

May 5, 1931.

N. R. STRYKER

1,804,127

SPEECH TRANSMISSION SYSTEM

Filed May 4, 1928

Fig. 1

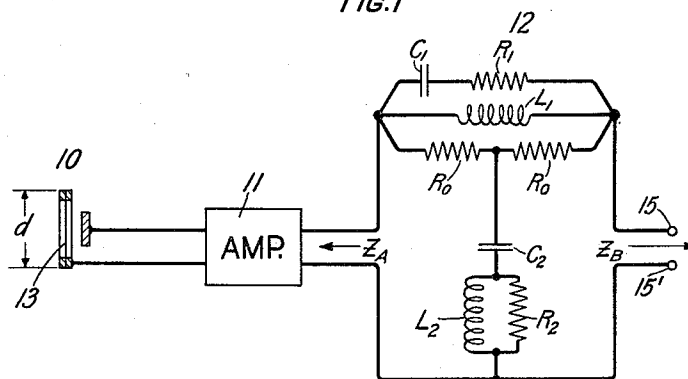
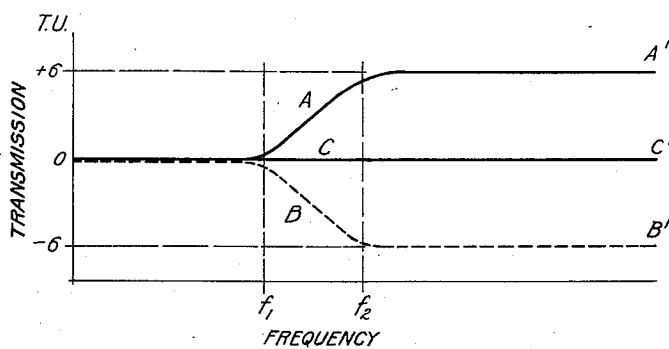


Fig. 2



INVENTOR
NORMAN R. STRYKER
BY
G. H. Stevenson
ATTORNEY

UNITED STATES PATENT OFFICE

NORMAN R. STRYKER, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

SPEECH TRANSMISSION SYSTEM

Application filed May 4, 1928. Serial No. 275,069.

This invention relates to speech wave translation systems and more particularly to acoustic pick-up systems of the type employing a diaphragm for the translation of sound wave energy into electrical energy.

An object of this invention is to improve the frequency response characteristic of acoustical-electrical translation systems. A further object is to compensate for the irregularities of electrical response due to the non-uniform reflection of acoustical waves striking the surface of an acoustical-electrical pick-up device.

It has been ascertained that the electrical response to an acoustic wave striking the diaphragm of a transmitter is not uniform with frequency, owing to the fact that waves of high frequency exert on the diaphragm approximately twice the incident sound pressure of the wave, while waves of low frequency exert simply the actual incident sound pressure. Incident pressure as used here defines the pressure propagating a wave in the direction of its motion. The incident pressure of a wave at a diaphragm is the pressure that would be existent at that point if the diaphragm were not present. The reason for the double pressure caused by a high frequency, or short wave is that practically complete reflection occurs at the diaphragm for waves shorter than approximately twice the diameter of the frame holding the diaphragm, but when a wave is longer in length than twice this diameter, it tends to pass on around the edges so that only partial reflection occurs. The pressures due to waves of different frequencies could be made substantially uniform by using a transmitter of such small transverse area that even the highest frequencies transmitted would be substantially unreflected, or by using a transmitter so large that even the lowest frequencies transmitted would be fully reflected. An alternative of using a transmitter of large transverse area would be placing an ordinary sized

transmitted in a baffle board large enough to reflect all waves. A corollary of this principle applies to receivers or loud speakers of the hornless type. The diaphragm of such a receiver, if of moderate size, will not support a long wave as well as it will a short wave, and it will impart to the long wave only half the acoustic pressure that the short wave will receive. Hence corrective devices of the same type may be used with such receivers as with transmitters.

