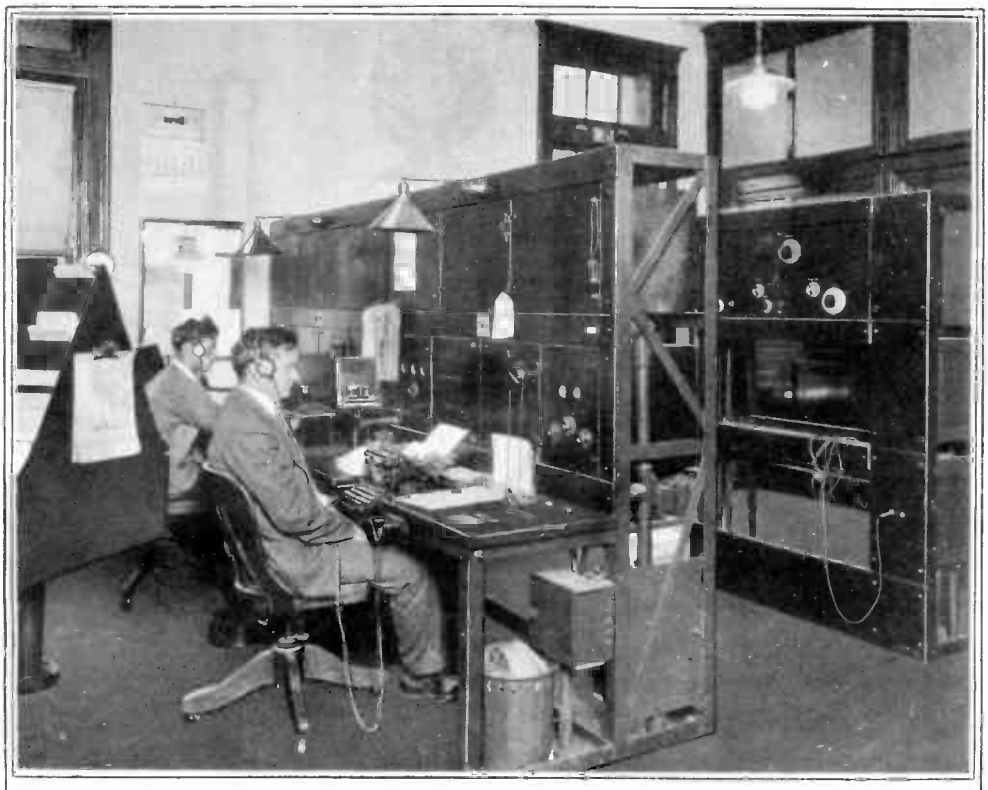
America's Oldest Radio School

RCA INSTITUTES INC

A Radio Corporation of America Subsidiary

HOME OFFICE
75 Varick Street, New York

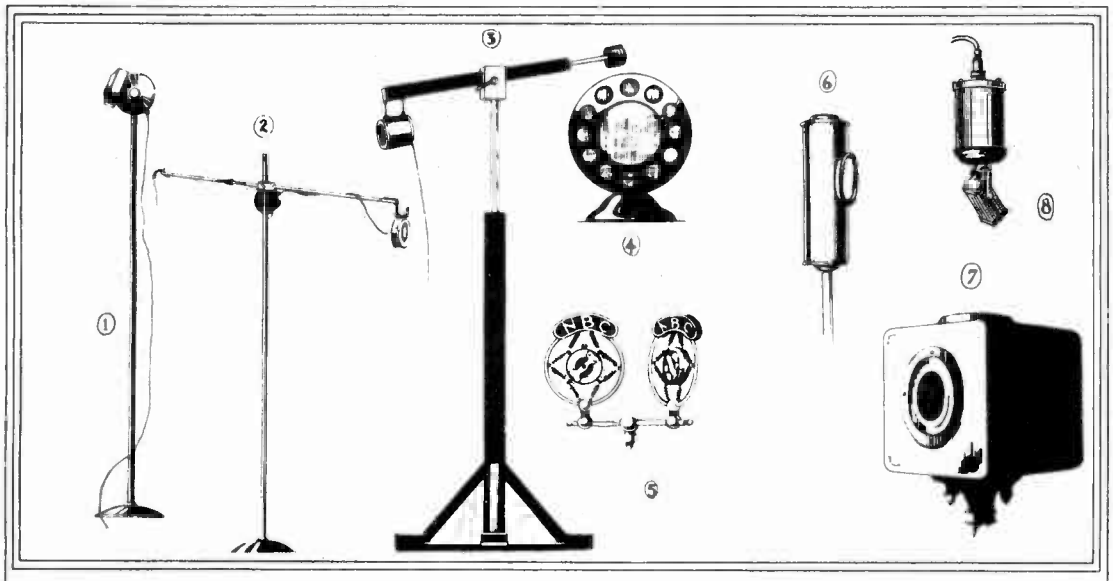


RADIO STATION WCC AT CHATHAM, MASS., THROUGH WHOSE CODE CHANNELS HAVE PASSED COUNTLESS MESSAGES BEARING WORD-PICTURES DESCRIBING HAPPENINGS OF PERSONAL OR PUBLIC IMPORTANCE.

Man's Early Efforts to Communicate by Word-Pictures

VOL. 59, No. 1

Dewey Classification R500.09



1 - The first microphone, ordinary telephone transmitter.

2 - Its successor was virtually the same mechanically.

3 - The "tomato can" was the first really successfull "mike".

4 - The "bird cage" which is now a symbol for radio.

5 - Its successor, is a refinement.

6 - The first condenser "mike" was a great improvement.

7 - The camera microphone, a refinement of the condenser "mike".

8 - The "ribbon mike", using electro-dynamic principles, is the last word in microphones.

America's Oldest Radio School

RCA INSTITUTES INC.

