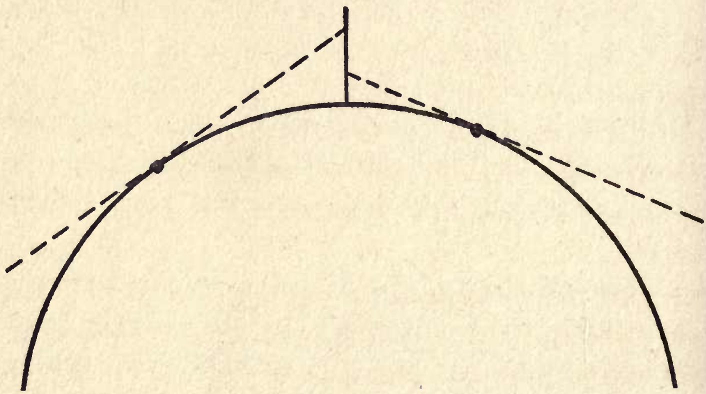
# *Extending the Range of Television Broadcasting*

OVER THE DESK of one television official hangs the familiar motto: "The difficult is that which can be done immediately; the impossible just takes a little longer."

The engineers in the field of television have indeed wrought the impossible; and one of the greatest obstacles that they had to overcome in television progress was the limited range of transmission. For the electrons which leap from the broadcasting antenna travel only in a straight line, and since the earth is round, and since the electrons do not follow the earth's contour, television broadcasting seemed limited to a range of about fifty miles.

Raising the television broadcasting antenna to a greater height brought a longer broadcasting range.

One can readily demonstrate this for himself by laying a ruler over two pins which he has stuck into two different points in an orange and which represent the broadcasting and receiving stations on the earth. When both pins protrude a quarter of an inch from the orange, the distance between the heads will be much shorter than when they protrude three quarters of an inch.



Signals broadcast from a high television antenna can be received at a greater distance than from a low one, since the beams travel in a *straight* line and cannot follow the curvature of the earth.

The range limit of television broadcasting discouraged many fainthearted people from continuing in the field. But the pioneer television engineer was not fainthearted, and was not to be discouraged. He calmly accepted the facts regarding the *impos-*

*sible* reception and proceeded to solve them. He proposed raising the broadcasting antenna to increase its range of reception, and using a higher receiving tower. These were accomplished when the broadcasting antenna was placed on the top of the Empire State Building, ninety stories above the ground, and the receiver erected on the top of a mountain one hundred and thirteen miles away. It worked!

The signal was a little weak after covering that long run. The engineers, who were out to *do the impossible,* conceived the plan of setting up an amplifier with the mountain receiver. This sensitive, efficient station would pick up the weak signals and boost them into the air at high intensity again, so that they would travel another fifty or seventy-five miles farther. Thus was born the relay system which killed the "ghost of the impossible." With successive relay stations picking up an incoming signal and boosting it over the airways again—to be picked up a little beyond the horizon each time—television became a practical possibility for coast-to-coast coverage.

Other engineers, proposing a logical extension of this plan, suggested floating a dirigible or circling a slow plane at twenty-five thousand feet altitude. Here the signals would be easily received and retransmitted through the ship's amplifiers. It is estimated that a radius of several hundred miles could thus be covered.

Only experiment and experience will prove its efficiency, however. Such a plane or ship would be equipped with receiver, antenna, and amplifier—and also with a sufficient power supply to instantly rebroadcast the incoming signal. Thus a ship hovering over Pittsburgh could pick up an uninterrupted, weak signal in a straight line from Philadelphia. At twenty-five thousand feet altitude this rebroadcast signal would cover another area of about three hundred miles radius.

It would require a crew of at least four to operate such a ship, and life on this aerial transmitter would really be "out of this world." Let us for a moment join such a crew.

To cruise above the clouds presents one thrill after another. While a rainstorm darkens the earth below, all is sunshine and beauty up there. There is an indescribable beauty of great white billowy masses in perfect definition of contour, like another world of white mountains and valleys, deep shadowy ravines, and gleaming promontories in the sunlight. Just as the sun sinks behind the cloud banks at evening, you may see a gorgeous rainbow formed in the mists. It is not the kind of rainbow we see here on earth, for this one is completely round in all its gorgeous colors, while the lengthening shadows in the white ravines present a picture no artist could paint.

The engineer who sits at his control board while broadcasting a scene from mundane earth, does not find it easy to maintain a normal sense of mental equilibrium amidst these celestial surroundings.

On stormy nights, with rain and lightning below, there is a sense of serenity in cruising the strange white billowy shapes under the blackest sky and the brightest stars you ever saw.

Since television has its largest audiences at night, it was pointed out that the television programs could be scheduled within the time range covered by only one gasoline fuel supply and manned by either a day or night crew; then when the audience retires, the television crew, taking their bearings by radar, could glide back to the home field on a fog-dispelling ray.

However, other engineers have pointed out that the establishing of relay systems for two-way service every fifty or a hundred miles presents a staggering problem. Not only would the erection of each station involve the sum of more than $50,000, but each station would require a crew of four trained electronic engineers.

This crew would have to be dependable, expert, brave, and self-sacrificing. Imagine such a crew on an inaccessible, wind-swept mountain peak in the high Sierras, or possibly a hundred miles from anywhere in the desert wastes of our great Southwest. There they would receive, review, and rebroadcast the most interesting scenes of life while the picture of reality that is presented through their window could be drawn by a single straight horizontal line on a white sheet of paper. That would be the horizon between sky and earth, from which all other visible life had fled—or died, hunting for "cool water."

## COAXIAL CABLES

Obviously, there are many physical and economic reasons why relay stations could not be considered exclusively for coast-to-coast television. Consequently, a special multiple-line cable was produced to carry the high-frequency pulses from the camera into the camera link in the control room. This is called a *coaxial cable,* and it has been developed to great efficiency.

As the length of the cable was increased, the difficulties increased with it. Due to resistance in the cable, the strength of the pulse would be lowered too much within a mile. To maintain the strength, a booster, or amplifying unit, had to be set into the line at about one-mile intervals.

The signals are amplified about three stages to start and then picked up and boosted over the next hop. This can be repeated for practically any indefinite distance. Therefore, where coaxial cables can be easily laid, it is more economical in sparsely settled or wide-open spaces. Where the cities are far apart, there is no point in wasting an area broadcast where there would be no one to receive it. In those areas the pulse can be carried on the linear cables to the objective city before being released on the air.

The difficulties of cable laying have been minimized with the developing of cable-laying machinery which has reached a high degree of perfection and efficiency. Since some cable is lead-covered, it is really quite heavy. It would be impractical to string it on poles, because they would have to be very strong and high, and furthermore, any storm could destroy the line. So the engineers bury the cable in the ground. But do not imagine that any group of American engineers would send anyone out to dig a ditch a thousand miles long with pick and shovel! Not in these mechanized days!

Let's watch one of the cable trains at work. First come the surveyors staking a straight line over deserts, fields, foothills, and creeks. The leading unit of the train is a bulldozer which pushes over and uproots trees, levels knolls, and brushes boulders aside like pebbles. It cuts down the creek bank, wades through the water, and pushes a wide swath up and out on the other side. Directly behind it more units of this ponderous mechanism thunder and roar on an endless chain of caterpillar, or track-laying, roller wheels. Like an animated monster crawling low on its belly, the first unit digs a ditch, sometimes three feet deep, piling the excavated dirt high on either side between its sprawling, revolving "legs."

Immediately following this noisy monster comes the cable drum carrier. A huge roll of lead-covered cable unwinds slowly from a great spool. Foot by foot it is pressed automatically into the bottom of the open ditch and is immediately covered by the plow plates that follow and bury it deep away from storm or disturbance, all in one operation.

The men who make up the crews of these great cable-train units must be men of the most rugged type, for physical endurance is one of the prime necessities. Sometimes the dust kicked up by these rolling monsters envelops the entire train in a cloud, out of which comes only the incredible clanking noise of the great tractors.

A man seated at the controls of one of these big machines looks very small—if indeed he can be distinguished at all from the dirt-covered machine that he drives. On and on these tractors roll, through creeks and over hills—wherever the advancing surveyors have left their stakes. One day they are fighting swamps and mosquito swarms; the next, they are laughing at the rattler and copperhead snakes wriggling to escape the noisy, irresistible train. The job is done once and once only, for when a cable is laid, it is laid for good.

The commissary section goes ahead to establish camp and to prepare a real dinner, complete in all essentials, with camp-baked pies and all the trimmings; and to this designated spot the cable train has to arrive on time—or else! The distance, however, is well planned and the men are seldom late. How glad they are to jump from their pounding, roaring, rolling mass of steel when the clang of the chef's triangle signals them to dinner. The sponge bath that they enjoy (without a sponge) at the bunk tent, while they sing of "cool water," is a luxury no city dweller has ever known.

So efficient is this method of laying cable that two such crews, working towards each other, one from the Mississippi and one from San Francisco, laid the 1,500 miles of cable in two years.

The ingenuity in laying coaxial cables, as well as the surprising accuracy of the engineers who direct the projects, was well illustrated in the following instance:

The National Broadcasting television studio of New York is situated in Radio City, whereas its broadcasting antenna is on top of the Empire State Building, several blocks away. In this building the engineer's broadcasting office is on the eighty-ninth floor, with the sign over his desk, "Stop, think, and live!"—to remind the personnel of that office that they are handling about 8,000 volts of electrical energy.

The control room and the broadcasting studio had, of course, to be connected with a coaxial cable. This was laid under the streets with great care, in lead-covered, moisture-proof casing. When they reached the Empire State Building, however, a lighter cable had to be used from the basement to the eighty-ninth floor. Because the building was still under construction and the walls had not yet been covered, it was an easy matter to hang the cable.

It is very necessary, however, when such a cable is being hung near steel girders, that it be *perfectly* insulated to prevent any loss of the high frequency and high voltage it carries. Accordingly, very special, dielectric insulating pins were ordered for this purpose. They had not yet arrived when the cable was being hung, so it was decided to use steel pins upon which to hang the cable temporarily and remove them later when the dielectric pins arrived.

This was done, and a few days before the walls were put in, all the steel pins were withdrawn and replaced by these perfect insulating pins; then the walls were finished.

Some weeks later, after the completion of the camera link, actual broadcasting was tried to test the equipment. There were ghosts in every broadcast attempted. A duplicate image followed every outline in mimicry. Every component of the link was synchronized, and many days went by without the cause of the ghosts being discovered.

At this point, one of the highly trained engineers gathered up an armful of resistance meters and began working on the cable—first from one end on the eighty-ninth floor, then from the junction point where it joined the lead-covered cable in the basement. His search involved a very technical formula of resistance, wire size, and length. With a high degree of mathematical precision, he worked out his formulas, returned to the office, and announced that somewhere between the eighty-ninth floor and the basement a workman had neglected to substitute a dielectric pin for a steel pin. His associates agreed that this was highly possible, and they wondered if it would be necessary to tear down the walls of the building from top to bottom until the pin was found. "No," the engineer assured them, "according to my formulas of resistance, taken from each end of the cable, you will find it on the thirty-seventh floor." They opened the wall at that point and found the steel pin within only two feet of the first opening.

Plans for laying coaxial cables are daily being extended. In an office of one of our great broadcasting chains is a map of the United States marked with red lines showing the actual and proposed coaxial cable connections and the relay station system even now being built to bring television to every city.

6

# *Fluorescent Rocks for Television*

WE CANNOT DISCUSS the subject of television without devoting some space to those strange rocks to which television owes so much and may in time owe much more. We have already seen the role that one of those rocks, willemite, plays in television. You may have some willemite in your own backyard or in a rocky acre near your summer camp, but have not been able to recognize it, or distinguish it from other rocks. It can be generally detected only by "black light," now used by willemite hunters. This black light emits a stream of dancing electrons at high speed, or frequency. We call it black light because our eyes are not keyed to see it; and in this respect it may be compared with the silent whistle used in the canine corps in the army, a whistle so high and shrill that our ears cannot hear it, whereas it can be easily heard by the more sensitive ears of dogs, cats, or other animals.

If a black-light beam were invisible, it would be useless. However, when the black-light beam of high-speed electrons strikes a fluorescent willemite rock in the darkness, the rock glows and trembles so violently that the surface molecules go into a high-frequency vibration and emit a strange, white light like a beam of moonlight. The willemite has no persistence or time-lag value. The moment the black light is turned off, the willemite is instantly dark again. This makes it a valuable screen in television because the picture must change rapidly.

The willemite prospector sleeps during the day and prowls the lonely hillsides, deserts, glades, and valleys at night. He swings his lantern before him; he resembles Diogenes searching for an honest man. Suddenly a flamelike color flares up in his pathway. It is a glowing rock. Should you go prospecting with a black light, heed this word of caution. If you see a patch of brilliant yellow or orange about as large as your hand, do not pick it up. Kick it first. If it runs from you, it is a scorpion. You may also find a gleaming red rock, or a speckled one resembling a gila monster.

Black-light prospectors have found over two hundred kinds of rocks which fluoresce vividly in the darkness under the impact of the black light. They may be blue, red, yellow, orange, green, purple, violet, magenta, brown, or cerise. This amazing array of vivid colors can only be seen in the dark under the black light. In daylight, these same rocks appear to be just like any other common stone.

When these stones were recently discovered, spectators were overcome with awe. The remark was made, "Maybe this is what the ancient prophets meant in the Scriptures when they wrote of 'stones of fire.'" Their vivid colors made them look as though they were burning, but they were cold to the touch.