Means such as these for securing uniform wave pressures at all frequencies transmitted, however, have disadvantages which preclude their use under ordinary circumstances. A transmitter, so small that it would not reflect even the shortest speech waves transmitted, would have to have a diameter of about $\frac{1}{2}$ ". Such a transmitter, in addition to other shortcomings would translate so little of the power of the sound wave into electrical energy that it would ordinarily be undesirable. Again, a transmitter, or combination of transmitter and baffle board, so large that complete reflection of all ordinary speech waves would occur, would have to have a diameter of about 5 or 6 feet. Obviously, such a transmitter would be too unwieldy for ordinary use.

In accordance with this invention, the compensation of the response irregularity due to the size of the transmitter is effected by inserting at some point in the system a device, the transmission characteristic of which is reciprocally related to the pressure-frequency characteristic of the transmitter.

It follows from the theory of reciprocity that this invention is not confined to transmitters but is applicable to the equalization of receiver characteristics as well.

The invention will be more clearly understood from the following detailed description and by reference to the accompanying drawing of which

Fig. 1 is a schematic representation of a system embodying the invention; and

Fig. 2 shows transmission-frequency characteristics of a system like that of Fig. 1.

Fig. 1 depicts an acoustic pick-up device, 10, of the type commonly known as a condenser transmitter, associated with an electrical system containing an amplifier 11, and a corrective network 12, the purpose of the latter being to compensate the frequency variation of the wave pressure on the diaphragm 13, of the transmitter. Other electrical apparatus, for example a line and a receiver, or a radio transmitter, which might be used with this system is not shown, but would connect to the output terminals 15, 15' of the network 12. The input impedance of such other apparatus is designated Z_B .

The transmitter, 10, is preferably a high quality type, of which the condenser transmitter is an example, since such transmitters are substantially free from resonances within the ordinary speech range of frequencies. The invention may, however, be used also in connection with other types of transmitters, although in certain cases it may be necessary to provide additional compensating means to eliminate distortion due to other causes such as mechanical resonance.

In Fig. 2 the ordinates represent level of transmission, and the abscissæ, frequency. Curve OAA' represents the pressure-frequency characteristic of a diaphragm, and corresponds to the response that the diaphragm of an ordinary condenser-transmitter gives at various frequencies to sound waves of constant incident pressure. For the purpose of illustration, line OCC' is arbitrarily chosen as zero level and is the line which would correspond to the diaphragm response if the response were the same at all frequencies as it is at very low frequencies. It is seen that up to a certain frequency, f_1 , the diaphragm response is substantially uniform. Between the frequency f_1 and another frequency f_2 , there occurs a period of transition in which the diaphragm response rises to a level which is 6 transmission units (designated TU) above the zero level. At frequencies above f_2 , the response is constant at plus 6 TU level. It is sufficient to state here that the transmission unit is a logarithmic measure of the level of the wave energy and is dependent on the pressure exerted on the diaphragm. Doubling the pressure results in a transmission gain of about 6 TU. A treatment of the transmission unit will be found in Chapter II of "Transmission Circuits for Telephone Communication" by K. S. Johnson, published by D. Van Nostrand Company, Inc., New York.

The type of characteristic shown, has been obtained by experiment on a number of different sized condenser-transmitters. It has been ascertained that the location of frequencies f_1 and f_2 is dependent upon the dimen-

sions of the transmitter. They are determined by the equations

$$f_1 = \frac{v}{4d} \quad (1)$$

and

$$f_2 = \frac{v}{2d} \quad (2)$$

where v =velocity of sound in air measured in inches per second, and d =outside diameter of the transmitter measured in inches. The point f_1 is the frequency up to which the reflection is negligible, while f_2 is the frequency above which practically complete reflection occurs. Experiment has indicated that the transmission characteristic between f_1 and f_2 is almost a straight line.

