

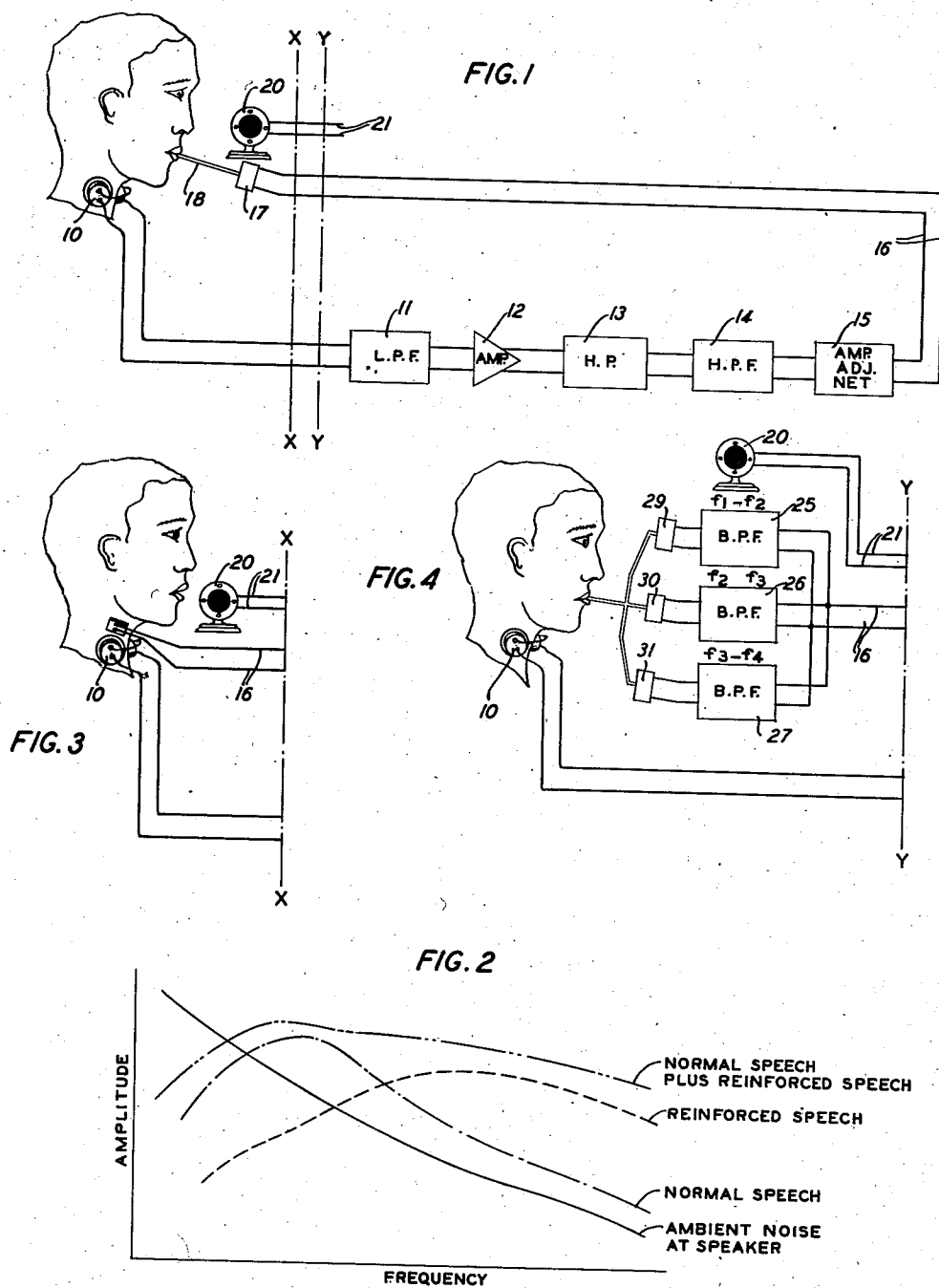
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APPARATUS FOR INTENSIFYING SPEECH IN THE HUMAN VOCAL CAVITIES

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APPARATUS FOR INTENSIFYING SPEECH IN
THE HUMAN VOCAL CAVITIESNorman R. French, Pleasantville, N. Y., assignor
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This invention relates to a method of and apparatus for enabling a speaker to deliver by his own voice speech vibrations having amplitudes which are larger than the amplitudes of the speech vibrations that he could produce by his vocal efforts alone.