When the television engineer observed these fluorescent rocks, he made a few deductions: "If we can make black-and-white television with willemite powder placed inside the tube, why can't we make natural color television by using a mixture of some of these colors and a multiple scanning beam to reproduce television in natural color?"

Of course, some time will be required for experimentation and production of scanning beams before this will be accomplished.

Drab rocks take on a breathless beauty under the "invisible ray" of black light. They seem certain to become valuable factors in television some day. Even at this time, when the practical value of most of them is as yet unknown, they command good prices for collectors who treasure them for their gorgeous colors when observed under black light. People with a black-light hobby are willing to pay as much as five dollars for a single rock no larger than your fist; and a black-light prospector can stumble upon a veritable treasure trove of fluorescent rocks anywhere. For those interested in searching for these rocks, a list describing some of the best known fluorescent ores, together with their location and color response, is appended at the back of this book.

There are no doubt many more of these amazing rock deposits; and they might well be found practically anywhere, since they do not follow any certain geological stratum or formation. They seem to occur in pockets or impregnated areas.

Many major inventions have been originated by someone with a hobby, and the whole secret has been worked out by a close study of nature itself. It is usually a theoretical physicist, working far into the night on his strange researches, who finally comes out with a weird announcement such as "the moon has certain effects on human beings." The world may look at his findings with disdain or incredulity. The older folks may say, "So, what?" while the younger folks may say, "Yes, I know." Then the man with the hobby may take it up and make the practical application.

So it was with the black light. Practical prospectors abandoned their gold-washing pans and started out in the night with a strange black light hunting for uranium, and whether or not they found it, they usually came back with one or more kinds or colors of the beautiful new "stones of fire."

## HUNTING WITH BLACK LIGHT

Let us take a trip with one of these night-prowling prospectors. We join him in his camp at sundown as he crawls out from under the shade of an overhanging rock, big tree, or pup tent, where he has been sleeping all day. He digs a small hole in the ground about two feet in diameter in which he builds a good fire. While the earth and the sand he removed are being thoroughly heated by the fire, he opens and cleans out a small prairie hen, shot earlier in the day. He does a good job of it, except that he does not remove the feathers. When the earth is very hot from the fire, he places the hen, feathers and all, on the glowing embers and scrapes the hot earth around the hole on top of the hen, then tamps it down.

Now, he calls in his burro, which has been grazing and assembles his storage batteries and black-light lantern for another prowl into the dark night. By the time he has everything about ready, he will pull the prairie hen from the hot earth, and shake it sharply; all the skin and feathers will fall off with the hardened clay, which has stuck to the feathers. If he has timed the heat and the size of the hen correctly he will have an excellent roast dinner, combined with his hardtack or biscuits and hot coffee. Have you ever smelled coffee, boiling in a tin can, over the hot earth of a wild country? (Wow!)

Now he is ready to start out. A "hot-shot" battery is slung over the saddle of the burro to counterbalance the weight of provisions on the other side. A pouch for sample ore and a sleeping bag make up the rest of the little burro's ample load. A line cord from the battery is attached to a black "Mineralight" which he swings slowly backward and forward at his side. By now it is dark; and since the black light gives no visible radiation, he carries a common oil lantern or flashlight in his other hand and may attach the burro's lead to his belt. Sometimes these patient little animals follow very closely without the use of a lead.

Slowly he moves on through the darkness, sometimes for hours, or perhaps for many nights, before he makes a discovery. Suddenly he stops. There, in the black earth before him, is one green light, shining like a "thing on fire." He dislodges it with his foot and turns up a small rock the size of a walnut, gleaming as though it were hot. With his white light he now determines that it is a crystal rock with a normal yellow appearance and he knows there should be more in the immediate vicinity. So he tethers the burro, straps the hot-shot battery over his shoulder, and starts making a wide circle with his black light. (A bell on the burro, at this time, might be a smart idea, since one is completely in the dark, and cannot afford to lose him.) Presently he comes upon a sight no one can well describe. It is as though he were standing on a high pinnacle, looking down over a lighted town, deep in the valley—or, perchance, were riding in an airplane and passing over a city far below him in the night, with its beautiful street lights and signs as the only visible evidence of its presence. There, before him on the ground, are thousands of brilliant little lights sending back their vivid gleam, reacting to the invisible rays of the black light as far as he can swing it. Such was the appearance of a wide area in western Wyoming, where this rock was found. It is called *dakite,* named after the man who discovered it, for usually the new fluorescent rocks are named after the prospector who discovers them.

If this is a wild country, the prospector stakes the claim and records it in the proper county court-house as soon as he can reach it, or at least finds out with whom he can make a mining contract to purchase or lease the land. This may mean he can stay there, open his own mining enterprise, and ship the material directly to the market, or maybe he will mine it and pay the owner a royalty. If he cannot do either of these things he may have to move on to new fields and new discoveries. Any color of fluorescent rock may be valuable in television sooner or later.

Of course, when you start out for yourself you won't need the burro. You can work around home and carry the hot-shot battery on your own back. If you do not care to go in for all-night hunting trips, you can buy a fifty-cent *argon* bulb, place it in any socket from a 110-volt A.C. outlet, and leave it at home. Then you can start out in daylight with an ore-sample bag on your back, picking up samples of any promising or unusual-looking rocks, to each of which you should affix a piece of adhesive tape and number the specimen. Keep a log of your operations, with a map of your territory, and put the corresponding number on the map to indicate the location where each numbered specimen was found. When you have procured all the rocks you care to carry home, take them back for observation under the *argon* bulb. This should be done only at night or in a thoroughly darkened room.

# 7

## *A Visit to the Studio*

THE FIRST STUDIOS for television broadcasting, between 1924 and 1934, were about the hottest places in which any acting artist could be expected to work and remain normal. This was due to the large number of brilliant lights that were then necessary. Carbon arc lights, mercury-vapor lamps, and huge spotlights contributed to produce a heat that was almost unendurable.

It was not uncommon to see a curl of smoke issuing from the top of the head of a singer as the brilliantine or oil vaporized from the hair. When one of the early prize fights was photographed for the movies under the same lights first used by television, both fighters complained bitterly of the intense heat from the lights under which they were obliged to box. A few years later, when both men became bald, they each steadfastly insisted it was caused by the intense heat from these lights.

Improvements in the type of lights available and the invention of the bright tungsten filament constantly improved matters by lessening the heat to some extent. When the whirling disk was discarded from the first television cameras and the electron beam was introduced, a further reduction of the intense heat from the lights was possible. The greatest improvement, however, was the recent advent of the "image orthicon tube." This highly efficient camera-eye can easily produce the picture of a man's face from the light of the match with which he lights his cigarette.

The reason for the easy production of this picture lies in the fact that the burning match generates a certain amount of infrared ray, to which the image orthicon tube is singularly susceptible.

Today, the television studio looks more like a movie set than a radio studio, and everywhere you look you may be facing a different situation. There may be different scenes of a drama on each side of the room, as widely different as summer and winter. There may be three or more television cameras, each mounted on a platform or dolly with rubber-tired wheels. The cameraman rides on a saddle, stands behind the camera, or may walk behind it and push it before him. He wears earphones and takes his orders from the control room at all times.

Scenery can be adjusted or rolled into position, much the same as in any theater. The lighting must of course be kept out of sight of the scene being televised. Overhead, the studio lighting equipment, beams floodlights on the scene by remote control.

Some of these light bulbs are also on dollies and are pushed around directly behind each camera. The attendants in charge of these floor lighting units wear headphones the same as the men behind each camera. Other lights are arranged in reflectors hung from the ceiling; they can be moved in any direction by a light-control man, using electric push buttons. Sound booms, supporting the delicate microphones, reach in from the sides over the scene of action. They are always elevated just outside the line of sight of the camera lens.

The question of lighting a television broadcasting studio presents the very newest problems. This has been occasioned by the different receptivities of different types of television camera tubes. The engineers are seeking and experimenting with every type of visible or black-light radiations.

In one studio, a brick fireplace was being televised in bright lights. The white lines representing mortar between the bricks were barely visible when all the bright lights were turned on. A so-called black light, in the short ultraviolet range was tried as an experiment. The result was remarkably good. In fact, it was found that when the white lights were turned out the fireplace was still shown in all its details on the receiver in the control room—but as far as the human eye was concerned, the studio was practically dark.

In another experiment, the studio manager was attempting to televise a rapidly revolving disk containing a multiple number of designs at equal distances from the center of the disk. The object was to obtain a televised stroboscopic effect. In regular white lights, this revolving disk appeared as many revolving disks, each rotating in a different direction on the same axis. Without the white lights and in the beam of the short ultraviolet black light this same whirling disk was seen on the receiver in the control room as a beautiful six-point star, standing perfectly still.

This illustrates some of the problems of the studio director and shows the wide range of possibilities in the use of lights with different frequencies. Truly it can be said, "The orth tube can see what the human eye cannot."

One of the very interesting problems which confronts the studio director, and of which the unthinking public would scarcely dream, is the care with which he must direct the cameramen in order to prevent "burning" the receiver screen. This means that if a stream of electrons is left to play upon the same spot too long, a certain deterioration in the fluorescent screen of the receiver will take place.

In televising any normal scene or stage performance, little or no attention need be paid to this feature, since all set scenes are filled with action and action keeps the stream of electrons changing constantly. In rehearsal, however, it often happens that no one is on the stage and there may not be a moving thing in the area covered by the camera, which is still in operation. It is inadvisable to turn it on and off repeatedly; therefore, the cameraman must keep the *camera* moving continuously, yet slowly, until some action comes within its range again. This same feature applies to televising natural scenery. In the case of a waterfall there is plenty of action, but a panorama of still scenery would require the same slow sweep of the camera.

Many of the studio cameras are equipped with a revolving turret on the front, containing four lenses for quick and easy focusing. The studio director must decide which one is to be used and when to make the change. One is for a close-up view of the principal actor or soloist. Another with a wide-angle range may be quickly substituted, by simply revolving the turret, to include the entire group in the picture. The other two are all set for different ranges without further focusing, and are simply turned in as needed.

Stagehands who work in the television studio must be extremely conscious of the wide sweep of the camera lens, in order to keep out of range of the picture being televised on the air. The studio director must be ever aware of this when ordering a change of sets. On one occasion a sixteenth-century scene was being enacted, with all the embellishments and requisites of that period. The scene was on the air, and the audience, watching their receivers, were deeply engrossed in the settings, costumes, and plot of that ancient era; but they were rudely awakened when a modern carpenter came striding across the screen carrying a very modern saw and hammer! He was an extra stagehand that day and was not yet "camera conscious."

## THE PICTURE CONTROL ROOM

In a small room which is sealed off from all disturbance, and from which the studio or anyone in it is not visible, sit two engineers before a thirty thousand dollar "camera link." This is called the control room. On a broad panel before them are hundreds of control knobs, and just above the panel, in line of sight for the engineers, are from three to five television viewing screens.

Each picture on these viewing screens is being taken by a separate camera in the studio at the same time. Each takes the same scene, but from a different angle: some close, one from the right, and one from the left. The control man can see them all at the same time, but on different screens. He must make instant decisions which picture is best to send out on the air.

The television *camera link* is a large mass of colored wires and radio parts built into a steel frame ten to twenty feet long, about six feet high, and two feet deep. Looking at it from the back, one sees many square compartments. Some are filled entirely with tubes. One wide compartment is filled with small laminated iron transformers in many shapes and usually painted black.

The rest of the inside resembles hundreds of birds' nests. There are many glistening parts and strange-looking tiny rolls about one inch long and one quarter of an inch in diameter. They will hold your attention by the intriguing way in which they are painted. You might even imagine the painter was trying to simulate a group of zebras, but then you find they are certainly not alike. Here is one, for instance, with a red band on the end, then a green band follows that, next a yellow band, while the other end has a silver tip.

The engineer who has been showing you the camera link is amused at your incredible surprise over the fantastic-colored bands around the tiny rolls. Sensing your bewilderment, he easily explains that this little roll you have just observed is a *resistor* of 250,000 ohms resistance, with a tolerance of ten per cent plus or minus.

He then points out another little roll with an orange band on the end, a green band following that, next a red band, followed by a gold tip on the other end. That, he tells you, is another resistor with 3,500 ohms resistance and a tolerance of only five per cent plus or minus.

You look closely and see there are no numbers on the resistors, so you ask him frankly how he knows he is correct. That, he explains is easily determined by the color code he had to memorize. Then he takes out a pencil and writes this list of colors, in premeditated order and numbers each one. Black stands for 0, brown stands for 1, red for 2, orange for 3, yellow for 4, green for 5, blue for 6, violet for 7, gray for 8, white for 9. A silver end stands for ten per cent tolerance; a gold end for five per cent; and no color on the tip means a tolerance of twenty per cent plus or minus.

Incredulously, you ask him how he can remember the colors in that order. He will smile, look you over carefully, and hesitatingly give you this answer. Put down the initials of each of these colors, then build a word after each initial which will weave itself into a sentence that you can remember. B-B-R-O-Y-G-B-V-G-W can be recalled very easily if you will weave them into the following sentence, "Bad boys rush our young girls, by very gay wooing."

On a resistor the first color band denotes the first number of its rated resistance. The second band denotes the second number, while the third band indicates how many zeros you add for your answer. In the case of the first resistor, the red band meant 2, the green 5, while the yellow band said, add 4 zero's, which gives your answer of 250,000 ohms resistance.

