Broadcasting by Remote Control

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PRINCETON was playing at Chicago. It was Princeton's ball on her one-yard line, and the score was much against her. Then the unexpected happened. A forward pass advanced the ball forty yards, a kick to Chicago, a fumble. Princeton's ball again, and a forty-five yard run for a touchdown. So was defeat turned, in a fraction of a minute, into victory.

As the applause swelled to its height, the door of a little booth in the press stand opened and the face of a man, tense with responsibility, was thrust out. With an attempt at a smile he said, "Here's where I turn my job over to twenty thousand rooters."

But it was only for an instant. The teams were already lining up for the goal. The door closed, the speaker was again in his little sound-proof booth, and with a hurried sweep of his hand over the moisture-covered window in front of him and his eyes riveted on the play, he again began his task of describing it step by step to his huge, invisible audience.

Before him stood a microphone transmitter which joined him telephonically to radio station WEAF in New York City, 900 miles away, and as he spoke, his words were immediately broadcasted to the hundreds of thousands of radio listeners within the station's range. With so vast an audience hanging on every word he uttered, it is small wonder that he felt a heavy responsibility.

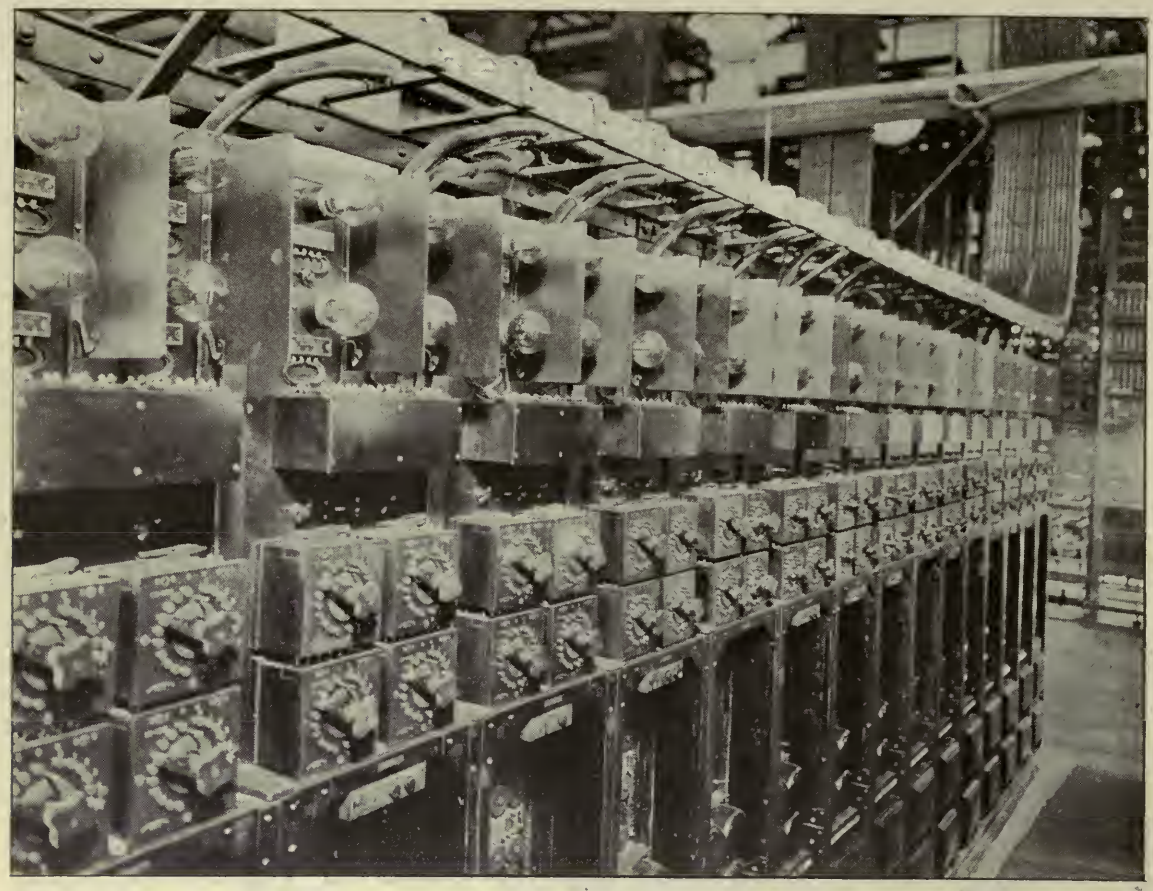
Now what significance is there in the fact that a great football contest is followed throughout its course by so many thousands of rooters of both sides who are scattered through half a dozen states?