When a speaker is immersed in ambient noise of a high level, he usually finds it difficult to raise the level of his voice above that of the noise near his lips, without tending to strain his voice. This means that such unfavorable speech-to-noise ratio exists near the speaker's lips that a listener even close to the speaker would have difficulty in comprehending the speech. The same difficulty would exist when the listener moved away from the speaker; and when the speech was reproduced at a distance from the speaker by means of a public address system or the like embodying a microphone positioned near the speaker's lips. This follows because such system would tend to attenuate or amplify speech and noise substantially to the same extent leaving substantially unchanged the speech-to-noise ratio of the transmitted speech and noise.

The present invention is concerned with increasing the level of the speech vibrations delivered by the human voice, and thereby the speech-to-noise ratio in proximity of the speaker's lips.

The present invention contemplates an arrangement for mechanically producing sound vibrations of certain frequencies and amplitudes and introducing them into the vocal cavities of a speaker, together with the sound vibrations produced naturally by the speaker and thereby substantially increasing the amplitudes of the speech vibrations delivered by the voice of the speaker.

The main object of the invention is to increase the amplitudes of the frequencies in a speech spectrum delivered by the voice of a speaker.

Another object is to increase the value of the speech-to-noise ratio of speech transmitted directly through an air transmission medium which immerses both the speaker and listener in ambient noise.

A further object is to increase the value of the speech-to-noise ratio of speech transmitted over a public address system arranged such that both the speaker and microphone pick-up are immersed in ambient noise.

As a talker in noisy surroundings raises his voice to make himself heard, he experiences difficulty because the higher voice frequencies which contribute greatly to intelligibility and which are relatively weak may still be too close to the noise level even when the talker is shouting. Experi-

ments show that if these normally weak higher frequency sounds can be greatly augmented so as to override the noise more effectively, the speech becomes understandable even though the normally stronger lower frequencies remain at roughly the same amplitude.

The present invention aims to take advantage of this fact by providing for selectively building up the higher frequency energy of speech waves to enable the speech to be understood through noise. In a particular case where the noise has a given type of frequency energy characteristic the invention provides for predistorting the emitted voice waves to better enable them to override the voice by giving them an improved frequency-by-frequency speech-to-noise ratio over the band.

In a specific embodiment, the invention comprises in sequence one or more electroacoustic transducers applied to the skin in the region of the throat of a speaker, a low-pass filter, an amplifier, a harmonic producer, a high-pass filter, a network for controlling the amplitudes of individual frequencies, and an electroacoustic converter whose output is introduced into the vocal cavities of the speaker.

In operation, the sound vibrations at the surface of the skin in the region of the throat of the speaker are picked up by the transducer and supplied to the low-pass filter which passes the current of fundamental frequency but suppresses harmonics thereof. This fundamental current is amplified and then utilized to produce a range of harmonic currents whose frequencies correspond at least in part to the sound vibrations produced in the speaker's throat. A high-pass filter suppresses the fundamental current and transmits the range of harmonic currents. Thereafter, the latter currents are individually provided with predetermined amplitudes. These harmonic currents are then translated into other sound vibrations whose frequencies and amplitudes correspond substantially to those of the harmonic currents. These sound vibrations are introduced into the vocal cavities of the speaker to be molded by the cavities of his throat, mouth and nasal passages into speech, together with the sound vibrations produced naturally in the speaker's throat. Thus, the amplitudes of the speech vibrations delivered by the speaker's voice are substantially increased with reference to the level of the ambient noise, without requiring a noticeable increase in the vocal efforts of the speaker.

A feature of the invention is that the mechani-

cally produced sound vibrations may be introduced into the vocal cavities of the speaker either through the mouth of the speaker, or through the skin in the region of the throat of the speaker. Another feature concerns compensation for the vocal output of the speaker as he tends to relax his vocal efforts.

The invention will be readily understood from the following description taken together with the accompanying drawing in which:

Fig. 1 is a schematic circuit illustrating the specific embodiment of the invention;

Fig. 2 is a family of curves illustrating action obtainable in Figs. 1, 3 and 4.

Fig. 3 is a partial schematic circuit showing a modification of the invention; and

Fig. 4 is a partial schematic circuit showing a further modification of the invention.