The ten per cent tolerance means that particular resistor can be used anywhere it is needed, between 225,000 to 275,000 ohms.

In another part of this camera link, there are several individual operating sections, or related circuits, and each one of these sections must be in tune or *resonance* with the other. Should one be slightly "out of tune," it may retard the electrons and throw the entire stream "out of phase." This would produce two pictures on the receiver—one strong picture, together with a duplicate behind and to one side of it making the same movements, like a ghost of the main picture.

Since electrons are always associated with atoms, and the atom is a basic unit which has been developed as a deadly weapon, these late electrons in the duplicate picture are often referred to as "atomic ghosts." Careful tuning of all broadcasting equipment and checking to see that there is no leakage in connecting cables will eliminate these ghosts. Sometimes they are hard to catch. We shall speak more of these ghosts in a later chapter.

To show you just how alert the engineer in the control room must be in making his instant decisions concerning the best picture to be sent out on the air, the following examples are interesting.

On one occasion a talented artist was singing in the studio. The control engineer became so absorbed in the beauty of her appearance and work—as he observed her from different angles on three screens at once—that he inadvertently touched the wrong button while switching the broadcasting beam from one screen to another.

The transfer threw two sections of the camera link one hundred eighty degrees "out of phase" and lo, he had the singer's head where her feet should have been, while her feet was where her head should have been. Of course the fault was easily corrected, but even that momentary error could not be eliminated or "cut out" as in the taking of a movie film. The television camera-eye is cruelly authentic in sending everything out on the air, just as it happens. Once it is on the air it is like the spoken word: it cannot be recalled.

In another instance, when a studio was televising a medieval scene in which a knight in armor was supposed to bow before the queen, the knight forgot to bow. The program director reached out from one side and placed his hand on the knight's helmet to push him down—as a reminder—completely forgetting about the relentless, all-seeing camera-eye. As a result, he had his own hand televised on the air, much to the amusement of the television audience.

In a certain event in which a ship was being christened, the televising camera was turned on the scene, the dignitaries were all in their proper places—looking their best—and the ship started "down the ways." The sponsor flung the christening bottle and missed the ship! A workman below finished the job. Newspaper reports could cover up the accident, but the television receivers all revealed what had happened and they couldn't take it back.

The control engineers have more to do however than just to watch and change the picture from one camera to another. They must know what every object should look like and see to it that everything comes out of the camera in the right proportions without being unduly wide or unnaturally high.

They control the vertical and horizontal sweep and can make a low building look like a very tall one or a small pond look like a wide lake. This of course could be a great advantage to a politician. A tall, thin person could be made to look very rotund or a short one could appear tall.

The chief engineer is in constant communication, by headphones, with each camera operator. He constantly directs the cameramen to move up close or retire to another angle. Every time you view the television screen and admire the perfect form of all the televised objects or persons, you may credit it to the work of some deserving, hard-working engineer. If something appears to be a little out of line, be patient. He probably has observed it first and is earnestly trying to correct it.

# 8

## *Acting Before the Television Camera*

WHEN TELEVISION OPENED its first studios, the question of acting personnel became a major problem. Naturally the management looked for people with related training, and a singing actress from the legitimate stage was brought into the studio for a trial performance. She started to sing to the blank walls and a microphone, when suddenly she stopped in the middle of her song, clasped her hands, and screamed, "I can't go on, I can't go on!" "What's the matter?" demanded the director, rushing unmindfully into the scene. "Oh!" she exclaimed, "I cannot sing with feeling to those glass camera-eyes!" Little did she know that there were a thousand people who saw and heard the break in her song, as they watched the scene back in the comfort of their own homes. Of course, she could not hear their encouraging applause.

The management then turned to those of radio experience. They came, and they were used to talking to blank walls, but they just moved their lips and stood still, like wax figures. If a director chased them around the studio, in some semblance of life and action, they found difficulty in remembering what to say.

Next, the management called in the more versatile professionals from the movie lots. It was soon discovered that these folks were used to carrying a theme for only a few lines or a few minutes at a time; then the picture would be *cut* and the actors would go to play golf or take a rest, and return the next day to finish the continuity, and then it was only necessary to tack the ends of the two films together. But television uses no film in the camera, so you cannot cut out a mistake or correction. You cannot do part of it now and part of it later, then connect the parts as in the films. The long-sustained action must be continuous. This means hard work, which usually does not interest cinema folks. It was obvious, therefore, that an entirely new group of dramatists must be trained for television performance.

Some schools of dramatic art are now including television acting in their courses. If you were to visit the American Television Laboratories where technical engineers and actors are trained, you would probably be surprised to see a group of young folks in the "Dramatics Classroom," lined up on each side of the room, facing each other, wearing wire masks and chest armor—and busily engaged in a multiple group fencing contest, with every motion under control as counted out by the fencing master at the head of the room.

You would probably say, "For what purpose in television are these young people studying fencing?" If you ask the master, he will indulgently explain that these controlled and artful exercises are intended to bring every muscle of the body into play. He will then explain that most people walk, sit down, get up, and walk again in the most mechanical way—all of which employs but a few of the muscles, day after day. Many other sets of muscles are never voluntarily brought into play, unless they are awakened by these or other exercises. After a short time the students are noticeably more graceful in walking or in using their arms, with every evidence of being alive from head to toe.

This word *alive* is the keynote or secret of successful acting before a television camera. One cannot just stand like a mannequin in a show window and barely move his lips. That would be all right in radio, but television is more demanding. One must be active in every facial expression and each natural movement of the body. You are not expected to exaggerate unnecessarily or flay your arms just for the sake of action, but even that would be better than standing perfectly still. There are clowns right now capitalizing on crazy antics.

It is a prerequisite that professional personnel appearing in television as performers, or as demonstrators of a sponsor's wares, must employ continuous, graceful, and natural movement. Facial expression is a major feature of the training. Some persons portray a natural animation, while speaking or talking, without effort at any time. Others maintain a "dead-pan" expression upon all occasions.

For such naturally gifted persons, who can raise their eyebrows, wrinkle their forehead in question, show laugh wrinkles for mirth, and smile with a merry twinkle of the eye, a golden opportunity awaits in television.

Few persons realize how very awkward most people are in the use of their hands. They seem never to know just where to put them or how to hold them. It is strange how quickly a television audience will detect and criticize such little things.

A common mistake made by the uninitiated is to forget the direction in which their invisible audience is located. When one is surrounded by walls, lights, and paraphernalia, it is very easy to lose track of the direction in which the audience is supposed to be. In one confused second the actor may easily turn his back to the television camera; and that is an unpardonable error, for behind that camera lens is the audience, a hundred thousand people, watching through a two-inch tube.

To some this thought is frightening. They may forget their lines or inadvertently reach for their notes. In such an emergency one must be trained to act naturally and not betray the hysteria of being "camera conscious." Situations can arise which might be extremely embarrassing and accidents can happen. The standard admonition for all such situations is: "Be natural," and do something animatedly to cover up or detract from the situation.

On the legitimate stage all emotions are necessarily overemphasized, but in television emotions must be accompanied by appropriate emphasized action, without which the expressed emotion would be lost. Thus one could say that facial and body expression must co-ordinate.

Many an aspiring television queen might possess beauty, animation, agility, and gracefulness—and still be a total failure just for the lack of a resonant voice. Voice is one thing, but a resonant voice—in the language of electronics—is quite another. It is an ever-present engineering problem to reproduce a human voice electronically.

The sound waves in the air must be translated into impulses. A microphone is the medium in which these electronic impulses originate. When sound waves strike the ribbon or carbon disk in the microphone, it is caused to vibrate in exact reproduction of the inflections of the human voice. But if this human voice has no resonance to cause these vibrations, the reproductions will be weak and faulty. One does not need to be born with such a voice, for it may be acquired; and that, too, is part of the television training curriculum.

Besides calling for a new type of actor adapted to the medium of the television camera, television calls also for cosmeticians who have learned what tricks the television camera does to make-up, and can apply their art accordingly. To appreciate the need for such cosmeticians, let us enter a television studio of the early days.

We see a beautiful girl entering to sing for us. The cosmeticians of the old school have applied her rouge and lipstick artfully; and ordinarily her appearance would reflect great credit on any studio make-up artist. But as she steps before the camera to sing, the director interrupts with "Cut! Cut! Where on earth did you find the ghost?" For he has been watching the reception in the control receiver, and he has seen that her face appears there as pale and lifeless, with half her teeth missing.

The explanation for such tricks of the television camera is that certain light frequencies used in illuminating the actors produce different results electronically from the impression that they make on the human eye. Rouge and lipstick do not show up under studio lights, so that, despite the application of the usual make-up, the skin coloring of the face does not appear any different from the skin coloring of the hands. Furthermore, false teeth, lacking the high calcium content of natural teeth, do not respond with the same brilliance. The new acrylic plastic teeth overcome this difficulty.

It is necessary for artists trained in television color response to apply special make-up, using purples, greens, and blues—colors that televise in such a way that the desired effect will be transmitted. If, however, one of the actresses made up in television greens and blues were to appear on the street, she would look most grotesque, since then she would be seen in normal light.

Nor does the color problem end here; it applies also to dress. Actors and actresses must select their colors in clothing with due regard for the new medium in which they are working. Their failure to do so may result in some embarrassing situations.

One such incident occurred when a shapely model appeared on the television set in a red, form-fitting bathing suit. Immediately the studio was flooded with telephone calls demanding an investigation, for, since television makes no color distinction between red and the color of flesh, the girl made a rather shocking appearance.

Thus we see that the new medium, television, calls for new skills in photographing scenes, in acting, and in make-up artistry.

# 9

# *The Meaning of Frequencies*

IT HAS ALWAYS BEEN a mystery to many people how so many radio programs and television scenes, of which we are totally unaware, can be floating around our heads all the time. Considering the large number of these programs which are continually in the air, it seems even more mysterious how anyone can reach out and get just any certain program he wants. If there is anything more miraculous than that, it is the many more vibrations which there are in the air and of which we little dream.

Consider the locust, the katydid, the beetle, and the butterfly. You have heard the locust and the katydid broadcasting because their frequency is within the range of the human ear. But who can say that the beetle and the butterfly do not also broadcast?

You remember they have antenna and it is interesting to speculate that there may be a functional similarity between the natural antenna of insects and the man-made antenna of a radio or television set.

This speculation is based upon the remarkable silent whistles developed for the scout dogs in the last war. This well-made and surprising little gadget could be heard by the sensitive ears of a dog at an incredible distance. It has a vibration frequency beyond the range of human ears.

In view of this discovery, one could naturally assume that certain insects may be capable of emitting frequencies beyond the range of our human ears. and if this were so, the assumption would follow that each species was broadcasting on its own frequency, unknown and unheard by any other species, including human beings.

The following story is told of an interesting experiment which was recently conducted in this connection. Two rare types of butterflies were brought from a very great distance and liberated in a remote area where there was no other known specimen of that species. They were released a mile apart. It was assumed that if either could in any way broadcast its location and if the other could receive and determine the direction of the broadcast, the insects would probably find each other, which they did. Thus it might be assumed that the insects have long used their antenna or other organs for "radio" broadcasting and receiving in much the same way that man has finally learned how to do.

Of course most scientists maintain that the butterfly finds its mate principally by the sense of smell in the same way it locates the flowers in the field. The electronic engineer, however, has made amplifiers which are reported to reveal the dying cries of insects, when stepped on in the grass. Proof will have to wait until perchance we may some day have antennas so delicately attuned and amplifiers so powerfully made that we may be able to pick up the "conversation" of the beetles.

The difference between any probable insects' broadcast and commercial broadcasting is merely a matter of frequencies, by which we mean the number of times the wave recurs in a second of time. The difference is in about the same ratio as high C on the piano and the roll of thunder.

Everything about us—the walls of the house, the rocks in the garden, the bannister on the stair, the window screen, and the bedsprings—are all receiving vibrations, but our unaided human ear is unable to detect them.

If we use a wire or a rod and attach a lead-in to it, we can amplify the signal and make it audible. In searching for a certain program we assist this pick-up, or feeling finger, by loading the antenna with an electric current of as nearly as possible the same frequency as that of the program which we are seeking. A variable adjustor is used so that by turning the control knob slightly the desired frequency can be matched exactly. If it is not the same frequency you simply will not get the expected program.

The television antenna is very complicated, compared with the wire we once used to hang out the window to pick up a radio broadcast. As in the case of the insects, both the broadcasting and receiving antenna may look very much alike. They are composed of three sections: one long rod, a central unit, and a smaller double or bent unit. The central unit is the transmitter, the smaller one is a booster, and the long one is the reflector or direction-control unit.

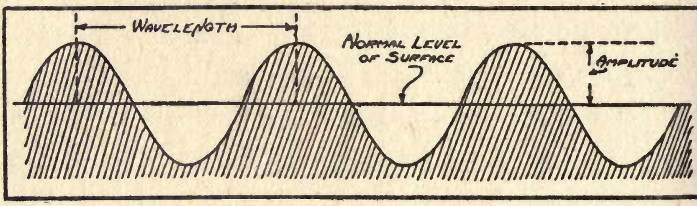
At the receiver the central unit is again assisted by the shorter one, or booster, while the long unit acts as a reflector to locate the wave. Since these three units in the receiving antenna are parallel to each other and parallel to the earth, it is customary to set them at right angles to a straight line drawn from the receiver's location to the transmitter's location. Because waves from the transmitter are coming in great circles, the more nearly you can place the antenna rods in line with these great circles the better will be your reception.