Curve OBB' of Fig. 2 is inverse to OAA' with reference to the zero transmission level. Obviously any device having a transmission characteristic OBB', inserted anywhere in the system, would effectively compensate the pressure-frequency irregularity of the transmitter and cause the resultant transmission characteristic of the combination of transmitter and corrective device, to conform closely to curve OCC'. The network 12, of Fig. 1 is of a type suitable for the purpose. Its position in the system is immaterial from the standpoint of proper equalization. As an example of the method to be followed in designing such a corrective network, suppose the diameter d , of the condenser-transmitter is 3.3", and the output impedance Z_A , of the amplifier 11, is 4000 ohms. From Equation 1, f_1 will be 1000 c. p. s. and f_2 will be 2000 c. p. s. Regardless of where f_1 and f_2 are located, the difference in transmission level between them will always be about 6 TU. Therefore the desired transmission characteristic for a corrective network is established. The particular type of network shown in Fig. 1 is described in U. S. Patent 1,606,817, issued November 6, 1926, from which the method of assigning values to the impedance elements may be ascertained. For the present example, the following values of impedance elements will impart to the network a characteristic of the required form:

$$\begin{aligned} R_0 &= 4000 \text{ ohms} \\ R_1 &= 4000 \text{ ohms} \\ C_1 &= .0092 \text{ m. f.} \\ L_1 &= .113 \text{ henry} \\ R_2 &= 4000 \text{ ohms} \\ C_2 &= .0071 \text{ m. f.} \\ L_2 &= .147 \text{ henry} \end{aligned}$$

The corrective network is not limited to the type disclosed, other satisfactory types being described in U. S. Patent 1,603,305, of October 19, 1926. In certain cases it may be satisfactory to compensate by means of a single impedance either in series with the line or in shunt thereto, impedances of the general type

forming the series and shunt branches of network 12, being suitable for this purpose.

What is claimed is:

1. In a speech-wave translation system, in combination, an acoustical wave energy translating device, and means for compensating the irregularities of the speech transmission due to non-uniform reflection of acoustical waves by said translating device, said compensating means comprising a combination of wave conducting elements proportioned in accordance with a pre-assigned attenuation characteristic determined by the surface area opposed by said translating device to sound waves incident thereon.

2. In a speech-wave translation system, in combination, an acoustical-electrical translating device and compensating means so proportioned with respect to the dimensions of the surface opposed by said translating device to sound waves incident thereon that said compensating means has a wave transmission characteristic substantially inverse to the frequency-pressure characteristic of said device due to the non-uniform reflection of sound waves at its surface.

3. In a telephone system, a telephone transmitter, a line, and an impedance network included in said line, said network having a pre-assigned attenuation characteristic determined by the diameter of said transmitter, whereby said network is adapted to compensate the frequency variation of wave pressure on said transmitter due to non-uniform reflection of sound waves incident thereon.

4. In a telephone transmission system, a telephone transmitter, a line, and means comprising an electrical network included in said line, said means being proportioned with respect to the surface area opposed by said transmitter to sound waves incident thereon whereby said means compensates irregularities in the frequency-response characteristic of said transmitter due to non-uniform reflection of the sound waves incident thereon.

5. The combination of an acoustical-electrical translating device and a compensating network, said network being characterized by substantially constant transmission from about zero frequency to a frequency f_1 , by substantially uniformly increasing attenuation between f_1 and a second frequency f_2 , and by substantially constant transmission above f_2 to the highest frequencies of importance in the transmission of speech and music, the transmission level above f_2 being about six transmission units less than the transmission level below f_1 , f_1 being equal to

$\frac{v}{4d}$ and f_2 to $\frac{v}{2d}$, where v is the velocity of sound in air and d the outside diameter of said translating device.

6. In combination, an acoustical-electrical

translating device and a low-pass wave filter, said filter having a cut-off at a frequency f_1 and having a substantially constant attenuation of about six transmission units above a second frequency f_2 , the attenuation increasing substantially uniformly from f_1 to f_2 , f_1

being equal to $\frac{v}{4d}$ and f_2 to $\frac{v}{2d}$ where v is the velocity of sound in air and d the outside diameter of the translating device.

In witness whereof, I hereunto subscribe my name this 3rd day of May, 1928.

NORMAN R. STRYKER.