Referring to Fig. 1, a microphone 10 of suitable structure is applied to the skin of a human in the region of his throat to pick up sound vibrations of fundamental frequency and harmonics thereof, as the speaker produces them, and to translate such vibrations into electric currents of fundamental and harmonic frequencies corresponding to those of the sound vibrations. The microphone as shown comprises a pair of electroacoustic converters connected in series. In accordance with the familiar practice, these converters may also be connected in parallel and may comprise one or more converters as desired.

These harmonic currents are supplied to a low-pass filter 11 which passes the fundamental current but suppresses the harmonic currents. The fundamental current is amplified in amplifier 12 embodying suitable automatic gain control, and thereafter impressed on a harmonic producer 13 whose output includes both the fundamental current and harmonics thereof extending over a certain range of audible frequencies. This range may comprise the entire audible range or a desired portion of it, and may correspond in toto or in part to the frequencies of the sound vibrations produced in the human throat as previously mentioned.

The harmonic currents are supplied to a high-pass filter 14 which passes the harmonic currents but suppresses the fundamental. The harmonic currents are then supplied to a network 15 which relatively varies the amplitudes of individual harmonics. For example, the range of harmonic currents appearing in the output of the network 15 may be preshaped with amplitudes of predetermined relative magnitudes with reference to the spectrum of a particular ambient noise.

The latter harmonic currents are then supplied over a pair of leads 16, 16 to an electroacoustic converter 17, and thereby translated into sound vibrations whose frequencies and amplitudes correspond substantially to the frequencies and amplitudes, respectively, of the harmonic currents. These sound vibrations are introduced via a hollow tube 18 into the vocal cavities of the speaker, such as the resonant chambers of the mouth, throat and nasal passages, for molding into audible sounds in the same manner as the molding of normal speech vibrations.

In the operation of Fig. 1, the sound vibrations produced in the speaker's throat are introduced into his vocal cavities for molding into audible sounds which are delivered by the speaker's voice in the familiar manner. The mechanically produced vibrations introduced into the vocal cavities in the manner pointed out above are combined with the naturally produced vibrations so

that the speaker delivers by his own voice speech vibrations whose amplitudes are substantially increased with reference to his naturally produced speech vibrations. In this connection, it is understood that the network 15 may be provided with such amplitude versus frequency characteristic that the combined speech vibrations delivered by the speaker's voice are provided with a favorable value of speech-to-noise ratio, with reference to the ambient noise spectrum in which the speaker may be immersed. Compensation for the tendency of the speaker to relax his vocal efforts is provided by the automatic gain control of amplifier 12 operating in the familiar manner. The combination of low-pass filter, harmonic producer and high-pass filter eliminates the tendency of the loop to sing.

Fig. 2 shows the value of the speech-to-noise ratio of normal speech produced in an assumed ambient noise spectrum; the value of the speech-to-noise ratio of the reinforced speech in the same noise spectrum; and the value of the speech-to-noise ratio of the combined normal and reinforced speech in the same noise spectrum. From Fig. 2, it is readily apparent that the amplitudes of the speech vibrations delivered by the speaker's voice, in accordance with the present invention, are substantially increased with reference to the amplitudes of the normal speech, and with reference to amplitudes of the noise in the assumed ambient noise spectrum in which the speaker is immersed. In the latter connection it is apparent that amplitudes of the combined mechanical and natural speech vibrations of the speaker are substantially increased without affecting either his vocal efforts or the level of the ambient noise. It will be noted that the summation curve representing normal speech plus reinforced speech indicates a less favorable addition than arithmetic addition to take account of possible out-of-phase relation that may be present.

Referring to Fig. 1, the speaker may apply the speech delivered by his voice to a microphone 20 connected by a pair of leads 21, 21 to a suitable public address system or the like, not shown, where both the speaker and microphone 20 are immersed in an ambient noise spectrum of a high level. When the listener, at the remote end of the public address system, is immersed in ambient noise which has a level equal to or less than that in proximity of the speaker, such listener would obtain substantially the full benefit of the improved speech-to-noise ratio produced at the microphone in accordance with the present invention as hereinbefore described.