A Radio Corporation of America Subsidiary

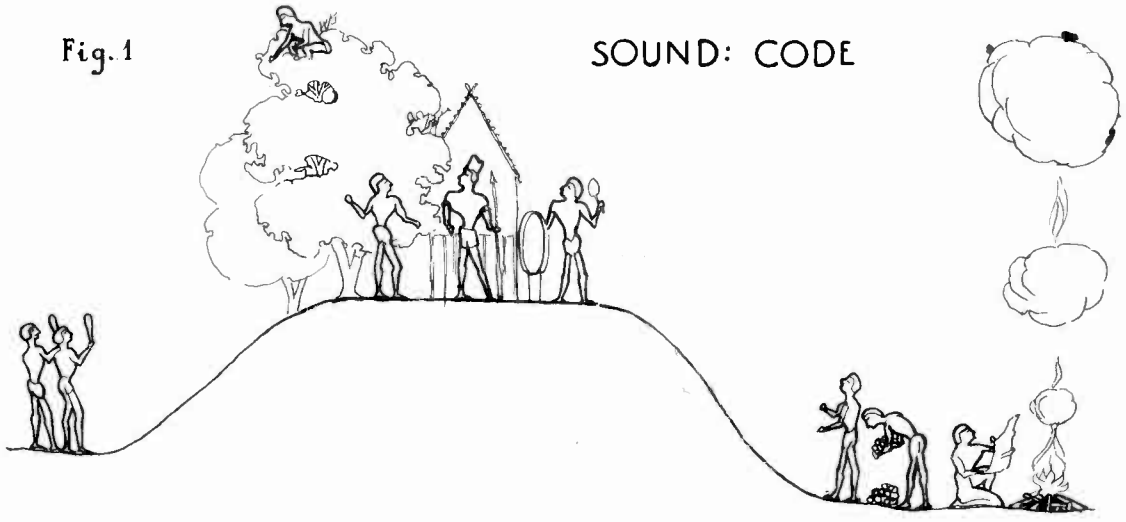
HOME OFFICE
75 Varick Street, New York

VISUALIZING AT A DISTANCE BY WORD-PICTURES.

Preliminary: In this lesson an outline will be given of some steps in man's progress toward the goal of bringing the whole world within the range of his senses of hearing and seeing.

Early Sound-Wave Systems. Let us consider the primitive scene depicted in Figure 1. The group of men, for protection of their lives and property, have stationed one of their number in the top of a tree, within calling distance. This elevated observer sees approaching from the left an enemy, and gives orally to those below a word-picture of the object and action. While these men are well within

Fig. 1



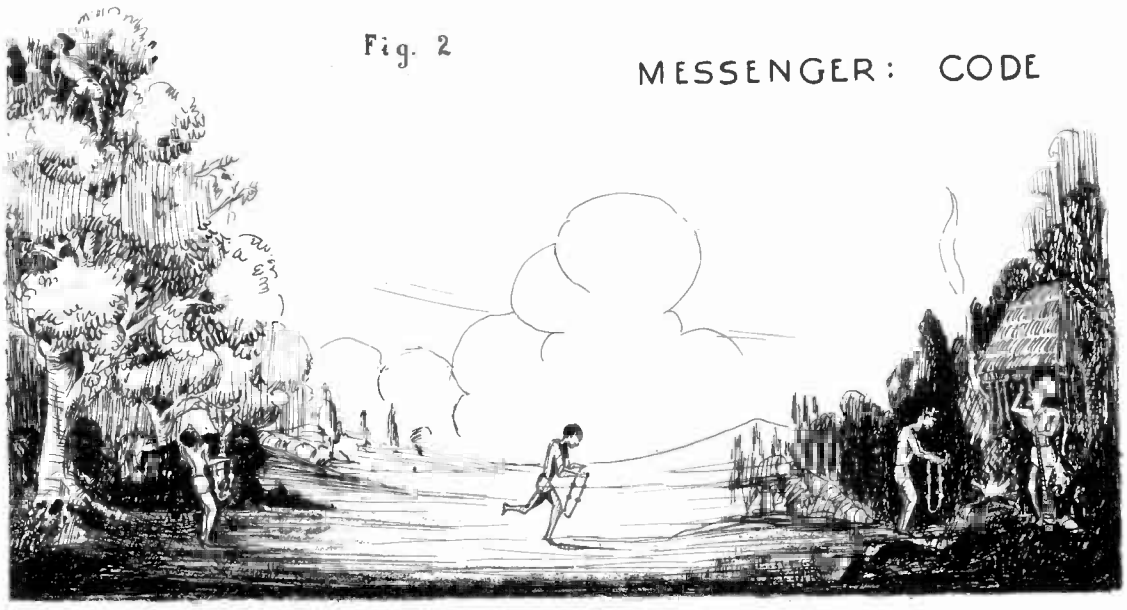
the voice range of the observer, they are too far away to summon vocally the remote workers in the fields below the village. Since voice amplifiers have not yet been invented, they have recourse to a source of sound power greater than that of their voices. A large drum of stretched skin, or a hollowed log, is mightily beat upon with the strength of their arms, and radiates sound-waves conveying a warning and a summons to those at the lower right of the picture. This signal may even carry an explicit word-picture describing the danger, by combining the drum-beats in certain groups. This is probably the earliest form of telegraph code. Even in these modern times it continues in the form of the tapping of a policeman's night-stick on the pavement to summon help.

Early Light-Wave Systems.

Another primitive method of conveying word-pictures a great distance is the use of one or more fires by night, or puffs of smoke by day (See Figure 1.) This system was elaborated into a code form for conveying a greater amount of information (a more detailed word-picture). This was by means of either a plurality of fires at unequal distances, or the successive revealing and concealing of the fire by the lowering and raising of a blanket between the fire and the distant watcher. This is actually a form of ether-wave transmiss on of intelligence, since light is one form of wave-motion in the same ether that serves to carry radiotelegraph messages and broadcast programs.

The above methods of increasing the "seeing power" of man are fairly quick, but the distance covered is limited by the sound-power or the light-intensity for signalling purposes. The next step to increase our distance of communication is to arrange a portable record of the word-picture we wish to transmit.

Fig. 2



Early Messenger Systems.