If there is to be more than one television broadcasting station in any one vicinity, it is found advisable to set the stations in close proximity to each other, within a reasonable radius of distance, so that the receiving antennas may all be facing the central location. Each receiver will then be able to pick up any station desired by simply being tuned for it. If, however, the broadcasting stations are widely separated, best reception may be obtained by having a receiving antenna which can be rotated to face the station desired.

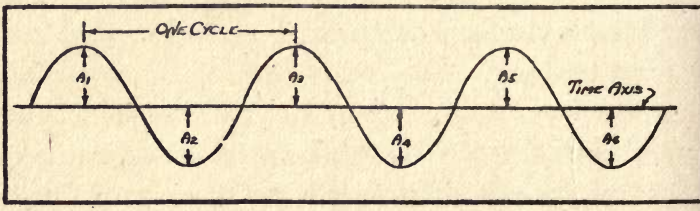
While we are on the subject of frequencies it may be best to inquire a little further into their meaning, and for this purpose it is necessary to define a few technical terms. Television, like every highly specialized profession, has a technical language of its own. Probably very few of us would hope to understand a physician's prescription, and yet few physicians would attempt to decipher an atomic scientist's formula for energy.

This story of the miracle of television has studiously avoided the use of technical terms, but a few of these terms have been used so frequently in the public press and other places that they have become familiar words without the users having sufficient knowledge of their meaning.

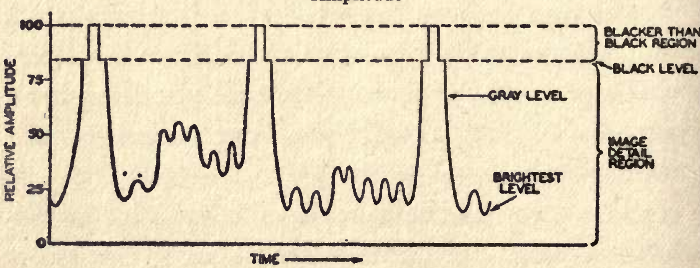
Wave Length




Cycle




Amplitude



Let us then bear in mind that a *cycle* is represented by a circle, but that in electronics we divide the circle in half, placing the upper half above a straight line and the lower half to the right below the same line. Both halves, drawn as one connected line, still constitute a cycle, but we now call this curved line a *wave.* The number of times this wave can repeat itself within the space of one second on the line is known as its *frequency;* for instance, the alternating electric light current in everyday use produces this kind of a wave sixty times every second, and we say it has a frequency of sixty cycles.

Now that you understand this, look at the line of strange-shaped symbols—in the picture of the author before a blackboard—shown in this book. Don't try to read it all at once! The odd row of symbols explains the different frequencies of most of the major electronic inventions since Franklin's kite and his lightning experiment to the discovery of atom bombs.

The semicircle *A* above the drawing represents the *sun:* from here many frequencies speed through our universe. The semicircle *B* below the drawing represents the *earth.* The horizontal, or reference, line is simply used as a clothesline, upon which we hang the symbols representing the major inventions or discoveries, according to their frequencies.

The wave length generated by a flash of lightning at *1* on the drawing is estimated to be nearly 3,000 miles long. The symbol at *2* represents *radio.* Marconi's first radio wave length was from one to one and a half miles long. This was later reduced by refinement to a meter or a meter and a half in length. But the cycles were repeated so rapidly that they could occur a million times in one second. Since *mega* in the metric system means million, these are known as *megacycles.*

At *3* the symbol of the di-pole (antenna) represents our *television* as the next practical short-wave unit and is very close to the symbol at *4,* representing *radar.* The radar wave is only one and one fifth inches long and is referred to in megamegacycles because this wave recurs more than a million million times every second. That means ultrahigh frequency, and the wave would have to be very short to recur that often in one second of time.

At *5* on the design is an unexplored portion of the Hertzian waves, named after Professor Hertz. The story is told that he was once a visiting instructor in Italy, and while explaining these rays to his class one day, said, with great conviction, "Within this band of electromagnetic radiations there lies tremendous undiscovered energy so great that I believe it will influence our entire civilization. Perhaps," he continued, "the inventor who will discover them is in this class today." And in his class that day sat young Marconi, who later did give us the first radio frequency found in the Hertzian Band.

Dr. Lee de Forest, the great American inventor, amplified these weak radio frequencies and became the father of our modern loud-speaking radio. It is interesting to note that most of our major electronic inventions have occurred within the lifetime of this one great man, who is even now experimenting with a new type of color television.

At *6* on the design, the frequency is so high that the wave length is very short indeed. This band is called the *infrared* band. Its wave length is indicated at 44,000 angstroms. One angstrom is one hundred-millionth of one centimeter, and a centimeter, you recall, is less than one half inch in length. These waves are still too long to be received as light rays by the human eye, so we call them "black light."

At *7* in the design, the symbol represents a very narrow band of white light. It is the only band of light the human eye can see. The symbol at *8* represents the *ultraviolet ray.* This means it is a band above the violet light. The wave length is so short and the frequency so high that again it is beyond the range of human vision. It also is known as black light.

The symbol at *9* represents the new Grentz ray, which kills disease germs. At *10* the symbol represents our well known *X ray.* At each of these symbols the wave lengths are shorter and still shorter. At *11,* the symbol for the *gamma ray,* the wave length is so short that it will penetrate iron and granite. At *12 the cosmic (death) ray* is so very short that its penetration has been found deep in the mines of the earth. At *13, atomic energy* is represented by the accepted symbol of the atom, wherein the nucleus or center is surrounded by electrons. The electron, you will remember, is the force with which the miracle of television has been performed.

Symbols are used extensively to represent the component parts of all television circuits. They are used constantly in designing the layout of the wires and parts. Such a design is called schematic. All electronic engineers use the same symbols to represent the different components that make up a television set.

They are drawn with care and lined up to show just how each tube, capacitor, transformer, or choke coil should be connected in that particular set. These engineers have a thorough knowledge of frequencies and shield them with partitions to prevent their radiating influence from interfering with each other in a tightly compact television set. A copy of this schematic design is usually printed and placed inside every radio, radar, or television unit. A service man searching for trouble in the set can determine, from a study of this schematic design, just where every wire was intended to be attached. However, the service man must have a thorough knowledge of frequencies, because in television there are some very high voltages used. Automatic circuit breakers in the set are always ready to protect the service man while he is working with these high voltages. Sometimes when shields are placed around some of the parts in the set to prevent radiating interference among these parts, correcting the position of these shields will often help him to correct or completely eliminate the trouble.

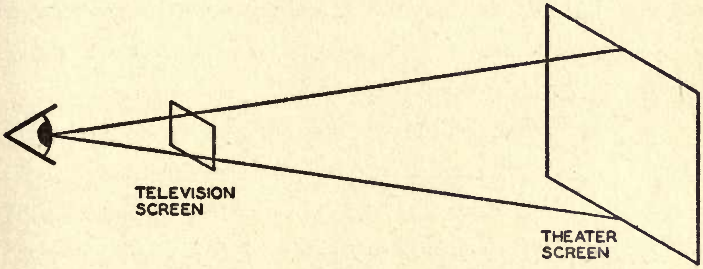
# 10

# *Improving Television Reception*

THE SIZE OF A TELEVISION PICTURE, as viewed on the receiver screen, seems to be the one fact of major importance with most people as they view this miracle of television for the first time. While it is true that television pictures have been projected and have been produced as large as the average theater screen, the question of size for each receiver screen is determined by the size of the room, hall, or auditorium in which the receiver is to be used.

## DETERMINING PICTURE SIZE

It is interesting to note how this size is predetermined. This can be illustrated by an experiment you can make the next time you visit a moving picture theater. You probably already know that if you sit more than halfway toward the front, your eyes may become tired or a headache may result because your eyes will naturally follow the focal point of action in the scene, from side to side. If you sit very close to the front, you will likely even turn your head in following the scene of action. If, however, you sit no closer than about forty per cent of the distance to the screen, you will enjoy the picture restfully and without eyestrain.




**At a proper distance both screens are *relatively* the same size—believe it or not!**

When seated about that distance from the screen, the next time you visit a theater, stretch one hand out in front of you as far as you can. Open your hand so that the tip of your fingers is in the line of sight with the top of the theater screen and your thumb in the line of sight with the bottom of the picture screen. Withdraw your hand without closing it and consider the distance between the thumb and fingers. It may not be over six inches, yet both your finger tips and your thumb were in the line of sight with the upper and lower edges of the theater picture. This means that a line drawn from the eyeball to the top edge of the theater screen, would be divergent from another line drawn from the eyeball to the bottom edge of the theater screen. In other words, at some point in front of you, say at the end of your reach, a picture no more than six inches high would carry the same activity in the same clarity and relative proportion as the large theater screen, probably fifty feet away.

A television receiver to be used in your living room would probably be observed by anyone in the room within a distance of eight or ten feet. At that distance, therefore a television receiver screen need not be larger than eight by ten inches to still give you the same visual satisfaction as a larger screen at a greater distance.

The television receiver screen size is thus figured out according to the rules of proportion. The size of the receiver you purchase should be relative to the distance at which you and your friends will be from the screen when observing it, or, in other words, relative to the size of the room in which it is to be used.

In the National Broadcasting Studio at Radio

City, New York, an audience of one hundred sit back about twenty-five feet from the screen. The picture is reproduced on a screen apparently three by four feet in size. But if you were to sit too close to it, you would experience the same discomfort you would have in sitting too close to the theater screen.

The quality of the picture could become a little thin if its size is too large. However, this is compensated for when viewed from a correspondingly greater distance.

## FM SOUND

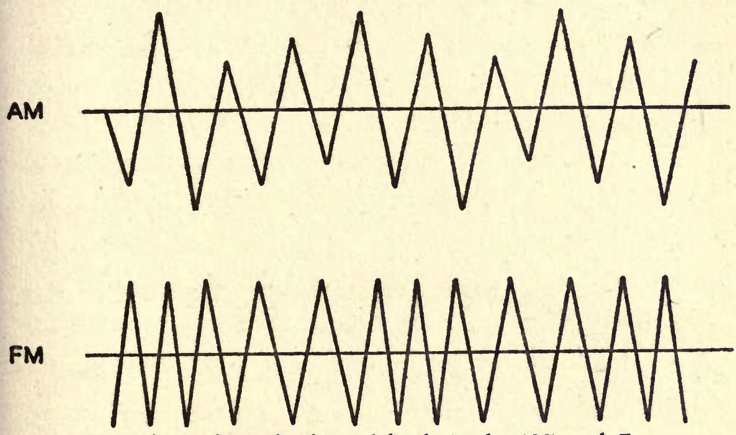
Technically the picture is being sent to you by a system known as "amplitude modulated frequency," commonly called AM. This is the same frequency used in regular radio broadcasting. The sound accompanying the picture is sent to you by another system called "frequency modulation": this is known as FM.

It would be more desirable to send the picture on FM also, but the FM band width is very wide; and it takes up so much room in the air that if several television broadcasting stations were operating in the same vicinity, it would be difficult for any one receiver to pick up more than a few of the several programs then being broadcast.

It is very easy to understand the advantage of these two systems if you will consider them as streams of electrons running in waves which repeat themselves a certain number of times every second. That is the meaning of frequencies. These electrical impulses which carry the television picture travel at the incredible speed of 300,000,000 meters per second from the transmitting tower to your home receiver. If you are interested in mathematics, you can figure out how long it takes a signal to reach you from your favorite station, after you have ascertained how far away that station is from your home.

Along with these impulses there is another stream of waves running at a different frequency. These are the FM waves, which carry the sound intelligence to your receiver. They cannot be heard by the human ear because of their high speed, or as we say "high frequency." But since they would be of no value unless we can hear them, a very unique process is employed to slow them down, after they reach your receiver, so that they can be heard, or are made audible.

In television the old system of transmission and reception of AM (amplitude modulated) waves has been replaced by the comparatively new system of FM (frequency modulation). The main difference between the two is that when someone speaks into the microphone of the AM transmitter the amplitude or height of the impulse will vary with the tone. When he speaks over an FM transmitter, however, the height of the impulse will not vary with the tone; instead, there will be a change in the frequency or speed of the impulse. In other words, the impulses will increase or decrease in their rate of vibration, conforming with the tone of the speaker.




Wave shape of Amplitude Modulated signal (AM) and Frequency Modulated signal (FM).

The advantage of the FM system is so great that the Federal Communications Commission has passed a regulation forbidding the use of any other mode of transmission of sound by all television stations. There are many advantages in its favor. The transmitting equipment is far less expensive for FM. Particularly interesting is the fact that there can never be any interference between FM stations when all stations are using the FM system. The most important feature in its behalf is that the FM system is not affected by man-made or static interference. Such things as electric razors, motors operating elevators or pumps, the hum of neon signs, or telephone dial clicks will not be picked up by an FM receiver. It can be easily seen that the Federal Communications Commission has accomplished a notable advantage in specifying this mode of sound transmission.

The process of eliminating superficial noises is very simple. Since these noises or static would appear on the height (amplitude) of the wave and the desirable signals or tones are carried in the heart of the wave, we simply level off the top of the wave or amplitude and thus eliminate the static. This is done by feeding the weak signal from the special antenna to vacuum tubes which amplify the very small electrical impulses that are picked up from the air. This signal is then fed into a special tube which is made to act like a lawn mower.