When the listener, at the remote end of the public address system, is immersed in ambient noise which has a level higher than that in proximity of the microphone, such listener would also obtain benefit from the improved speech-to-noise ratio at the microphone in a manner that will now be explained. This is accomplished by increasing the gain of the public address system to such value that the transmitted noise is reproduced at the listening location at a level which is higher than that of the noise at the listening location. This means that, at the same time, the transmitted speech is also reproduced at the listening location at an increased level which maintains the speech-to-noise ratio produced at the microphone as above mentioned. Should the transmitted speech be reproduced at a level too high for physical comfort, the listener may restore the reproduced speech to a comfortable level by em-

playing ear defenders, or similar means, for attenuating both the speech and noise in the ear canal before they reach the ear drum.

Referring to Figs. 1 and 3, the sound vibrations produced in accordance with Fig. 1 may be applied directly to the skin in the region of the throat of the speaker as shown in Fig. 3, and thereby introduced into the vocal cavities of the speaker. In this connection, it is understood the circuit portion shown to the left of the line X—X in Fig. 3 may be substituted for the circuit shown to the left of the line X—X in Fig. 1; and further the operation of Figs. 1 and 3 is substantially the same as that hereinbefore explained with reference to Fig. 1.

In Fig. 4 the harmonic currents supplied over the pair of leads 16, 16 are divided into three bands by the band-pass filters 25, 26 and 27, and thereafter into three bands of corresponding sound vibrations by the electroacoustic converters 29, 30 and 31, respectively. This serves to reduce the peak factors which tend to increase the required maximum excursion of the diaphragm of the electroacoustic converter 17, Fig. 1.

In Figs. 1, 3 and 4, the microphone 20 and associated public address system may be omitted so that the speech is directly transmitted through the air as the transmission medium from the speaker to the listener, where both the speaker and listener may be immersed in an ambient noise spectrum as hereinbefore mentioned. The arrangements of Figs. 1, 3 and 4 minus the public address system operate substantially identically as described previously in connection with Figs. 1, 3 and 4 using the public address system.

What is claimed is:

1. In reinforcing the amplitudes of speech vibrations produced in the vocal organism of a human and delivered by the human voice, including sound vibrations of fundamental and harmonic frequencies in the region of the skin of the human throat after being naturally produced therein, the method which comprises translating the fundamental sound vibration picked up from the skin of the throat into a plurality of other sound vibrations extending over a certain audible frequency range corresponding at least in part to the frequency range of the vibrations produced in the throat but not including the fundamental vibration, and having amplitudes increasing with frequency over said part of said certain frequency range, and introducing said other sound vibrations into the vocal cavities of the human for molding into articulate sounds, together with the vibrations naturally produced in the human throat, whereby the amplitudes of the speech vibrations delivered by the human voice are substantially reinforced.

2. In reinforcing the amplitudes of speech vibrations produced in the vocal organism of a human and delivered by the human voice, including sound vibrations of fundamental and harmonic frequencies in the region of the skin of the human throat after being naturally produced therein, the method which comprises translating said fundamental vibration picked up from the skin of the throat into a plurality of electrical currents having frequencies related harmonically to said fundamental vibration and extending over a certain range of audible frequencies, translating said harmonic currents into a plurality of sound vibrations whose energy is lower than normal speech energy at one end of the speech range but higher than normal speech energy at the

opposite end of the speech range, and introducing the latter sound vibrations into the human vocal cavities for molding into audible sounds, together with the vibrations naturally produced in the human throat, thereby substantially increasing the amplitudes of the speech vibrations delivered by the human voice.

3. The method of increasing the amplitudes of speech vibrations produced in the vocal organs of a human and delivered by the human voice, including sound vibrations of fundamental and harmonic frequencies at the skin in the vicinity of the human throat after being naturally produced therein, which method comprises picking up the sound vibrations from the human throat and translating them into an electric current of a fundamental frequency corresponding to that of said sound vibrations, translating said fundamental current into a plurality of harmonic currents whose frequencies extend over a certain audible frequency range corresponding at least in part to the frequency range of the vibrations produced in the throat but not including current of the fundamental frequency, preshaping the amplitudes of said harmonic currents, converting the preshaped harmonic currents into sound vibrations, and introducing the latter sound vibrations into the vocal cavities of the human for molding into articulate sound, together with the speech vibrations naturally produced in the human throat, thereby substantially increasing the amplitudes of the speech vibrations delivered by the human voice.