In the voice form, these word-pictures are learned verbatim by a messenger (memory record). He travels or is transported to the immediate vicinity of the intended recipient of the information. There the word-picture is released by vocal "delivery". In the code form, a string of beads is made of unequal spacings, for example, in accordance with a pre-arranged system of word-substitution. These would be carried by the messenger to the recipient, as in Figure 2.

Now our communication system is getting more complicated. We achieve an improvement at the cost of an increase in personnel, some of whom

may be specialized to some extent. For instance, an ACTION occurs at some point, an OBSERVER especially qualified by good eyesight informs a TRANSLATOR who has a particular skill in quickly, accurately, and economically setting up the string-and-beads equivalent of the word-pictures. Then a messenger of tried speed, endurance, and trail-knowledge becomes the MEDIUM of conveyance to the locality where the information is to be used. Since even a tribal chief may be too dumb, busy, or proud to be qualified in bead-reading, we may find here an INTERPRETER. The latter speedily and clearly changes the bead-and-string arrangement into vocal word-pictures which the RECIPIENT can understand. He does this by a process of visualization, which is forming visual images or mental representations of objects not present to the senses.

Modern Light-Wave Systems.

We have by no means finished with the possibilities of light-waves as a means of communication. While limited as to distance and path,

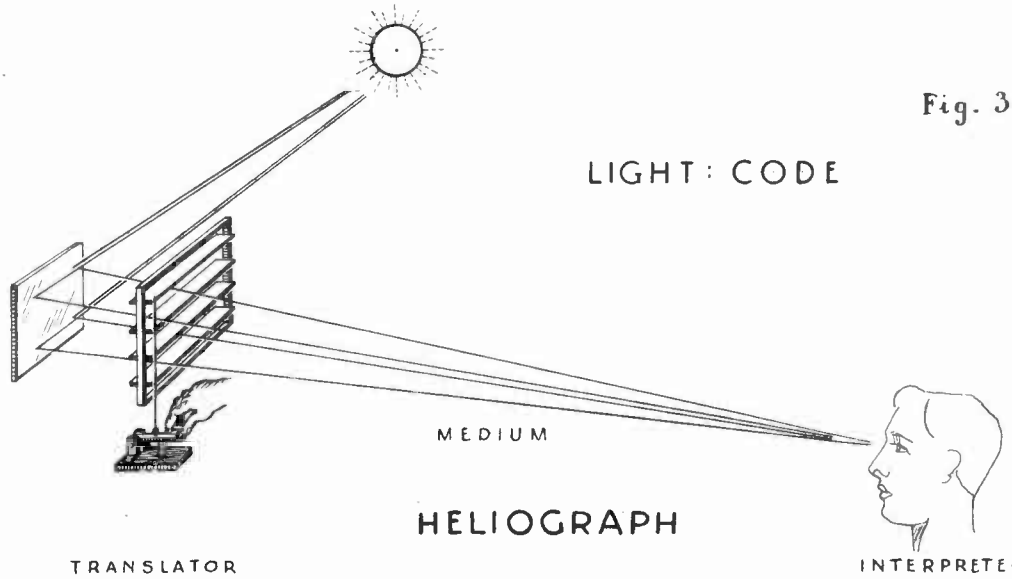


Fig. 3

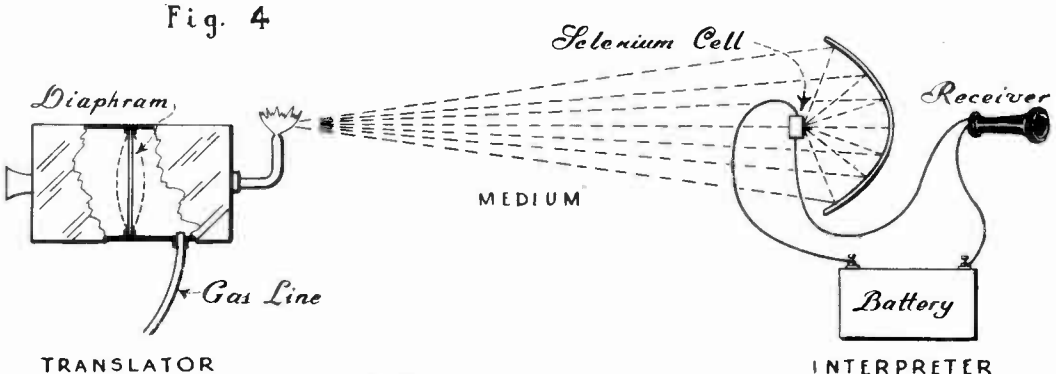
there is the advantage of using as a medium the all-pervading ether, of which light is one form of wave-motion. No physical medium need be constructed between sender and receiver as in the wire systems which we will discuss later.

The heliograph is a return to the code form of word-pictures, as shown in Figure 3. It uses the sunlight reflected by a mirror, with a shutter controlled by a key lever to break the light beam into code impulses, much like the blanket and fire system. This progressed to the use of an electric searchlight with a similar key-and-shutter control. By such a method, signalling was permitted by night and during the day when the sun was not available as a source of light-energy due to intervening clouds. Another form of this consists of a key controlling the switching on and off of the electric current which causes a lamp filament to become incandescent.

We find that at one time experiments were conducted with the transmission of voice over a beam of reflected light. Very little public

attention was given to this because of its limited usefulness. The light from the sun or other source was caused to fall on a mirror which reflected the light continuously toward a receiving point, like the heliograph minus the shutter. The mirror was held loosely in a frame, at the rear of which was a mouthpiece. The sound waves of the speaker's voice vibrated the mirror, causing a variation in the completeness of reflection toward the distant point. Here a curved reflector contained a selenium cell at the focal point where the received light was concentrated. A selenium cell is a device whose effectiveness as an electrical conductor depends on the amount of light received on its surface. When this cell was interposed between a current source (battery) and a telephone receiver, the voice-ripples on the light-beam caused voice-ripples in the otherwise steady stream of current between battery and receiver. Now a telephone receiver is a form of air-pump operated by ripples in an electric current stream. Therefore the over-all result was that the receiver created air pulsations (sound waves) which were an approximate imitation of the voiced words of the distant speaker.