You know, of course, that the lawn mower cuts all the grass to a certain height by trimming off the tallest blades. This special tube, which is called the "limiter," does the very same thing to the radio signal. Thus all the static due to atmospheric or man-made devices, which was riding on the outside of the wave or amplitude, is simply cut off and eliminated.

These noise-free impulses then travel to another tube which is known as the "discriminator." Up to this point, the impulses were so high in frequency that they could not be heard by the human ear. Now, this discriminator lowers their frequency so that they can be heard on an earphone. When the impulses leave the discriminator they are again amplified until they are strong enough to be heard on your home receiver.

This is accomplished on a device known as a loud-speaker, which changes the electrical impulses into sound waves. The loud-speaker consists of a specially constructed cone, in the center of which the electrical impulses operate magnetically to push or pull the cone, forward or backward, in the same frequency as the signal. This taut cone will cause the air in front of it to move outward to strike the ear, thus causing a reproduction of the same sound which originally started the signal from the broadcasting station.

## OBTAINING PERFECT PICTURES

It has been confidently predicted that television may become the most popular form of entertainment and may be the major factor in keeping the American family at home. This prediction is, of course, predicated not only upon picture size of television and good sound reproduction, but also upon perfect pictures.

It may not be uncommon for you to be enjoying the graceful movements of a ballet dancer and then suddenly discover that her ghost is dancing with her, approaching stealthily from one side, moving slowly across the screen towards her, and then, just as stealthily, moving towards the other side, mimicking every act of the performer. You have indeed seen a ghost—a television electronic ghost.

The explanation of this may really be very simple. A large metallic transport plane, high up in the air, may have just passed over your home. Some electrons, reflected by the metal of the plane, came into your receiver a little late; they were "out of phase" with your direct reception. Such disturbances soon disappear and nothing can or need be done about it.

Or another time the smooth reception on your receiver screen may be rudely shattered, as though a blizzard had struck in all its fury, driving the snow horizontally in blinding streaks. You may discover it was all caused by "the man who came to dinner" as he plugged in his electric razor on the same line carrying the A.C. power supply to your television set. All you can do about that is "grin and bear it." He will soon be through shaving.

Perhaps a straight line will seem to cut your picture in the middle and the two halves are apparently inverted. You may find that the "sump pump" in your basement or an electric motor on your furnace has suddenly started by automatic control and is momentarily consuming an extra load of power, which would throw the electron beam in your receiver "out of phase." There is not much that can be done about that, but it usually does not last long.

If a passing trolley car disturbs your picture it may be that your antenna is poised exactly parallel to the trolley tracks. Moving the direction of the antenna slightly by rotating it a few degrees will usually eliminate this trouble.

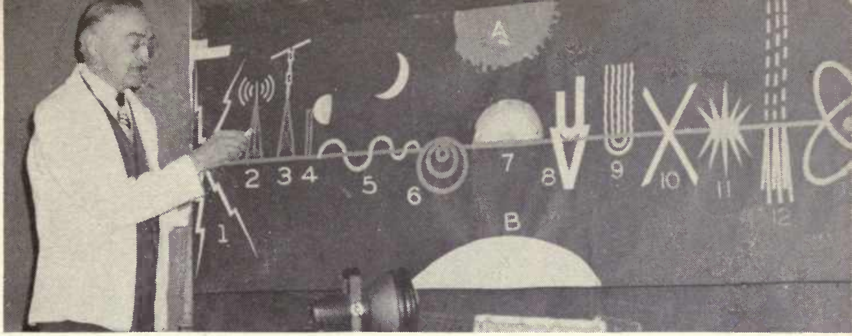
Some heavy trucks carry high-voltage generating units. If you live close to a main-line highway, it is possible to obtain and attach a small eliminating choke to correct this and several other similar ills.

If you live near a physician's office, especially a physiotherapist, who frequently uses one of the older models of diathermy treatment instruments, you could have a great deal of trouble with perfect television reception when he treats a patient with this short-wave instrument. It might be well to pay him a visit and explain the situation. He can probably obtain an attachment from the manufacturer of his instrument to eliminate the trouble at its source. At least, he might co-operate by avoiding prolonged treatments during the period of your favorite television hour. X-ray machines never cause much trouble because of the short duration of their application, which is never more than a few seconds.

These things are explained for the sole purpose of making it clear that poor reception is seldom due to faulty broadcasts, and even more unlikely due to any inherent inefficiency of the television receiver itself. Most of these neighborhood disturbances can be corrected, either as suggested or by calling on an installation engineer who can very likely find and adjust everything in one visit.

Sometimes much trouble is created if the combined length of the two poles of the antenna is not in exact mathematical proportion to the length of the lead-in which runs to your receiver. If the installation has been made by an expert, you will have no trouble on this score.

On the front of your receiver are sufficient control knobs to center and clarify your picture by alter-



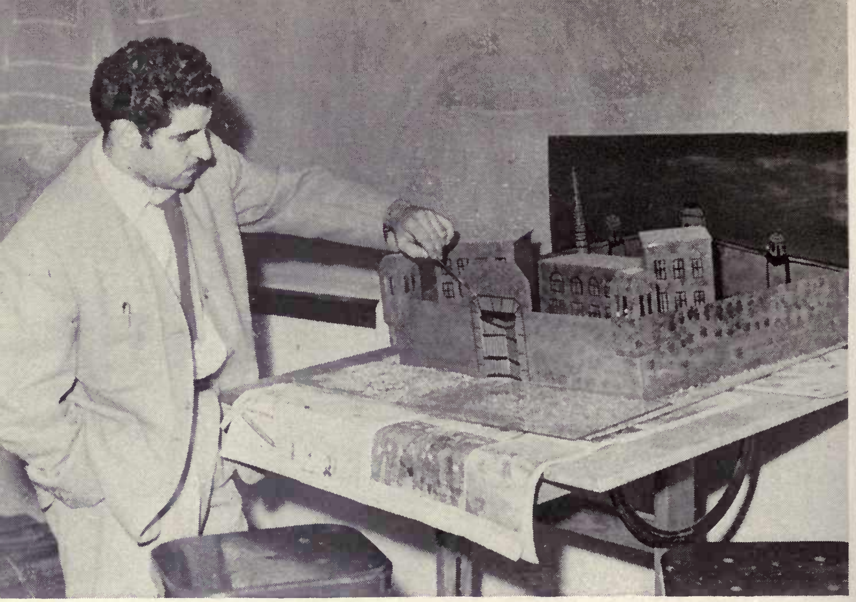

*The author explains the meaning of frequencies, using fluorescent symbols with the aid of black light.*

*Do you yearn to go prospectin'? The modern prospector does not carry pick and shovel, or a pan for washing gold nuggets. His equipment is a black-light lamp and a "hot-shot" battery—his object, not gold but fluorescent rocks and uranium ore.*

*Who pays for television? The advertiser, of course—but even commercials will be different in the new field. Here a puppet show is worked out for a sponsor who wishes to offer something different.*

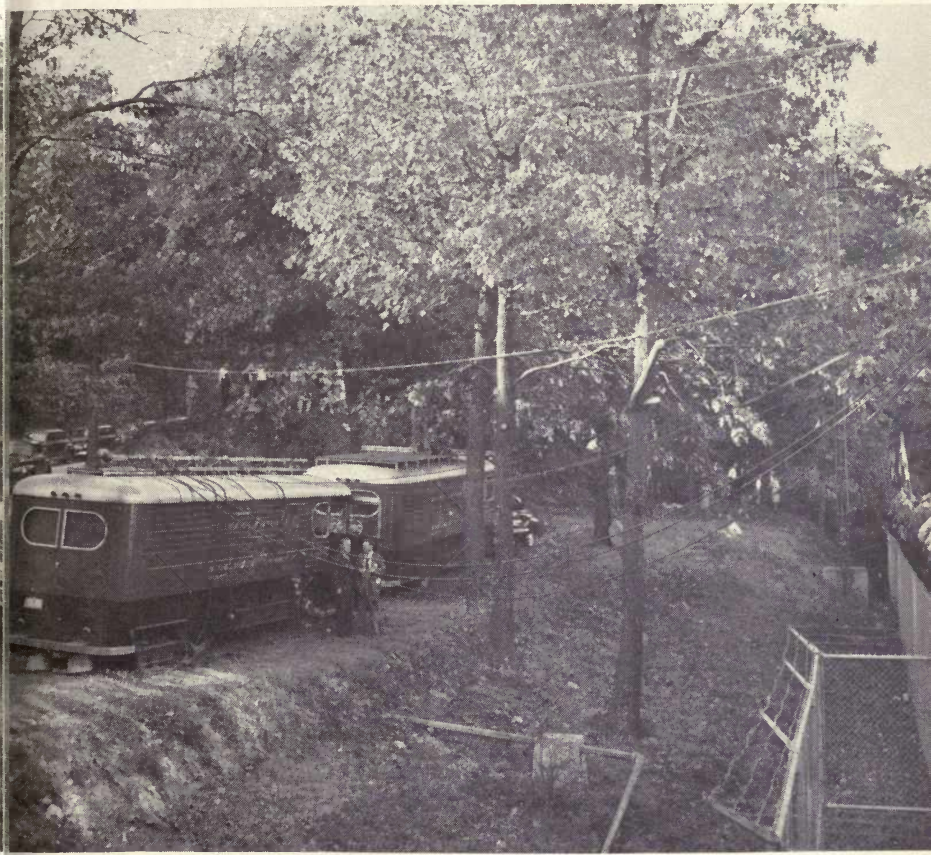
*A necessary feature of most television shows is the written subheads and captions. These are usually hand-lettered well in advance of the broadcast.*

*Direction, acting, and camera techniques require special training for television. Even the make-up used is different from that of stage or motion pictures. No one except performers may get within camera range after the broadcast starts. The director (wearing earphones which transmit messages from the control room) kneels just out of range and indicates his directions by signals.*



*"Props" are not often used in television, but here a miniature set helps to create an illusion of flying over the Connecticut State Prison.*

*Mobile television units can go almost anywhere, and do! Here a horse race is being televised. The field electronic camera sends impulses through a coaxial cable to the mobile unit for broadcast to the studio, which will then rebroadcast to all receivers.*

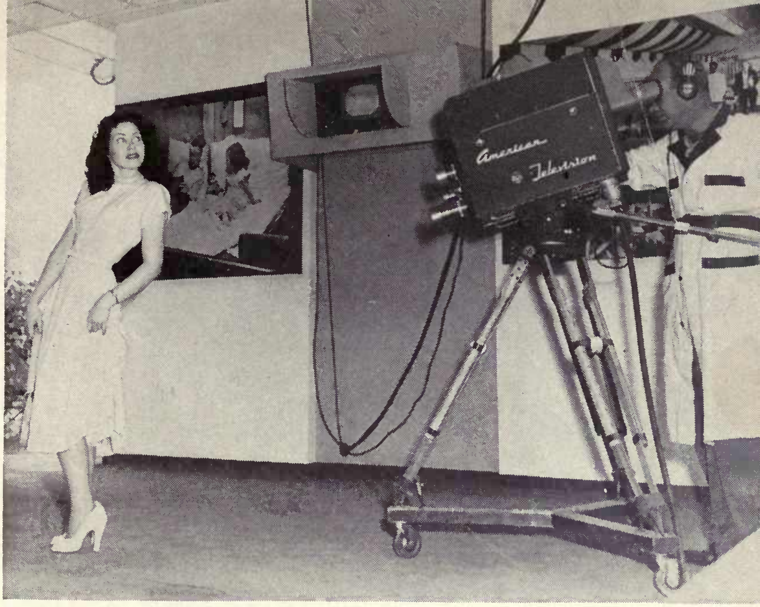


*Television "spot news" will bring happiness to many shut-ins, for now the hospital patient will see the home run or the touchdown which wins the game, the stay-at-home will visit scenic spots half the world away, and the busy housewife can attend a matinee in her own living room. Here a mobile unit picks up a ball game.*

*(NBC photo)*

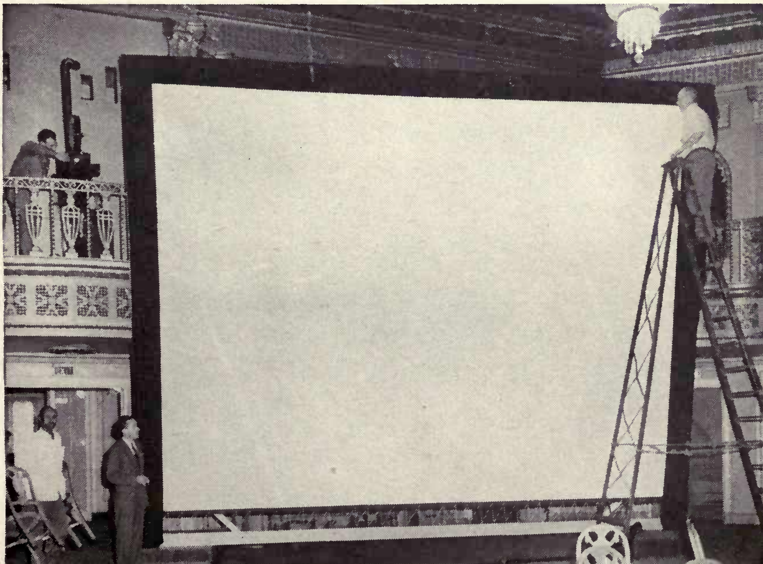

*Field units may even invade the "on the street" interviews. Here is the forerunner. "Just walk in front of the television camera," says the sign. As easy as that!*