4. In speech transmission in noisy surroundings the method comprising picking up vocal energy from the talker with a high speech-to-noise ratio compared with the ratio existing in the air in said noisy surroundings, deriving from the energy so picked up a sound wave having frequencies extending over at least all but the lower portion of the speech range but with the energy in the higher frequency half of the range greatly augmented in comparison with the level of frequencies in this portion of the band, relative to lower frequencies, in the case of normal speech, and introducing said sound wave into the talker's vocal cavities to enable the talker to mold such sound wave into articulate speech.

5. In speech transmission in the presence of noise of a predominant frequency characteristic, the method comprising picking up vocal energy directly from the talker's vocal parts at a point where the speech-to-noise ratio is higher than in the surrounding air, deriving from such picked-up energy a sound wave in which the ratio of high frequency level to low frequency level is much greater than in the case of normal speech, shaping said sound wave with respect to the noise frequency characteristic to increase the ratio of its amplitude to that of the noise, frequency for frequency, and introducing said shaped sound wave into the talker's vocal cavities to be molded by the talker's vocal parts into articulate speech.

6. In combination in apparatus for increasing the amplitudes of speech vibrations in the vocal organism of a speaker and delivered by his voice, means for picking up the fundamental vibration from the speaker and translating it into a plurality of sound vibrations having frequencies extending over all but the lower portion of the speech range and having amplitudes preshaped such that those of the higher frequencies are larger than those of the lower frequencies, and means for introducing the latter sound vibrations into the human vocal cavities for molding into

articulate sound, together with vibrations produced in the throat, whereby the amplitudes of the speech vibrations delivered by the human voice are substantially increased.

7. In combination in apparatus for increasing the amplitudes of speech vibrations produced in the vocal organism of a talker immersed in an ambient noise spectrum and delivered by his voice, means for picking up vocal energy from the talker and translating it into a plurality of harmonic currents, and means for translating said harmonic currents into sound vibrations and for introducing the latter sound vibrations into the vocal cavities of the talker for molding into articulate sounds, together with the sound vibrations naturally produced in his throat, so that the amplitudes of the speech vibrations emitted from the talker's lips are substantially increased with reference to the amplitudes of the frequencies in the ambient noise spectrum.

8. The combination according to claim 7 in which said fundamental translating means includes means for relatively varying the amplitudes of individual harmonic currents.

9. The combination according to claim 7 in which said harmonic current translating means comprises means for introducing the latter sound vibrations into the vocal cavities of the talker through his mouth.

10. The combination according to claim 7 in which said harmonic current translating means comprises means for introducing the latter sound vibrations into the vocal cavities of the talker through the skin in the region of his throat.

11. In combination in apparatus for reinforcing the amplitudes of speech vibrations produced in the vocal organism of a talker and delivered by his voice, including sound vibrations of fundamental and harmonic frequencies in the region of the skin of the talker's throat after being naturally produced therein, means for picking up the vibrations from the skin of the throat and translating them into an electric current of a fundamental frequency, means for utilizing said

fundamental current to produce harmonic currents whose frequencies correspond at least in part to those of the harmonic vibrations produced in the throat but not including a frequency corresponding to the fundamental vibration, means for relatively varying the amplitudes of individual harmonic currents, means for converting the harmonic currents of varied amplitudes into sound vibrations, and means for introducing these sound vibrations into the vocal cavities of the human for molding into articulate sound, together with the vibrations naturally produced in the throat, so as to reinforce the amplitudes of the speech vibrations delivered by the human voice.

12. A system for reinforcing the intensity of speech produced in the vocal organism of a speaker immersed in ambient noise and delivered by his voice, comprising in sequence, means applied to the surface of the skin of the speaker's throat for picking up sound vibrations of fundamental and harmonic frequencies and translating them into speech currents including a current of fundamental frequency and currents harmonically related to said fundamental frequency, means for selecting said fundamental current and suppressing said harmonics thereof, means for amplifying said fundamental current, means for utilizing said amplified fundamental current to produce further harmonic currents, means for selecting said further harmonic currents and suppressing said fundamental current, means for relatively varying the amplitudes of individual further harmonic currents, and means for translating the varied harmonic currents into sound vibrations, and for introducing the latter sound vibrations into the vocal cavities of the speaker for molding into articulate sounds, together with the vibrations naturally produced in the speaker's throat, and thereby substantially reinforcing the amplitudes of the speech vibrations delivered by the human voice, with reference to the ambient noise spectrum.

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