Fig. 4



OPTICAL TELEPHONE

Another system, somewhat similar, was called the optical telephone (see Figure 4). The transmitter consisted of a small box divided into two compartments by an india-rubber diaphragm. One compartment was connected to the open air by a mouth-piece. By means of a pipe, illuminating gas was supplied to the second compartment and passed out through another pipe to a burner. The brilliancy of the flame depended on the flow of gas, and this in turn depended on the pressure of the gas at the compartment end of the burner pipe. In operation, the voice of the speaker at the mouth-piece caused the rubber diaphragm to move back and forth in accordance with the impressed sound waves. This movement of the diaphragm increased and decreased the pressure of gas in the second compartment. The gas flame rapidly rose and fell, giving a light-stream that was moulded or modulated by the speaker's voice. The receiver arrangement was the same as for the preceding system.

We even find that any of these systems could be developed to give station selection. If sunlight passes through a prism it is broken up into the colors of the rainbow. The primary colors are red, yellow and blue, and these are actually trains of light-waves of different wave-lengths. Applying a red glass filter to a heliograph transmitter, only the red component of the sunlight will be transmitted when the shutter is opened. A second heliograph could be equipped with a blue glass filter, and only the blue wave-length

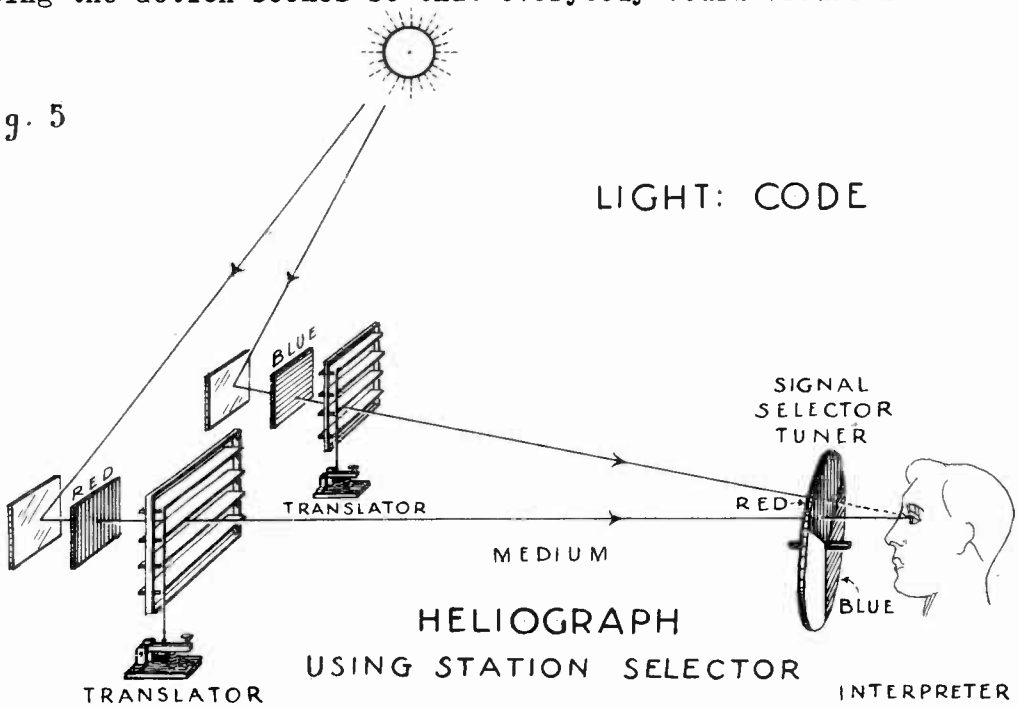
will be transmitted. Each of these heliographs transmits a different message. It is clear then that the receiving eye can be "tuned" to either the first or second transmitter station by holding up a red or blue filter respectively before the eye. (See Figure 5).

Modern Wire Systems.

Telegraph: The earliest wire system is the electric telegraph. Historically it would be grouped with the early photographs of the messenger systems, and the optical telephone method of the light-wave system.

The telegraph (and cable) was a great step forward in aiding high-speed communication. Events all over the world were transmitted to our local newspapers, which in turn printed the word-pictures describing the action scenes so that everybody could visualize how the

Fig. 5



events took place. The telegraph has long been the standard means of long-distance communication. The system has a limitation in that a path (wires) for conducting the electric currents must be constructed between the two points. The word-pictures are transmitted by a code system of impulses in the flow of electric current. This can be roughly compared with the heliograph system of code impulses in light.

The working principle is quite different. An electric current will flow along a path only when it can return to its source, in general terms. It may "go" on one wire and "return" on a second wire; or the return path may be the conducting properties of the earth itself. A source of electric energy is inserted at some point of the circuit, and devices worked by the current may be inserted at any point in the path. The simplest telegraph (see Figure 6) consists of a current source (battery), a conducting path (wires), a path-interrupter

(key), and a work-unit (sounder). The latter is merely an electro-magnet and an armature. When the current flows through the magnet coil which is part of the current path, the armature is drawn to the magnet and makes a clicking sound. A somewhat different sound is made when the armature returns to its normal position of rest. The time between the down-click and the up-click is a measure of the length of current flow constituting a dot or dash of the code system. This flow is controlled by the key at the transmitting point.