Consider for a moment certain important stages through which broadcasting has passed. In the beginning, we find here and there an amateur, particularly enthusiastic and resourceful, rigging up a transmitter which we would now consider most diminutive, but which in its day was the marvel of his community, and for the amusement of a few neighbors occasionally placing a phonograph in front of his transmitter. By this arrangement, his little audience could hear snatches of ethereal music at very irregular intervals. Such was radio broadcasting not so long ago.

Another and very important stage began with the opening of the celebrated WJZ by the Westinghouse Company. In the two years which have elapsed since that time some five hundred other broadcasting stations have sprung up over the country and a small army of radio experts and musicians are busy every

THE ANNOUNCER'S BOOTH

Installed by the engineers of the American Telephone and Telegraph Company. On the flag pole just above the booth will be noticed one of the microphones used for picking up cheering. The amplification which the output of these cheering microphones undergoes can be varied at will. When the announcer is silent the volume of cheering can be run up, and then diminished before an announcement is made



A TYPICAL TELEPHONE REPEATER INSTALLATION

As used on long distance telephone lines. Repeaters such as are here shown were also used for the remote control of W E A F when broadcasting the games between Brown and Yale, Princeton and Harvard, Yale and Princeton, and Harvard and Yale

day and evening putting on programmes. Moreover, the radio audience has grown from hundreds to hundreds of thousands and is to-day a body of people which, for enthusiasm, breadth of interest, and size, could not be gathered together by any other agency than the radio telephone.

This fact means that even greater stress must be placed upon the quality of the radio programmes. From where will they come? The only answer is that they will come from everywhere. Just as broadcasting replaced the amateur's phonograph programme, so it is reaching beyond the programme which originates in the radio "studio." The studio is not to be supplanted, but it is not enough. The time is rapidly approaching when the radio audience should have available a nation-wide, *even a world-wide, programme!* From boxing contests to grand opera, from church services to great political mass meetings, from football and baseball games to international yacht races, from the inauguration of the nation's president to the dedication of great engineering achievements, there is a wealth of radio programme material which even the imagination can scarcely compass. But these events cannot be brought to the broadcasting station; *the station must, in effect, go to them.*

The purpose of this article is to discuss some of the technical developments by which this end is being accomplished.

Since broadcasting involves transmission of the voice or other sounds in only one direction, the problem of attaching a long-distance telephone circuit to the radio apparatus does not involve the use of such equipment as a hybrid coil and balancing network that are necessary whenever a two-way radio link is associated with a two-way telephone circuit. On the

other hand, the telephone circuit itself is of a special character designed to transmit without distortion the wide range of frequencies required for the accurate reproduction of speech and music. Two devices characterize the long-distance telephone line which is connected to broadcasting station: the electric wave filter and the telephone repeater.

Everyone appreciates the fact that music consists of sounds whose pitches range over a wide interval of frequencies. This interval extends from about 100 to about 5000 cycles per second for both instrumental and vocal music. It is not generally known that the normal speaking voice contains in it just as wide a range of frequencies as is used in music. The speaking voice consists of very complex sounds, in which the characteristic of pitch is not apparent. However, were one of these complex sounds to be carefully analyzed, we would find it to consist of pure tones ranging in frequencies all the way from about 100 up to 5000 cycles per second. If it is desired to transmit the voice electrically either by radio or over a telephone circuit, and at the same time to preserve its individuality, we must therefore use an electrical system which will carry electric currents of frequencies from 100 up to 5000 with equal efficiency.