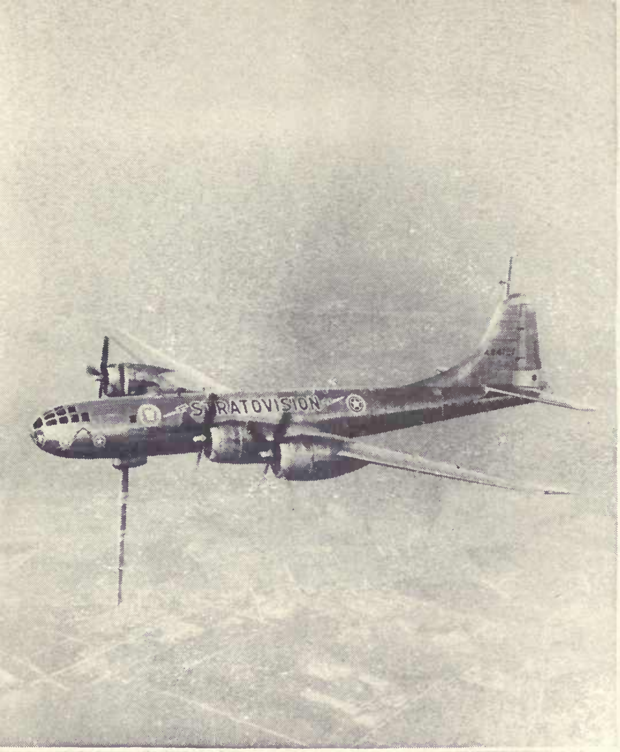
*Between the acts . . . the opportunities offered by television are bringing to its fold many young people who have the qualities needed for performance in the new field. But the demands of these new professions are great.*




*This new medium requires new acting techniques. Complete relaxation and absolute control of movements and voice are necessary. The television camera makes new and greater demands upon the actor or actress.*

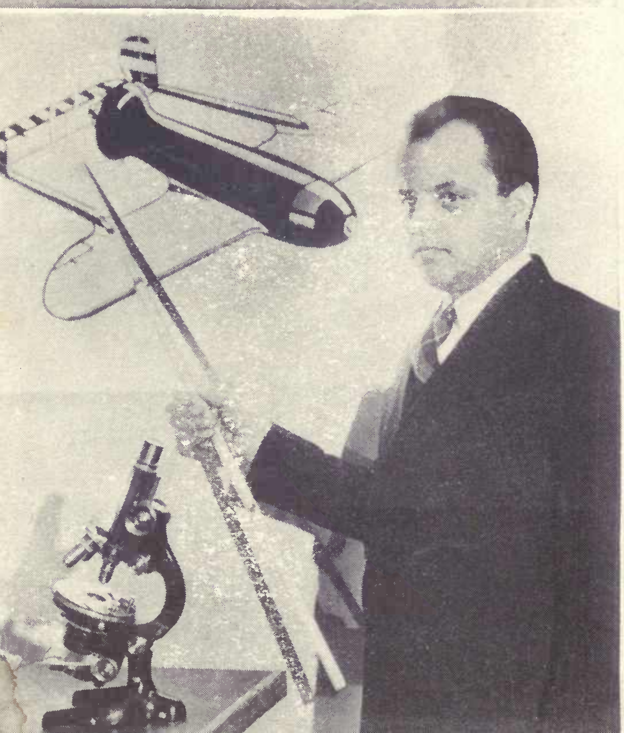
*Don't demand the biggest screen available for your television set. You might get this one—a 20′ x 15′ television action picture made from a 7-inch receiver tube, "blown up" for projection by a 20-inch mirror.*






*Stratovision planes have been suggested as possible relay stations where it would not be feasible to build towers high enough. This is a Westinghouse stratovision rebroadcaster.*

*(Westinghouse photo)*



*The war of the future will be made more terrible by television. Nations will learn quickly to take into consideration the utter devastation which must result from the use of such devices as the robot pursuit plane with television eye and automatic control, which will follow and quickly overtake the enemy. It may be equipped with jet propulsion.*

ing the height, width, or the amount of light employed. This you should do before the picture starts. For an hour or two prior to their programs most broadcasting stations will transmit their own private pattern.

Each station has a different pattern, like a trademark. Whatever else this pattern may contain, there will always be several black parallel lines. They are drawn in groups of three or four each: some vertical, some horizontal, and some at cross angles. They quite resemble the charts which an optometrist uses to test your eyes. When you want a certain program, therefore, simply hunt for the pattern which designates the station broadcasting that program.

The pattern as you first receive it will probably look very much out of shape. The black lines may seem very heavy in one direction and very light in the opposite direction. You can correct this by turning the other two knobs, one of which controls the vertical sweep and the other the horizontal sweep. As soon as you have all the black lines in the pattern even, straight, and symmetrical, you will know that the program, as it comes on your receiver, will be properly received.

There are from eight to fifteen more control knobs inside the back door of your television set. It is highly inadvisable to open this door. There are from 6,000 to 8,000 volts inside, waiting for you. If the door should be opened, however, the current will be automatically broken, so there is no real danger from the current. There are charged capacitors which could teach you quite a lesson, but hardly more than that. Just leave the back door shut. The installation engineer will make those adjustments once and for all.

# 11

# *Television Extends Our Mastery of the World*

ALREADY IT IS FORESEEN that coast-to-coast television can easily employ as many people as our magnificent telephone system does today. One of the most exciting and interesting jobs in this new industry will be working with the crews that man the mobile television pickup units. Every broadcasting station will need from one to a dozen televising cameras on wheels. They will be manned by a crew of engineers trained in electronics. These chosen men, like newspaper reporters, will have a "nose for news," an eye for the beautiful, and the exotic instincts of a news photographer.

## MOBILE UNITS

No television studio could expect to be one hundred per cent efficient while operating on the forty-fifth or top floor of the tallest building in town, when their avowed purpose is to keep the public informed as well as entertained. This means that every studio must have news reporters. These reporters cannot just run into the studio and shout, "Extra! Extra! I just saw a big fire, with people jumping from the windows!" No, indeed, he can't! He will be sitting in a mobile television unit when the report of the fire comes in to him over his mobile radio set.

These mobile units will be located in every principal city. In some cities, several such units will cruise the streets searching for the unusual and interesting, educational, and historical events which are happening on the spot. Many television broadcasting studios in different parts of the country will set up, at predetermined scheduled hours, different types of programs according to their locale. Through these you may be able to watch, with the cameraman, the bears in Yellowstone National Park or visit Carlsbad Caverns in New Mexico. If Mohammed had lived in this Atomic Age we might never have had that fine old English proverb, "If the mountain won't come to Mohammed, Mohammed must go to the mountain." Because literally, we shall soon be able to bring the mountain to you.

The launching of great ships, the "doings" of famous people, scenes on the beaches and elsewhere, will be picked up and relayed to the central broadcasting station. There, each scene will be selected for its national interest or importance and sent out on the airways to the home receivers in every state.

Some of these mobile units will make scheduled trips to the zoo, and children at home can watch the animals. The incessant chatter of the monkeys and the fierce roar of the lions will accompany the moving picture which the shut-in can see from his bedside.

A mobile unit will stand beside the doorman at a society ball. You may sit at home and watch the guests arrive and hear the merry laughter of *free* Americans at play. "And who will pay for all this?" you ask. The answer—American advertisers—in the good old American way.

No longer will you be bored by the announcer who *tells* you why you should eat a particular biscuit. The mobile unit will take you on a personally conducted tour where you will *see* why that certain biscuit has all the vaunted merits. You may watch the white-clad attendants direct the clean, sparkling machinery turning out a delicious-looking product.

### EDUCATIONAL ADVANTAGES

With mobile units, the wide range of factual and visual aids in education is practically unlimited. What could be more interesting than a visit to the great fish canneries of the Pacific coast? You can watch them processing millions of salmon or sardines. Surely, you would enjoy this more on your home television receiver than by making a personal visit! Did you ever see a fur pelt being tanned? You would probably enjoy that better by television, too. Manufacturers of national brands are eager to have you visit their factories by television.

The fabrication of a steel bridge, from the ore to the river span, could be an educational feature unparalleled in visual education. For instance, a western telecaster might announce a mountain-climbing party for a certain day. Imagine yourself, some hot summer day, hunting a cool breeze on the porch. Switch on your television receiver and pick up that party climbing over the glacier of a snow-capped western peak. If you want to enjoy the harvest, without the sweat and toil of being there, tune in a Montana broadcasting station where the mobile television unit is following a high-powered reaper on the great wheat field of level plains.

What could be more thrilling than a television visit through the majesty of the redwood forest, or the lumber belt of the Oregon cedar camps? There you will see the lumberjacks cutting their way to set up the pneumatic-driven saws to fell another giant of the forest. You will hear the buzz of the saws; see the flying sawdust; hear the foreman's thrilling, resonant call, "*Timber!*" There she topples! See the men scatter before the crashing thunder of its fall. You will see the donkey engines winding up the steel cables that drag the logs to the great trucks or the narrow-gauge flat cars, and follow the logs to the sawmill. You will watch the band saws rip them into lumber and the "straddlebugs" feed the cranes that load the lumber on the ships at the dock.

What class in school would not be thrilled to visit an ornamental or commercial glass-blowing plant? Perhaps they would enjoy a copper- or brass-molding foundry? Such amazing examples of American enterprise as the building of a locomotive, could furnish an educational thrill for everyone. In World War I, the co-ordinated efforts of more than fifty thousand people resulted in the finishing of a complete, powerful, freight locomotive, with steam up, ready to go out, every forty-three minutes.

This could all be seen on your home television receiver. You could even hear the clank of the steam hammers, the hiss of steam, and the blast of the locomotive whistle. The ultimate objective of television is to bring you some day the pleasure and educational advantages to be found in every National Park and all over America, while you sit at home and the advertiser pays the bill! Well, "this is America."

Soon you may learn by visual visits how people in other parts of the world live. A mobile television unit could easily take you on a visit to a coal mine where you could see the miners at work, then follow them to their lowly homes in the mountains and watch them feed their chickens or hoe the garden.

Naturally, the splendor of the Mardi Gras at New Orleans or the Carnival of Roses at Pasadena is a job for television—without competition. Surely no writer or commentator has ever done justice to the magnificent Ice Carnival at St. Paul or the Water Regatta at Minneapolis. Have you ever seen the Mummers' Parade in Philadelphia on New Year's Day? All these gorgeous events should come to you soon over your television receiver.

Far-sighted television planners really anticipate very little direct competition with radio, moving pictures, or the theater. The live-actor theater, with its hushed audience, will always hold its charm—along with the bright lights, the excitement of the cafés, and the throngs of the Great White Way. The movie has built its greatest appeal in the acted drama, with celebrated performers. They started out well with scenic travel and the beauty of nature. You could watch the rose unfold as the movie camera took one picture every hour. Thus you saw the evolution from the bud to the bloom. Now, the movie czars seem to think people want nothing but fights, drama, and fiction brought to life. Maybe some folks do want that, but television plans to take you on excursions to remote and almost inaccessible places of great interest as rapidly as new facilities are developed to safeguard the camera and its crew.

Television offers little comparison to radio, since it must show you what really happens or exists. It cannot resort to clever voices and sound effects to make you believe that you see what is not there as the radio can. Television must *show* you what is there. A television studio could hardly be expected to stage a murder every day, which some writers for the radio seem to think the public wants.

Television planners believe people will be better satisfied with the thrilling, uplifting actualities to be found in the natural beauty of every diversified field. Of course there will be some division of the program between radio and television, but the races and athletic events will undoubtedly bring their announcers with them to the television screen, leaving radio for the news commentators.

## CLOSE OBSERVATION OF DISASTER AREAS

In addition to the great educational possibilities that it opens for us, the mobility of the television camera can bring this substitute human eye right into the heart of disaster areas.

As awful as a sudden volcanic eruption is, few people realize how closely related it may be to the man-made atomic bomb. It now seems that very often there is a definite relation. With our present understanding of the electron, it is even possible that electrons, atomic energy, volcanoes, radio, radar, and television may all be first cousins.

Consider the eruption of Mt. Pelée a few years ago. Volcanic dust fell to a depth of several inches as far as twenty miles away. Observations on other eruptions have determined that certain fine mineral dust was shot so far and so high into the air that it was nine years coming back. This was determined by sighting the camera across the crater in photographing a distant object. It was found that the color of the sunsets thus photographed seemed to change from year to year as apparently different elements, in almost colloidal dust form, were slowly settling down to earth. Uranium was one of these. It permeated the sandy soil and even the fiber structure of trees.

Floods have deposited it in pockets throughout southwestern Utah and western Colorado, where petrified trees have been found to contain much uranium.

It has been suggested that since some uranium may have come to the surface by volcanic action, there may be much more of it deep in the earth. Atomic energy scientists say that critical volumes of critical radioactive elements in critical proximity could result in explosion. Deep in the earth, changes result by disintegration of radioactive elements, and atomic eruption could occur at long intervals. Disintegration releases free electrons which constitute radio, radar, and television impulses. Thus the implied relationship of our electron with the greatest forces of nature, makes it important that top scientists should study *well* all phases of volcanic action; but this is considered an extremely hazardous effort.

Now comes television to help the observer. By remote control, this soulless thing can look into the fiery depths of a volcano where even angels would fear to tread. Operated by remote control from a safe distance, scientists could literally observe the development and actions of a great eruption from a ringside seat while they personally were far enough away to be out of all danger.