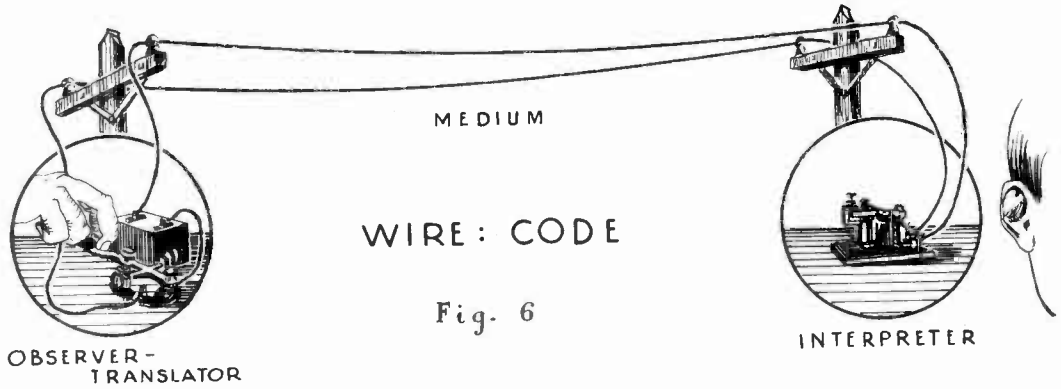


Fig. 6

The foregoing description is of the very simplest telegraph. By placing a key and sounder at each end of the circuit, two-way communication is achieved without the addition of a second pair of wires.

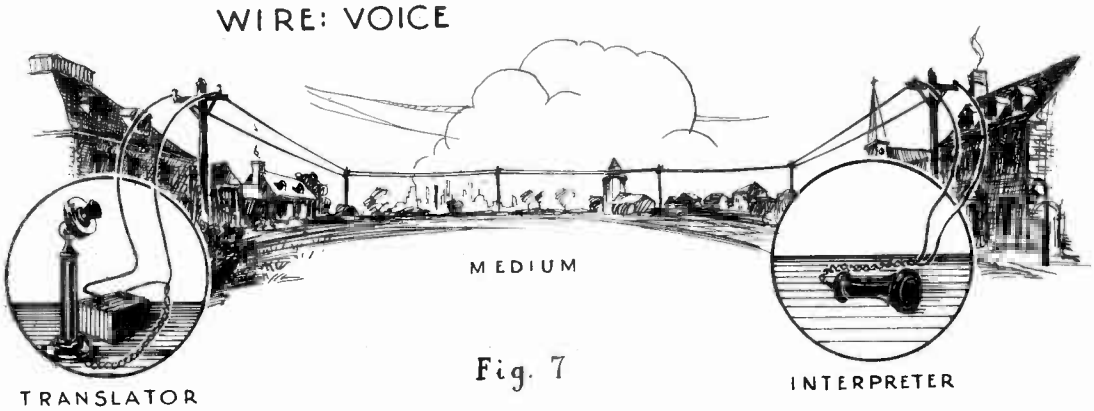


Fig. 7

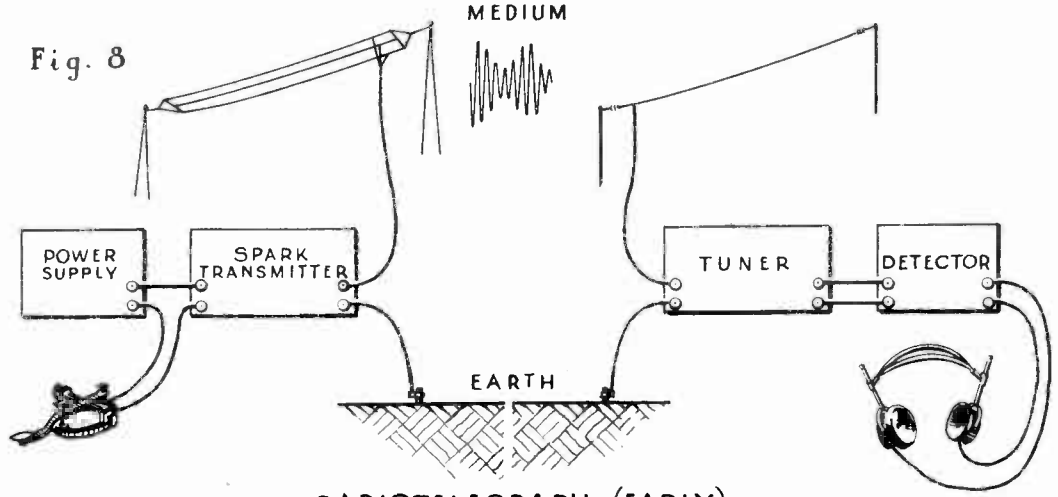
Telephone: Continuing our advance with mankind, the telegraph was not universal enough to meet his needs in quick accurate descriptions that he could send and receive himself. Some means had to be developed whereby he merely had to talk to an instrument which would convey his words directly to a distant person. The earliest development of this kind was the telephone. We can get a good understanding of this by going back to the telegraph. Let us replace the TRANSLATOR of the telegraph (operator and key) with a microphone; the telegraph INTERPRETER (operator and sounder) then is replaced by a telephone receiver (Figure 7). With the same wires, we now have a one-way telephone circuit.

In the telegraph, the key was either closed or open; the current was either flowing steadily or was not flowing at all; the sounder arm was either down or up. In the newer telephone system, a small steady current flows whenever the parties are connected, and the air is quiet at the microphone. When sound waves caused by a voice impinge on the microphone, the current flowing through it is rapidly varied or modulated. The effect may be described as putting voice-ripples in the steady stream of current through the wires and the remote receiver. These ripples cause the receiver diaphragm to move back and forth across its normal position of rest, with an air-pump action that creates sound waves. The total effect of these on the ear is a good imitation of the voiced words of the person at the transmitter. The central switchboard has been omitted because it is just a means of connecting one pair of wires to another, regardless of the complexity of the method. As with the telegraph, two-way communication was achieved by using a microphone and receiver at each end of the pair of wires.

Radio Systems.

