Sound Transmission System for Two-Way Television*

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In this paper is described the speech transmission part of the two-way television system described in companion papers. The system is designed to produce the best possible illusion of face-to-face communication between speakers located at a distance. Some of the novel features of the system described include the use of distant pick-up transmitters and loud speakers concealed in the wall of the booth, also the use of heavy glass windows through which the scanning beam and the reproduced image are projected as a means of preventing the admission of noise into the booth.

IN the design of a sound transmission system to be correlated with a visual system, the requirements as to perfection of results desired are no more stringent than for other high grade sound reproducing systems [1] that have been described in the literature from time to time. Rather in this case the peculiarities of the system are largely those incidental to the adaptation of old technique to meet new conditions.

The principal limitation of the sound system imposed by the visual system is that the user be relieved of all necessity of holding a telephone in close proximity to the head. Such a limitation is highly desirable in order to secure the most natural pose of the features and the most satisfactory scanning. Obviously, the best way of meeting this limitation is by the use of telephone instruments of the type adapted for picking up and reproducing sounds at a distance. The use of such instruments has the further advantage that they can be located near the vision screen and so reproduce any peculiarities in tone quality that would result if the speaker were actually located at the position of the image. Of, course, the sharpness of this perspective effect obtained is influenced by the loudness of both the original and the reproduced sounds but the matter of location of instruments is also very important.

It would thus seem that the use of distant pick-up and distant projecting instruments offers certain rather fundamental advantages but it is also true that it presents certain other disadvantages. One of the disadvantages is that the distant pick-up microphone gives less output than a close-up device because of the reduced sound pressure on the diaphragm; also a sound producing device to give suitable reception

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[1] "Public Address Systems" by J. P. Maxfield and I. W. Green in A. I. E. E., Feb. 14, 1923. Also "High Quality Recording and Reproducing of Music and Speech" by J. P. Maxfield and H. C. Harrison in A. I. E. E., Feb. 1926.

at a distance must be supplied with a higher transmission level than would a close-up instrument. It thus becomes necessary to provide for greater gain in transmission and greater electrical power capacity than would be required were the instruments held close to the head. The use of the more elaborate transmission facilities is in itself disadvantageous but it also tends to increase the feed-back from the loud speaker to the microphone; also the effect of any noise at the microphone position or at the listening position tends to interfere more seriously with the successful conduct of conversation. In the design of the two-way television system recently installed between the Bell Telephone Laboratories at 463 West Street and the American Telephone & Telegraph Co. at 195 Broadway in New York City, it was felt that it would be possible to overcome these technical objections to the distant type instruments and that the advantages mentioned would justify any measures necessary to do so.

The question of instruments was solved by the use of the Western Electric 394 condenser type transmitter [2] and a dynamic direct radiator loud speaker. The transmitter is one of the type generally used for phonograph and sound picture recording and for other purposes where good quality, high stability and quietness of operation are essential. The direct radiator type of loud speaker was used instead of the usual horn type because of the limited mounting space available. It consists of a dynamic structure with a rigid duralumin diaphragm about 3″ in diameter flexibly supported at the edge and radiating directly into free air. While such a structure is not highly efficient and permits of only a small sound power output these considerations are of secondary importance in this case. The instruments were located in the front wall of the booth about 2′ from the position of the user and adjacent to the viewing screen in order to enhance the perspective as described above, the microphone being above and the loud speaker below as shown in Fig. 1. These instruments were (in this particular case) connected into a four-wire circuit although in certain cases it might be desirable to use a 2-wire circuit. Such a change would of course be entirely feasible. The remainder of the apparatus used consisted of amplifiers located at the transmitting end of each channel and an attenuator at the receiving end, the two ends being connected by means of a loop of approximately 3 miles of non-loaded non-equalized cable. The amplifiers and the attenuators were each readily adjustable so that the sounds of different speakers could be reproduced at the optimum loudness. Observation of the performance of the system was made possible in each of the control rooms by means of a monitoring head