Great flood areas or forest fires can now be observed by the use of robot planes equipped with television cameras and operated by remote control. This will be a well-developed and very important feature in the event of another war. Not only will television planes send every action of the enemy direct to headquarters, but robot televising planes can be directed into radioactive areas where no human could safely live. By remote control these planes will be directed to fly close over any desired spot to observe the extent of the damage or to determine if life still exists.

With the use of infrared equipment on these robot planes, their performance and efficacy becomes almost incredible. Already such facilities have been operating on reconnaissance planes for regular cameras. Such Signal Corps planes have taken pictures five miles above enemy territory at night through the fog and smoke of battle, and done so with such amazing clarity that the individual railroad ties in the enemy railroad beneath were plainly discernible.

Ordinarily, there is sufficient invisible infrared in any good daylight with which a regular camera, properly equipped, can pick up and reproduce a landscape with amazing detail over wide distances. At night, however, a strong infrared beam can be produced. This is a very interesting trick and was used by German sharpshooters with a small machined plastic cylinder attached to the rifle barrel as a television receiver.

Infrared light is produced by charging a multiple gang unit of capacitors, connected in parallel for five minutes, from a portable gang of dry cells. After the charge is absorbed by the capacitors, a switch discharges them through a different system of wiring. This switch disconnects the parallel wiring after the capacitors are charged, and instantly connects them with another system of series wiring which discharges all the capacitors in about five seconds.

During these five seconds a special frequency and force is developed in the range of the infrared band which shoots through the air to the target area and returns to the receiver to outline the target image. This simplest of all forms of modern television units does not present a picture of lights and shadows like those which appear on your home television receiver. In this case, it is simply a silhouette outline in contrasts. It was sufficient for a sniper to use in locating a moving object in the dark.

The peace-time application of this "sniperscope," as it is called, has been oddly designated a "snooperscope." Even if a room is dark, observation from the outside can be made at night, unless the invisible object is obscured by a very good blind. Police will find its use of great advantage in crime detection or for plant protection, since wide areas can be scanned by this simple form of night television to locate and rout prowlers.

Fire wardens in our great forests will no doubt be equipped with these little units. They are used something like a telescope. The infrared beam from a very small fire could easily be spotted. The hot engine of an automobile or tank generates enough infrared to portray its position day or night on this little receiver. Even airplanes hidden in the clouds would emit sufficient infrared from their hot engines and be spotted in the same manner.

As these newly discovered facilities come into general use there will be many valuable developments in refining and improving their operation. Any potential disaster area, such as an oil field, could be guarded by these television units operating on infrared rays. They could be the watchdogs to sound the alarm in the event of any unusual light, heat, or movement. A sputtering spark of an electric line would be reported, with its location, before disaster could occur.

## CONSTRUCTION PROJECTS AND PLANT CONTROL

Besides such accomplishments, the industrial use of television is opening up a new chapter in this fast-developing miracle of modern times. The system is not always dependent upon a central broadcasting station distributing information to the public. Already, private operating systems have been designed for the superintendent or president of a company, with a receiver placed in his office. By manipulating a button on his control panel, an executive can bring to his office any part of the plant that he wishes to observe.

The possibilities this suggests are enormous. The building of the Nicaragua Canal, for example, or any great construction project involving long distances over difficult terrain, could be greatly enhanced and facilitated with the new private televising control system. No longer would the directing engineer need to travel hither and yon, from one location to another. Seated within the confines of his own comfortable office, he could visit, observe, and direct every remote and critical operation. The building of mines, tunnels, and great dams could be expedited with greater ease by a central director, with the use of this method, ordering his mobile unit to cover any point of the project he might wish to observe.

In the case of new construction projects covering a wide area, several mobile units could be dispatched by the director. With the use of a two-way radio system, he could direct each unit in the same way that metropolitan police chiefs direct the activities of the police squad cars cruising their routes. He could simply speak to the televising crew through the microphone on his desk and send a mobile unit to the location he wished to visit. Then on the television receiver he could soon observe the action of the workmen and the foreman directing them.

He could ask the unit chief to call the foreman to the car. There before him on the screen he could see the foreman through the close-up lens of the televising camera, hear his report, and issue his orders on the radio system. The televising crew could simply revolve the turret of the camera and throw in a long-range lens; then the director could see the foreman return to the working crew to carry out his orders.

Any foreman could call up the superintendent and over the television unit show him his problems and obtain his personal advice at once. In this way a superintendent could make scores of inspections and render his decisions in the same time which was formerly required, perchance, to make one visit on horseback and to render a single decision.

In the case of a permanent installation, such as a great steel mill, there could be a televising field unit or single camera mounted at each location where critical observation must be often repeated. Any strategic area, such as a steam hammer, an ingot roller, a cupola loader, or an open furnace, could be instantly observed right from the superintendent's desk.

Other units could be concealed in the framing girders overhead to observe the activities of a group of operators without their knowledge. This would be done by an infrared beam which is invisible to the human eye. These workmen would not know when, or if, the unit was in operation; and, while it should not be used as a whip to spur production, its presence could serve as a moral deterrent against the recent practice of "operations slowdown."

Recently a large manufacturer processing a paper product explained that the company used several automatic fabricating machines, each one of which is nearly a block in length. That concern was asking for quotations for a number of television pickup tubes to be installed at several strategic places along the line of these machines. Through coaxial cables these several tubes would report the progress of the work direct to the foreman's receiver at the head of the machine. Errors in the process at these points would be discovered by the foreman on his receiver and he would send workmen to correct them immediately, thus saving the cost of the installation of these tubes by the reduction in the spoilage of the product.

There are many large industries that could use this type of television reporting. There is no broadcasting involved, because the moving image is carried to the foreman's desk by a coaxial cable. The method is very desirable in chemical plants, where the fumes or heat are a deterrent to human inspection. This process will become of greater and greater value as more industries become involved in manufacturing radioactive products involving the use of the new atomic energy derivatives, such as radioactive isotopes.

The public press has often made mention of the great care and caution exercised to prevent operatives at our new atomic ovens from being injured by radioactivity. Some readers have thought that the extreme precautionary measures were a little overplayed. The author was one of the first to realize this real danger, when, in 1913, he was involved in the refining of the first commercial radium in America. Here men died, until it was discovered that lead would restrain the invisible but deadly radioactivity.

In the atomic bomb plants at Oak Ridge and Hanford, operatives are protected by lead, cement, or water-partitioned, screens. Now comes television to help in these great research plants. The observation tube would fear no lethal effect, but would report any operation from a danger area to the chemist —safe in his own office—through the coaxial-cable system. In fact, without leaving his desk, he could watch this critical process at any strategic point throughout the great atomic plant.

Among the many applications for this commercial system of television observation by coaxial cables could be its use in department stores to prevent shoplifting. The installation of the tube would not be concealed; and whether or not the chief detective was observing that particular section from his office, certainly no shoplifter would risk being seen at work in that vicinity.

These tubes would pick up everything within range with invisible infrared rays and no shoplifter would know whether the tube was operating or not. A few well-publicized arrests in a store equipped with television spotting tubes should certainly tend to eliminate the shoplifting process entirely in that store. It might even be advisable to place a visible red light near the iconoscope tube to draw the attention of any would-be shoplifter prowling in the vicinity of the jewelry, handbag, perfume, silver, or any other counters displaying valuable merchandise.

Certainly the imagination and needs of our highly specialized industries will find many more applications for the use of this tireless televising eye, which fears neither cold nor heat, fumes nor radioactivity.

## SCIENTIFIC REVELATIONS

In addition to the great mastery that television gives us in promoting education, surveying disaster areas, and expediting the construction of great projects as well as production in manufacturing plants, let us point to the enormous scientific revelations that may be uncovered by the mobile television camera.

A certain deep-sea explorer is currently planning another trip into the dark and mysterious depths of the ocean. If his bathysphere is not crushed by the great pressure found two or three miles or more down, if his air supply is not pinched off, or fails, and if his light beams can penetrate and reflect back through his pressure-resisting eyepiece—then this man may see plenty of amazing things which the rest of us might find hard to believe.

Laudable and scientific as this undertaking is, it would seem—to an electronic television engineer—that this great man, Dr. Beebe, is risking his life unnecessarily and going about it the hard way.

On a recent trip to the depth of one mile, the doctor reported having a glimpse of a great shadowy form which moved past his bathysphere portal—its body illuminated with fluorescent lights along its sides so that it resembled an ocean liner all lit up for a party night.

Such a story of amazing life in an unknown but recently accessible realm has furnished the lure for adventurous television engineers who are secretly preparing to have a good look at that mysterious country on the very floor of the deepest valley on earth, reportedly 10,800 meters, or about six miles, below the surface of the great ocean just off Mindanao. Incidentally, that is approximately twelve miles lower than the peak of Mt. Everest; and down there, anything could happen.

Therefore the television engineers do not propose to risk life in such a venture. They are waiting to learn if Dr. Beebe's new pressure-resisting chamber can "take it," and at what depth. Then, after improvements are made (if any), it is proposed to equip a bathysphere with an orthicon-tube television camera connected with the tender ship by coaxial cable and really take a good look at the bottom of the world.

Lighting for this electronic televisor would be by infrared rays generated in intermittent flashes having a penetration of between 15,000 and 30,000 volts.

In the darkness of such forbidding depths these penetrating black-light infrared rays should reveal the mysteries of the deep as plainly to the orthicon camera as the human eye would see a tree on the surface of the earth.

Since this television tube, with the aid of infrared black light, can see many things which the human eye cannot, it is obvious that there is a tremendous advantage in its use in these black depths, since there would be no risk to human life in making the trip.

Better still is the fact that a score or more of scientists on the tender ship could make the observation simultaneously without having to question the credulity, in an almost unbelievable report, of a lone observer returning from such an exploration.

Considering the outside of our earth, scientists have long wanted to study this planet from some remote point far enough away to view the entire globe at once. Today they are on the way to doing just that. The first steps have been solved. Rockets have been out sixty-five miles, and some still pictures have been taken from great heights; but again, the television engineer is considering the problem as a scientific aid. We have robot planes. We have stratovision equipment to pick up programs from earth and rebroadcast them for more earthly receivers hundreds of miles away. In this case no coaxial cable would be necessary as in the ocean depths, for what the orthicon camera would see could be rebroadcast instantly to the scientist's own studio, where again a score of men could make simultaneous observation.

There is probably no more thrilling application of television to scientific observation than to televise a surgical operation, which would be observed and studied by student surgeons on the receivers in their own different classrooms. This was not possible until recently, for the previous need of a great volume of light not only created a glare in which much important detail was lost, but it created so much heat in the operating room as to be an inhibiting factor, not only to the surgeon and his staff but to the well-being of the patient as well.

Today the orthicon tube is so sensitive that in many cases a filter is used to prevent too much light from destroying definitions of detail, but with the use of infrared black lights greater detail is brought out.

The obvious advantage is that through a single lens in the orthicon camera suspended over the operating table, a thousand students may be looking on through their remote receivers, while the normal atmosphere, lighting, and decorum of the operating room is unimpaired.

During the war the army built simulated jungle chambers here in the States, wherein all the humid, hot, tropical conditions of a Malay jungle were duplicated for experimental research. Men had to work in them, and while this was a no greater task than our soldiers "enjoyed" out in the natural jungles, it inhibited clear thinking somewhat. Now, an orthicon camera in the chamber can make these observations continuously and the results can be studied in the comfort of the director's air-conditioned office.

Chemical changes and reactions can now be watched in gas chambers where no man could live, and scientific research is reaching new fields of investigation and learning by the aid of this miracle of television as it is now being put to work for something more than amusement.

A visit by television to the home of the author's good friend, Bob Zimmerman, would be of tremendous human interest. He lives in a glass house on the bottom of the sea, just off the Bahama Islands.

In water clear as crystal, this professional deep-sea diver raises pearls in his undersea gardens. He enjoys watching the many strange fish which come to visit him and peer in through the glass walls with about the same interest with which we would watch goldfish in a glass bowl.

Of course his home is electrically air-conditioned and he goes in and out through double doors with the aid of evacuating pumps. A simple helmet, with oxygen tank, is all he wears while cultivating his garden of rare and colorful aquatic plants. About the only way most of us will ever see this water hermit feed the oysters that grow his pearls, or hear him call his visiting fish by name, will be when a mobile television unit is sent out there on a yacht and lowered by coaxial cable into his parlor. Surely science is on the way to make some startling disclosures—and you may have a ringside seat before your own television receiver.

# 12

## *The Future of Television*

TELEVISION IS HERE. Those young men and women who best recognize that fact will make great strides toward a successful career in the electronic industry in our new Atomic Age. There were those who laughed to see a man in goggles and duster crank his horseless buggy and drive away. When Bell promised that men could talk to others at a great distance, the scoffers laughed and told him he had better use hollow wires. The wise ones who built coast-to-coast telephone are the executives of five thousand communication centers today. The scoffers are seeking "social security."

Remember Billy Mitchell who prophesied a few airplanes could sink a whole navy? You will recall the repudiation and disgrace under which he was "retired." That was before Pearl Harbor and the battle of the China Sea, where fourteen B-17 planes sank twenty-three Jap convoys with seventeen thousand Nip soldiers in one day!

It was ever so. When Galileo upheld the theory of Copernicus that the sun is the center of the universe and that the earth revolves around it, the people of his day rejected this theory and forced him to recant. Socrates, the great philosopher, taught his followers to stop worshiping false gods and directed them to the One True God, and set up the principles of the Golden Rule; and for doing so he was forced to drink the cup of hemlock, so that his followers might be discouraged and scattered.