Early Radiotelegraph: Nearly seventy years ago a scientist had asserted, from purely mathematical considerations, that a form of electromagnetic ether-wave energy existed of a different order from

Fig. 8



RADIOTELEGRAPH (EARLY)

light. He laid down a concept of the other wave form which was forty years later proven to be correct. These waves were known then as Hertzian waves, after the man who first made a practical demonstration of transmission of the waves and an indicating method for their presence at a short distance. For two decades more considerable scientific thought was given to a study of the nature of the phenomena. Various inventions were made improving the wave-generating and wave-indicating systems. This work was chiefly of the across-the-room type. Most communication systems remain within four walls for some time, as did this one. However, a rude shock was given to the laboratory minds of the day when one young man sought an every-day and everyman utility for the new science. To Marconi is given the credit of bringing the new radio art into being. Actually his chief contribution at the beginning was the use of the earth as one electrode, and an elevated aerial wire as the other electrode.

It is probable that as much credit is due the British Government for their open vision when Marconi first proposed to them his system, and for their persistent faith and financial backing of the costly experiments in the first few years of his work. We can readily see why that government would be one institution above all others which would have a vital interest in such work. The Empire has the British Isles as a relatively small "headquarters". The main area of the Empire is scattered over the face of the earth. The chief means of rapid communication between its integral parts was the telegraph and cable, mostly the latter. These were subject to complete interruption through being cut in the water. Also, some lines had sections actually crossing and owned by other countries. Therefore any means of communication which would pass by or over other countries without possible interruption of service meant increased security for the lives and property of the Empire, as well as economy in construction.

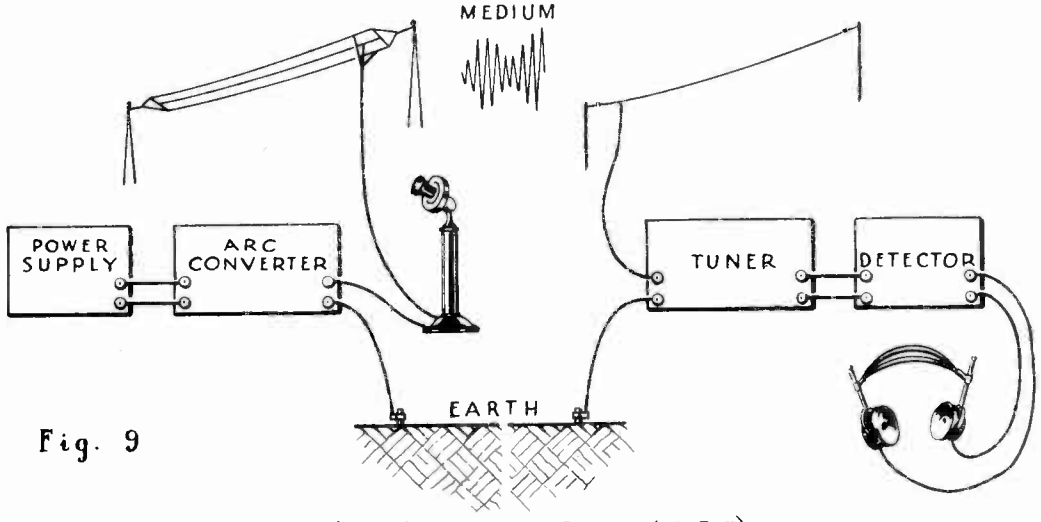


Fig. 9

RADIOTELEPHONE (1905)

His early work was followed, confirmed, and added to by men of other countries, largely encouraged by their own governments. Many uniquely varying circuits and equipment were devised to generate and detect the Hertzian waves, as they were known. These waves were transmitted from an aerial and ground system on which were impressed very high-frequency currents of an oscillatory nature. As sources of these oscillations there were used several types of arcs and sparks associated with Leyden jars (condensers) and wire coils (inductances). In order to make code impulses of the transmitted energy a telegraph key was used, (see Figure 8). This interrupted the power circuit supplying the oscillation generator in spark systems. The keying for arc systems had several variations and usually occurred in the circuit of the oscillation generator rather than in the power supply to it. The two wave types required different methods of detection at the received point. Just as the selenium cell was required for the change from light-wave energy to electrical energy, so another form of detector was required to transfer the radio-frequency currents into electric currents capable of operating a telephone receiver. These detectors were of the coherer, electrolytic, magnetic, and crystal types.

Early Radiotelephone. Even during this era of the code systems, much attention was being given to the telephone use of the new medium. Some oscillation generators, of the arc type, provided the constant amplitude of energy stream which is the beginning of voice methods, comparing with the steady value of battery current in the wire telephone before voice modulation is put on. But the value of the oscillatory current to be controlled in the radio transmitter was considerably higher than the battery current, and no microphones had been built which would stand up in this heavy service. However, a considerable amount of experimental voice transmission was done, including some of a broadcast nature to the general field of amateurs (see Figure 9). The crystal detector and headphones made audible the voice-modulations on the radio carrier wave stream. Usually a heavy background of noise, originating in the transmitter, rendered the system unfit for programs of an entertainment nature.

In the matter of station selection by the receiver, we are not faced with quite the problem we had with light waves, where most of the light-energy sources produced a number of wave-lengths. In a radiotelephone transmitter adjusted for good efficiency, the very principle of oscillation generating determines that in general the