[2] E. C. Wente in *Physical Review* of May 1922.

type receiver bridged across the mid-point of an attenuator tying the two channels together. The attenuation used in the monitoring circuit was such as to give no audible feed-back in either booth. The results obtained with this set-up were considered satisfactory from the standpoint of both volume and quality. Ready recognition of familiar

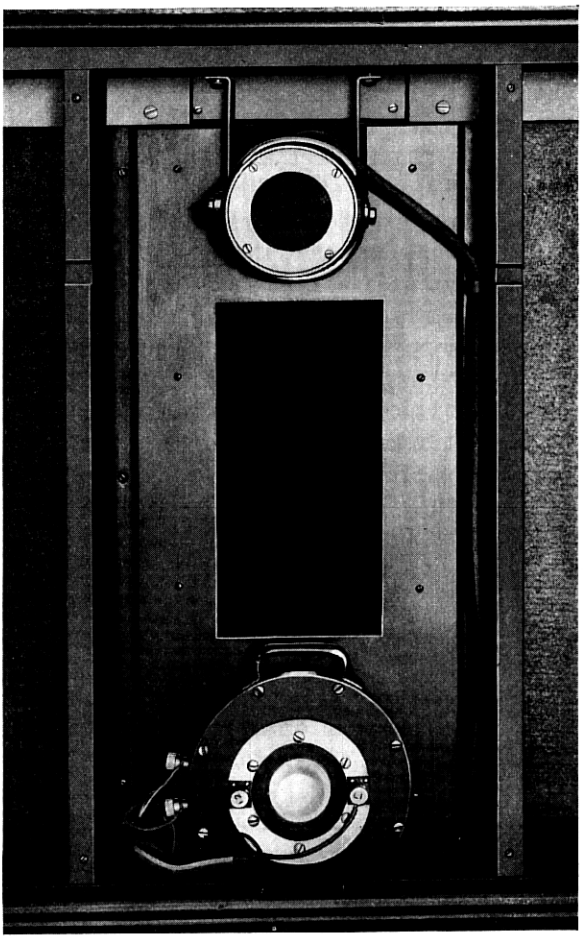

Fig. 1—Microphone and loud speaker in position above and below television scanning and viewing aperture.

voices and the association of the source of the reproduced sounds with the image were the usual occurrence. Figure 2 shows in block form the complete circuit set-up and Figure 3 shows the combined response frequency characteristic of the microphone, amplifier and loud speaker.

The ordinates of this curve represent variations in sound pressure from the loud speaker for constant pressure on the transmitter diaphragm. These data were obtained with the loud speaker located in a heavily damped room. The measurements were made on the sound axis at a distance of 2′, representing the relative position of the observer under conditions of actual use.

In setting up such a system the chief consideration is in regard to the acoustic feed-back from the loud speaker to the microphone and in this connection the design of the booth is an important factor. The booth must necessarily be so shaped that the user, looking at the viewing screen, can be satisfactorily scanned and the light reflected from