## GUIDED MISSILES

Even today, some of our older scientists and some government agencies are seeking to discredit television and to discourage the pioneer spirit. But in spite of everything, television is moving forward with great strides, invading all realms.

One of the most important fields that it has entered is that of defense against foreign invaders, and one of the most important projects upon which the television engineers are at work is guided missiles. Near the close of World War II television scientists had already invaded the Ordnance Department of the United States to a certain extent. It looked for a time that jet-propelled missiles with televising eyes might be introduced, thus rendering our great battleships obsolete. At the close of the war, such missiles were ready for production. They could already be guided by radio impulse, and they could return sufficiently clear signals to enable the control operator to steer them at will. If the receiver screen showed that a guided missile was missing the target, the flying projectile could be lifted, nose-dived, or directed to the right or left as required.

Many unique and daring applications of television were held under close secrecy during the war, and the author has no intention of revealing restricted information. Instead, some possible applications of the television principle will be presented simply as an inspiration to the reader's imagination—and thus help us to perfect them.

The defense of our seacoasts and borders is still a major concern of increasing importance as America realizes that other nations have ocean-spanning craft which could fly over and strike disaster without a moment's warning.

Our present defenses against such an attack are at best only automatic alarms. What good is it, however, to be warned by our radar that a *strange* ship is approaching, if with all our present means at hand we should fail to destroy it? By a *strange* ship is meant any aircraft headed for America without having clearance from our foreign consuls to make such a trip. These reported or expected ships would not be *strange,* but any ship approaching our shores without this clearance would be considered "enemy" and deserving of destruction before it reached our cities.

Shooting at such a ship might not be successful —we could miss—and if one such enemy ship came through to drop an atomic bomb on Washington or New York, the rest of us could say our defense had failed. Now comes television to reduce the chance of failure in destroying any such *strange* or enemy ships.

Mr. U. A. Sanabria, founder of American Television Institute of Technology, suggests a destroying aerial scout plane equipped with a televising nose. It would need no pilot or crew, but this mechanical watchdog would have an electronic brain. It would be an automatic, robot-controlled, highly explosive, and deadly weapon. It would be able to see where it is going and change its course, altitude, and direction by electrical impulses from its own televising eye in much the same way that the human eye reports a post in the path of a walking man.

The nervous impulse of alarm is sent from the eye to the brain and the brain telegraphs more nervous impulses to the leg muscles; then the walking man promptly sidesteps the post. In action, this flying missile would control its elevators and fins in the same way from a brain made up of vacuum tubes, amplifiers, and relays to make and break contact, which would be controlled by the image seen on the televising tube, or eye, on its front.

In the event of an enemy ship being reported by radar, one of these flying missiles, with its deadly load of high explosives, would be launched in the general direction of the incoming enemy ship, but without regard to aiming it. Its uncanny electronic brain and televising eye would take care of that.

As soon as its televising eye "sighted" the enemy ship it would automatically head straight for it, turning, diving, or climbing, as might be necessary to pursue the fleeing enemy. The instant the image of the enemy ship would move away from the center of the televising camera eye, the electronic nerves would automatically steer the vessel to the right, left, up, or down, to return the vision of the enemy ship directly to the center of the eye again. That means that this automatic missile with its televising eye would follow the enemy ship until a head-on collision would result. There would seem to be no escape from such a thinking thing. Of course, this "tracer scout" with its lethal load would have the incredible speed of jet propulsion, with a lightweight unit which could overtake anything in the air.

It is planned that this Frankenstein "terror of the air" would never chase or attack friendly ships, and if this arouses your credulity, please remember it has an electronic brain. In other words, a friendly ship with clearance would simply show its passport and the lethal scout would "zoom over it" aud return to base. Are you still incredulous?

This passport would be a small electronic device to be issued by the clearing officer to friendly ships. It would beam out a ray, which would be stronger than the televising impulse; this would automatically trip the relay and raise the elevator so that the scout plane would zoom over the friendly ship. In the event of a mission foiled the scout plane would return to its base or, when the fuel is exhausted, it would nose-dive toward the earth; but the moment that the image of the earth or the water beneath filled the television eye, another relay, with higher resistance, waiting for this full-screen image, would automatically close the switch and explode the lethal load in mid-air.

Far removed from any habitation, our defenses are being prepared on proving grounds where accidental failure would be no disaster. The use of a televising nose on the front of any projectile is well within the possibilities of our present development of electronics. Such a televising-equipped projectile would constantly keep the controller informed on his receiver at the base—as to whether the projectile is on the beam and will hit the target squarely. If not, the controller could alter its course accordingly. The deadly accuracy of such projectiles would compensate for their cost in the saving of many lost projectiles which do not hit their targets at present.

War necessities do develop many diabolic and cruel devices; but, with the coming of peace, even these are being developed into highly efficient machines to save time, space, or lives. For instance, it is now suggested that this idea of the guided missile with its televising eye and jet-propulsion carriage might soon be used for mail delivery. Not only would it gain much time as the ground control crew guide their pilotless robot mail carrier unerringly to its landing field, but it could be sent into inaccessible places, over mountain and desert wastes, with great speed and accuracy.

In the event of an accident en route, the ground crew, who are watching every move as the signals return to their television receiver, would be able to identify the exact location by the number of markers it had passed as it followed its course to its destination. With such a televising unit, mail could be delivered to a ship at sea; but, of course, the final development of these suggestions will be accomplished only after long periods of experimenting by our modern electronic engineers.

## COLOR TELEVISION

Nevertheless, despite the great progress that television has already made and is still making, the man sitting at home with his family before his television set is not yet satisfied. He wants his television in natural color, and color television is another project which concerns the future of television.

Color television would indeed be a miracle; would indeed be that *impossible* achievement of which the broadcasting executive smilingly says, "It will take a little longer to achieve."

Such things are not always accomplished by any one man or woman. They grow like an oak from the acorn, out of the combined ideas and suggestions of everyone involved.

Many of the thousands of young men now studying television engineering as a career will contribute to this final achievement. The different plans for its accomplishment now on the trestle board will be detailed to you here in the hope that you may be inspired to contribute a new invention to the success of the miracle of color television.

One method proposed is the use of a revolving disk containing three smaller disks of three prime colors which rotate consecutively before a projected image from a television receiver tube. It is expected that the rotation will be sufficiently rapid to be undetected by the eye, but the different colors would supposedly alter the impact of the electron in the beam of projected light and render a different vibration in the proper area of the receiving screen. This, by contrast and different rates of vibration, would create in the final picture the different colors which were actually present in the scene or action being televised.

Another system involves the production of three prime color beams, each controlled by an electronic beam of different frequency and focused on a final receiving screen. Here, it is believed, all three images meet under such intensely high frequency as to appear in smooth continuity and in natural color.

Each of these methods involves high-precision mechanics. This is objectionable because of the size and weight of the instruments and because of the great cost involved in construction and maintenance. It will be remembered that the first successful television was produced by great revolving disks, which were discarded. Therefore, the use of any high-precision moving mechanism should be discouraged.

The reader is referred to a previous chapter on fluorescent rock relative to cathode-ray tube coating. The two hundred fluorescent rocks found by black-light prospectors while hunting willemite may hold the secret of successful electronic color television. Under the impact of a high-frequency beam of electrons, certain specimens of calcite respond in vivid reds. Opals respond in green. Selenite rock responds in yellow. This is controlled by the impact or frequency of the impinging stream of electrons.

Black-and-white pictures are produced by willemite which fluoresces to a certain degree of whiteness by a given frequency. Various frequencies produce different effects. It can, therefore, be reasonably assumed that different fluorescent rock could be mixed with the willemite on the screen of the cathode-ray tube. Since each color response is produced by a difference frequency, three separate electron beams of required frequency could be directed to play upon the same screen simultaneously. Each would produce the same picture, each beam separately activating its own color response on the screen. Where one would become brilliant, the others would be either blended or canceled. This would entail three sections of the electron guns and three sets of deflecting plates all working in unison. The results should be perfect pictures in natural color. Of course, this will involve years of experimenting and research, but is not beyond the ability of American television engineering.

Even as this manuscript is being prepared, we learn that Dr. Lee de Forest has just been granted new basic patent rights on another type of color television. For many long days he sat before a trestle board in the American Television Laboratories, painstakingly placing tiny pieces of colored plastic, row upon row, each piece no larger than an eighth of an inch long, shaped like a diamond, and fitted in an amazing mosaic which would tax the patience and eyesight of a man fifty years younger.

The nation celebrated Dr. De Forest's seventy-fifth birthday in 1948 and it counted up to his credit more than three hundred patents, which constitute many of the basic principles of our highly complex electronic science of today. This colorful mosaic of translucent plastic may hold the secret of electronic television pictures in natural color. But do not wait for them. It may still require five years or more before all the related components will be ready to accomplish this new miracle of television.

The wise ones are helping to build these and other marvels. The scoffer waits until others have taken all the good jobs and then complains of his "bad luck." We are living today in a new age of which the prophets spoke, "In the last days, knowledge shall be increased, and men shall run to and fro." And this new age is the mystic Electronic and Atomic Age, in which man is harnessing the powers of the universe—nuclear fission, dancing electrons—to attain wireless power, fuelless engines, bigger crops, and, we hope, longer lives; for unless this new wisdom is tempered by due respect for the One True God and all His children—these could well be our last days.

Marvel not at the prospect of nation-wide television's becoming civilization's greatest intercommunication system, employing millions. Study well and gain the scientific habit of mind. Question causes. Reject foolishness. It is the trained ones who will be the push-button engineers of this Electronic and Atomic Age. They will help to raise human society to a common level of culture by giving the deprived every opportunity to see the world and thus rise to the level of the best, whereas the godless and the indigent will seek to level society by tearing down the best and reducing them to the level of the lowest.

You can be a television engineer and show the world the great opportunities and beauty of the American Way. We are at the *crossroads.* With atomic energy, we must "do or die." Don't be a scoffer. Think for yourself. Think constructively, and then *act,* before you, too, become an atomic ghost!

# *Fluorescent Minerals*

## *Fluorescent Minerals*

| MINERAL ROCK | FROM | COLOR REACTION TO BLACK LIGHT |
|---|---|---|
| Aragonite | Death Valley | orange bands |
| | La Junta, Colo. | cream white |
| Aragonite geode | Chuckawalla, Cal. | white |
| Autonite | New Hampshire | green |
| Benitoite | San Benito, Cal. | deep blue |
| Calcite | Barrego Valley, Cal. | rose |
| | Brewster, Tex. | blue |
| | Hollywood Hills, Cal. | red |
| | Last Chance Canyon | red |
| | Miles, Tex. | blue |
| | Nogales, Ariz. | red |
| | Paicines, Cal. | white |
| | Randsburg, Cal. | orange |
| | Terlingua, Tex. | yellow bands |
| Calcium-larsenite | Franklin, N. J. | yellow-green |
| Chalcedony | Barstow, Cal. | green |
| Colemanite | Inyo City, Cal. | green-white |
| Curtisite | California | yellow-green |

| | | |
|---|---|---|
| Fluorite | Durham, England | blue |
| | Duncan, Ariz. | blue |
| | Cave-in-rock, Ill. | white |
| | Clay Center, Ohio | green |
| | Castle Dome, Ariz. | blue |
| | Colorado | blue bands |
| Hackmanite | Ontario, Canada | orange |
| Halite | Amboy, Cal. | red |
| Nasonite | Franklin, N. J. | blue |
| Opal (Semi-opal, banded opal, hyalite opal) | Western, U. S. | green |
| Pectolite | Paterson, N. J. | red |
| Powellite | Nogales, Ariz. | white |
| Scheelite | Western U. S. | orange or yellow |
| Selenite | Lovington, N. M. | yellow |
| Sodalite | Moultonboro, N. J. | orange |
| Sphalerite | Mexico | gold-orange |
| Spinel | synthetic | red |
| Stalactites | Cheboygan, Mich. | white bands |
| Wernerite | Ontario, Can. | apricot |
| Willemite | Franklin, N. J. | bright green |
| Willemite and Calcite | Franklin, N. J. | green and red |

# INDEX

DR. LUTHER GABLE not only writes about science, but has lived a life of scientific accomplishment. When still a very young man, he developed the first American luminous watch dials as well as twenty mechanical devices for therapeutic use. He helped invent a lead screening which has saved the lives of chemists and scientists. Combining his interest in science with a love of exploration, he found the first United States radium deposits (in Colorado), and more recently located pitchblende in the Arctic.

His life, one of colorful adventure and achievement, shows itself in a forceful and vivacious personality. Dr. Gable is much in demand on the lecture platform and has spoken before thousands of clubs and groups. He has also been a contributor to many periodicals, both professional and popular.

As a speaker, Dr. Gable has experienced enthusiastic response to his lectures on television. During his recent work as instructor at the American Television Institute of Technology in Chicago, he became aware of the widespread interest in this subject. He decided to write a book which would answer the many questions people have been asking about television as it is today, and which would also give them a good insight into the developments of tomorrow.

That he has succeeded in his purpose will become quickly apparent to every reader. THE MIRACLE OF TELEVISION brings the subject to life so vividly that its reading is a stimulating and rewarding experience.

JACKET DESIGNED BY STANFORD W. WILLIAMSON

*Preparing Iconoscope Tube for Heat Treatment*

*Dr. Lee de Forest,*

"FATHER OF RADIO," is also one of the pioneer inventors in the field of television.