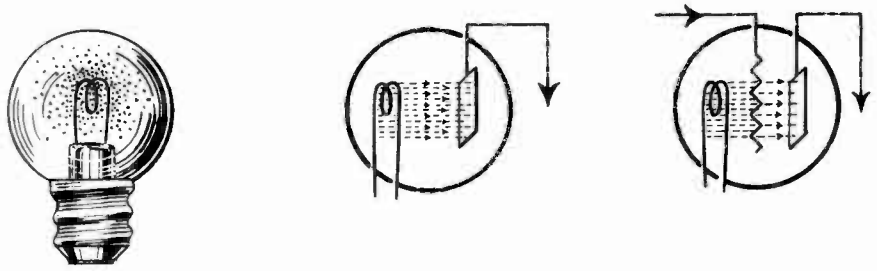


Fig. 10

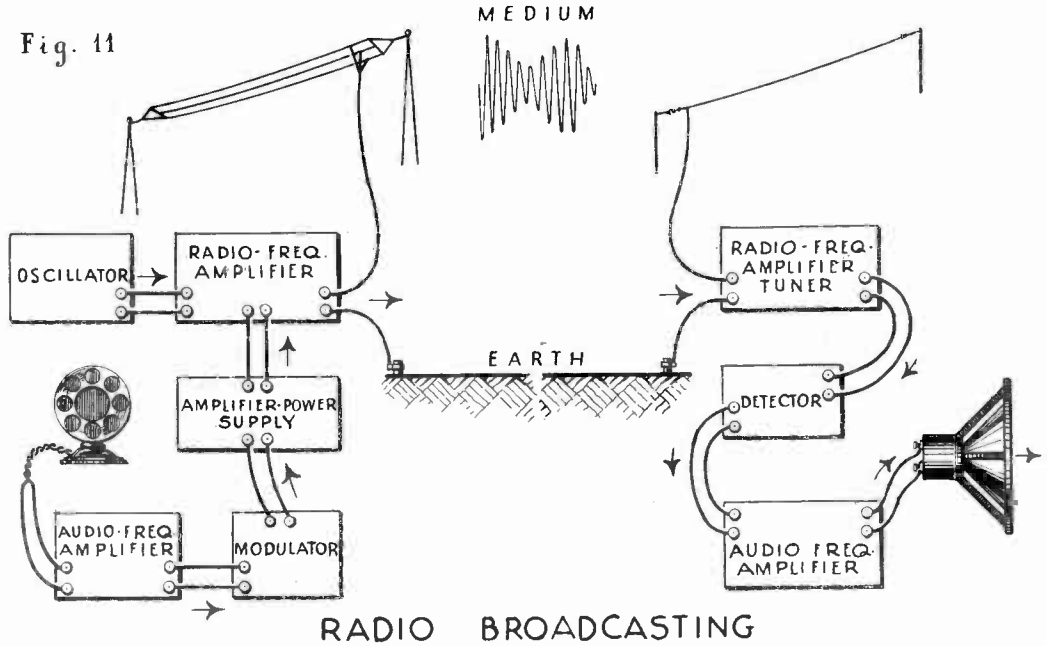
radiation will be at only one wave-length. We have in the receiving equipment an analogy to the color-selecting filter placed before the eye for the colored heliograph signals. The circuit connecting the receiving aerial and the detector contains an electric filter called a "tuner". It passes the current of the desired signal on to the detector and phones; it wastes the signal current of undesired stations on other wave-lengths, just as the red glass filter wasted the light coming to it from the blue heliograph transmitter.

The Vacuum Tube. While Edison was still in the early stages of developing his incandescent lamp, he observed some effects of what we now know to be the emission of electrons from the hot filament. Later a metal plate was included in the lamp bulb and connected to the filament by an external conductive path which included a battery. It was noted that a current flowed through this circuit when the positive battery terminal was toward the plate, but not when the positive terminal was toward the filament. This one-way conductivity gave the tube the name of "valve", and it was first used as a detector of modulated radio-frequency currents in a receiver.

It had the property of changing a modulated wave-stream into a pulsating direct current which would operate the headphones.

A most important step was the addition of a third electrode, or grid, to control the electron flow, (see Figure 10). The new tube was first used as a detector and proved much more sensitive than the crystal type. Subsequent study and many experiments brought out its use as an amplifying device and as an oscillation generator, when connected to circuits of proper design. As a radio-frequency amplifier, several tubes were associated with several tuned circuits. In a receiver this provided a greater sensitivity (for distance) and better selectivity between stations. As a generator it gave a relatively pure output of greater stability of oscillation-frequency than previous methods had done.

Fig. 11



RADIO BROADCASTING

The microphone came into its own. It was now able to mould the wave-stream of the most powerful transmitters, through the use of other vacuum tubes as amplifiers of the weak voice-frequency currents at the microphone. (See Figure 11). The effective distance range of the wire telephone was increased tremendously by similar amplification to compensate for the losses in hundreds of miles of wire. Multiplex telegraphy and telephony brought a new speed of transmission of word-pictures. The improvement in telephone methods meant that a radio station might be erected in a locality which provided best transmission through the ether medium to the destined point. The microphone was brought, in effect, into the transmitter room by the long-distance telephone.

Radiotelephone Broadcasting. During the World War the development of the art was speeded up considerably by the unusual demands of a military emergency. This applied not only to the commercial equipment for point-to-point communication. It affected appreciably the interest and technical qualifications of the thousands of amateurs who had gone into radio service in the war and returned home with

an increased fascination for "the radio game". In addition, thousands of young men of no radio experience before the war had received months of schooling and actual operating experience. Their restlessness found expression in the far-flung world of amateur radio. We see then that there was a fertile field for the experimental broadcasting of music and voice programs by the Westinghouse engineers in 1920. The popular interest shown in these occasional programs brought into being the famous pioneer station which was given the call letters KDKA after broadcasting the election returns of November, 1920. This started the ball rolling in what has become not only a major industry but a major public service as well.

A great portion of the program hours is of the nature of directed entertainment, and hours are devoted to matters of a real educational value. As a news service, it brings not only the immediate words of important men, but is the medium of conveying word-pictures of events almost simultaneously with their action. That the public is interested in visualizing at a distance is proved by the interest shown in descriptions of the scene as well as the action, in broadcasts of athletic and political events.