It is in this connection that a special form of the electric wave filter known as an equalizer performs a very important function. The filter is the invention of Dr. G. A. Campbell of the American Telephone and Telegraph Company, and, as its name implies, will separate currents of different frequencies somewhat as a screen will separate gravel of different sizes. In one sense, every long telephone circuit consisting of two parallel wires is a filter. It tends to transmit certain frequencies more readily

GETTING THE GAME PLAY BY PLAY

A crowd gathering around a loud speaker stand in Park Row, New York City. The input of the loud speaker was supplied from a radio receiving set located on the truck. On the upper left-hand corner of the truck may be seen a small loop antenna for receiving

than others, and this condition is particularly noticeable in cables, for there the two wires are twisted together with merely a thin paper insulation between them. Such a cable carries the lower frequencies with less alternation than the higher frequencies, and therefore distorts the speech currents sent through it. If it is necessary to use more than a few miles of cable in a long telephone line, and it was in the New York–Chicago line which was used to broadcast the game between Princeton and Chicago, this distorting effect must be counterbalanced. The use of equalizers accomplishes this. These special networks are introduced into the line at proper intervals and are so designed as to transmit most readily the frequencies which the line tends most to attenuate. The result is a conducting path for the speech currents which passes all the essential frequencies equally.

It is apparent that the use of equalizers will reduce the strength of the speech current which a line delivers, for, in effect, the transmission of the line for every frequency is reduced to the value it has for the least readily transmitted frequency. This difficulty, which at first sight might appear to be serious, is easily removed by the proper use of telephone repeaters. The repeater is a special form of vacuum-tube amplifier and can be installed at various points in a long telephone line to amplify the speech current and give it its original or an even greater value. In the New York–Chicago line, these amplifiers were installed at the football field in connection with the microphone transmitter, at Morrell Park, Illinois, at Beaver Dam, Ohio, at Pittsburgh and at Harrisburg, Pennsylvania.

As already indicated, the function of the telephone line is to deliver to the preliminary amplifier of the broadcasting station a speech current of about the same strength as it would receive were the transmitter at the station.

In accomplishing this, the spacing of the telephone repeaters at approximately equal intervals along the line is a most important factor. The alternative to such an arrangement would be to introduce enough energy at the sending end so that, without amplification at any point along the line, there would still remain the amount required by the radio apparatus. This would necessitate an enormous power input and is not at all practicable. To take a concrete case, suppose that the speech current energy entering the preliminary amplifier at WEAF (New York) should be 0.01 watt. The attenuation of the New York–Chicago line is such that at Harrisburg, the nearest repeater station, the speech energy present in the line should be 0.14 watt. If there were no repeaters, then at Pittsburgh the line energy needed would be 2.9 watts, at Beaver Dam 41 watts, at Morrell Park 860 watts, and at the field 200,000 watts.

While it would not be impossible to-day to construct an amplifier with an output of 200 kilowatts, it cannot be regarded as a practical alternative to the five amplifiers which were used and none of which was required to give an output of more than a watt. Nor is this an extreme case. Were it a question of using a telephone line twice as long as that between New York and Chicago, the initial energy needed without intermediate repeaters would be the enormous figure of 20,000,000 kilowatts.

This comparison between the use of repeaters spaced along a line and providing all the necessary energy at the sending end gives rise to the question of how many intermediate repeaters it may be practicable to use successfully. While it is not possible to set a definite upper limit, it may be pointed out that an artificial telephone line, the equivalent length of which was 24,000 miles or the circumference of the earth, and containing thirty-six repeaters, has been successfully demonstrated. The area over which a broadcasting station may "reach out" for its programmes is therefore practically unlimited.