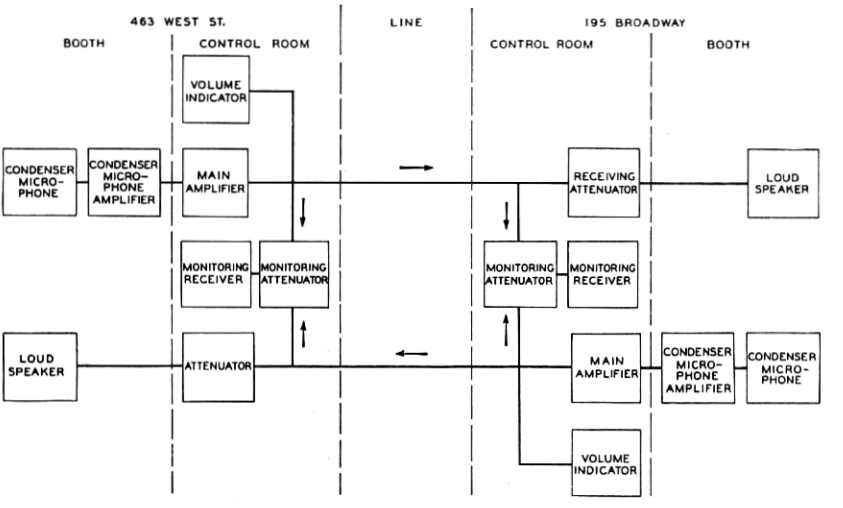

Fig. 2—Circuit diagram for sound transmission system for two-way television.

the scanned areas will strike the banks of photoelectric cells required for the reproduction of the visual likeness. This requires that the person scanned be located in close proximity to the scanning disc and to the photoelectric cells as well as to the microphone and loud speaker. Such an arrangement is objectionable from an acoustic standpoint in that in the present state of development the cells are necessarily large and poor absorbers of sound. They thus tend to cause part of the sound output from the loud speaker to reflect back into the microphone. If the sound so reflected or fed back is equal or greater in magnitude than the original sound picked up and is of the proper phase relation, the system will "sing" and the sound system become of no practical use. A further effect of the design of the booth is that as a closed cavity, it tends to cause sounds of a certain pitch range to be accen-

tuated. To reduce these effects as far as possible, the television booths were made as large as other considerations would permit and all surfaces were covered where possible with acoustic absorbing material. They have a floor area of about 35 sq. ft. and are about 8 ft. high. Because of the increased transmission required for the proper interpretation of sounds in the presence of noise, the booths were made of heavy masonry material to insulate the user and the microphone from the noise incidental to the rotating parts of the television apparatus. It was thus necessary to project the scanning beam and to view the illuminated image through a window located in the front wall. The microphone and the loud speaker were fitted into this wall, which was then covered over with a thin screen to improve the appearance as

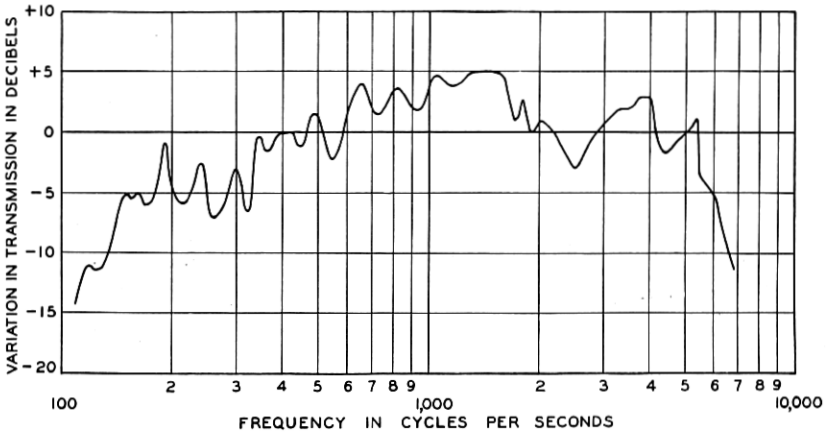

Fig. 3—Response frequency characteristic of microphone, amplifier and loud speaker.

shown in Fig. 3 of companion paper, "Image Transmission System for Two-Way Television." These means effectively reduced the noise in the booth to an unnoticeable amount and reduced reflection effects to the extent that the average speaker talking in a conversational manner could be reproduced at a loudness best suited to the general effect. The optimum loudness seemed to be about the same as would be obtained from the speaker direct at a distance of about 10 feet, the apparent distance between the image and the observer. At this loudness the gain of the amplifiers was 12 db less than that required to cause singing.

While the system demonstrated was operated over a distance of only a few miles, it will be appreciated that the same terminal facilities might have been used over much greater distances. Thus for the first time in the history of electrical communication it can be said that complete freedom of exchange of both visual and aural expression between distant users of the telephone has been made possible.