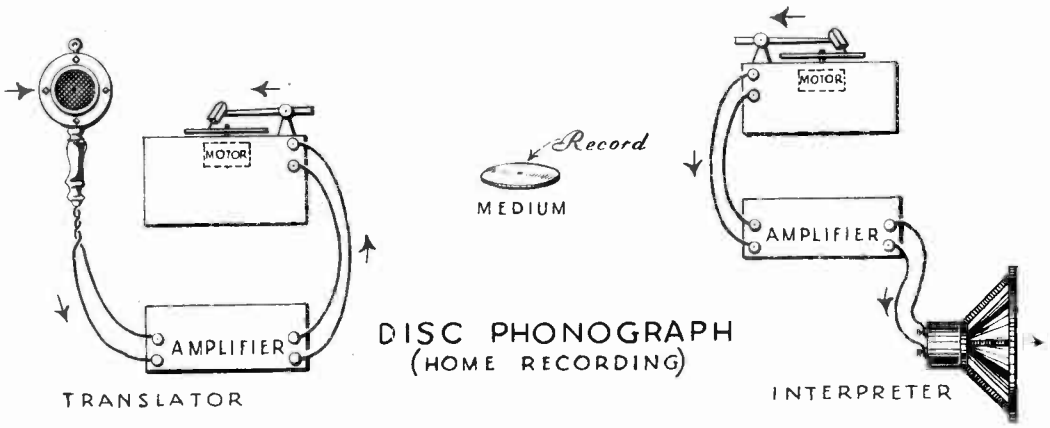


Fig. 12

The TRANSLATION function is performed by the series of apparatus commencing with the microphone and ending with the antenna and ground connection of the transmitter. This equipment is actually much more complex than shown in the functional diagram of Figure 11. It includes telephone lines, their associated repeaters, volume indicators, switchboards, loudspeakers for monitoring of quality, etc. The INTERPRETING function commences at the receiving antenna and ground, and ends at the diaphragm and baffle of the loudspeaker. It is obvious that this system can transmit only word-pictures, and that therefore a great deal is still left to the visualizing powers of the individual.

Modern Messenger or Common Carrier Systems.

Disc Phonograph: The phonograph is chiefly known as a means of conveying vocal and instrumental music to a number of recipients remotely scattered. We have a good example of its use as a means of transmitting word-pictures. This is the home-recording electrola (Figure 12). It has served particularly to make a permanent and

portable record of words describing the actions and events in one home to interested recipients in another home. We note that the OBSERVER speaks the descriptive words into a microphone connected to an amplifier and recorder, which operates in the spiral groove of a disc rotated by a motor. This system becomes the TRANSLATOR of our general case. The result is a complex series of waves in the otherwise clear spiral groove of the record disc. The MEDIUM of conveyance is of the messenger type, as represented by the postal or other carrier system. The INTERPRETER consists of a system comprising a motor, pick-up, amplifier, and loudspeaker.

Film Phonograph: Another form of phonograph, chiefly used in sound movies, is that in which the sound record is made on a strip of photographic film. (See Figure 13). In recording, the amplified output of the microphone controls the intensity or width of a beam

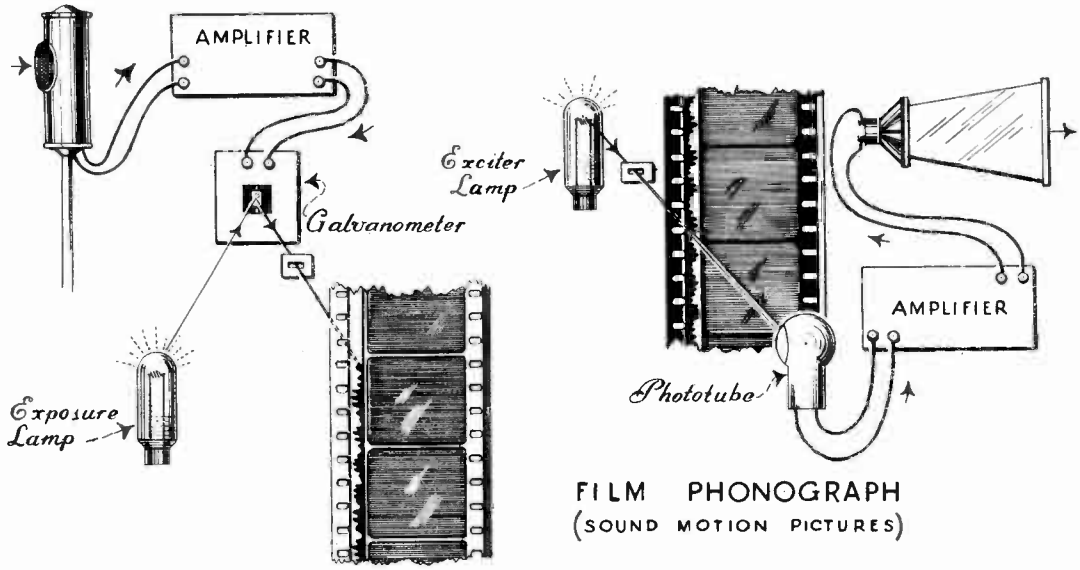


Fig. 13

of light. This shines on a narrow section of a moving negative film strip. Along the entire length of this strip is a sound track which either has a constant density and variable width, or a constant width and variable density. In the projector a light beam is passed through the sound track and directed to a phototube. The illumination of this tube (and therefore its electric current) is modulated by the sound track as the film moves rapidly and at uniform speed past a point in the optical path between the light source and the phototube. The electrical modulation here is a reproduction then of the current modulation originating at the microphone. Suitable amplifiers and loudspeakers provide the desired sound projection.

In the film phonograph, the record usually represents the miscellaneous sounds and conversation accompanying the action photographed for a motion picture. The latter itself is capable of providing sufficient visualization of the action, and seldom requires word-pictures of a descriptive nature.

EXAMINATION QUESTIONS

1. Name three kinds of waves used for communication.
2. Which two of the three kinds above occur in the same connecting medium?
3. What is the fundamental principle of the sun-ray telegraph?
4. Compare it (the heliograph) with the radio telegraph.
5. How does a radio receiving tuner compare with a bunch of colored light filters?
6. Why, in your opinion, is the optical telephone impractical?
7. What is the principle of the telephone transmitter, better known as a microphone?
8. How is its action different from a telegraph key?
9. What particular device was most responsible for the final success of radiotelephone broadcasting?
10. Name two types of phonograph records which differ in the material used and the method of recording.

THE SMALLEST AND LARGEST VACUUM TUBES REQUIRED TO OPERATE RADIO STATION WEAF AS A 50-K.W. TRANSMITTER.

P.O.1363A

PRINTED IN U.S.A.

VOL. 59, No. 1