

Oct. 31, 1939.

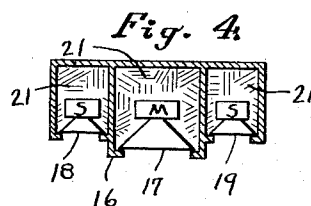
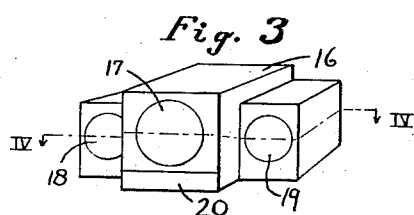
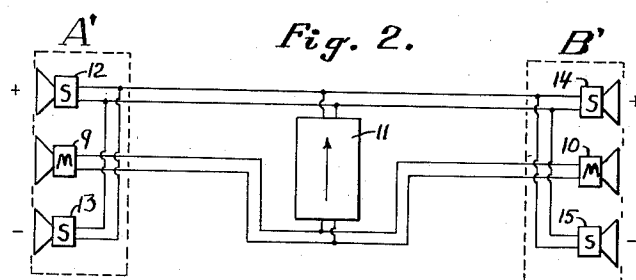
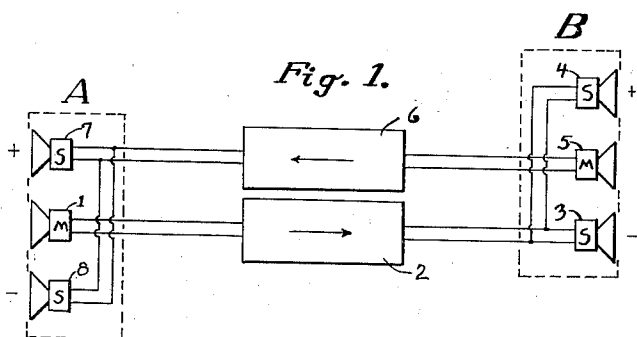
L. G. ERICKSON

2,177,769

LOUD-SPEAKING INTERCOMMUNICATING SYSTEM

Filed Dec. 24, 1938

2 Sheets-Sheet 1



INVENTOR.

L. G. Erickson

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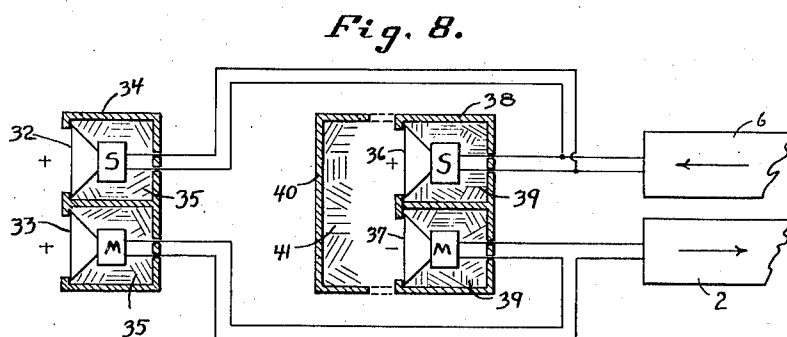
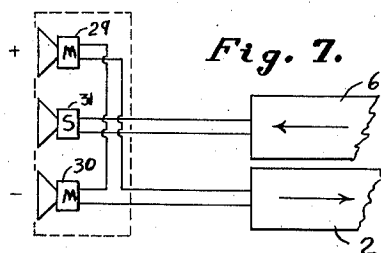
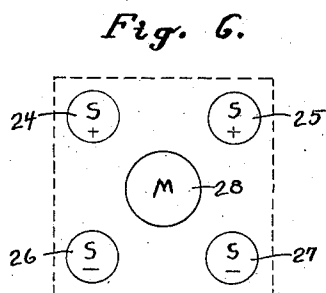
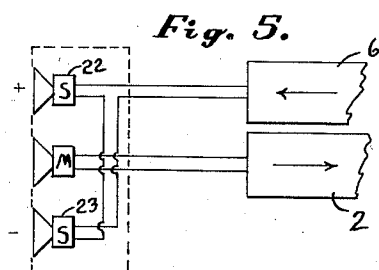
L. G. ERICKSON

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LOUD-SPEAKING INTERCOMMUNICATING SYSTEM

Filed Dec. 24, 1938

2 Sheets-Sheet 2.



INVENTOR.

Lennart G. Erickson

UNITED STATES PATENT OFFICE

2,177,769

LOUD-SPEAKING INTERCOMMUNICATING
SYSTEM

Lennart G. Erickson, San Francisco, Calif., as-
signor to Frank I. Du Frane Company, Inc., San
Francisco, Calif., a corporation of California

Application December 24, 1938, Serial No. 247,572

12 Claims. (Cl. 179—1)

This invention relates generally to intercom-
municating telephone systems. More particu-
larly, this invention relates to certain new and
useful improvements in such systems and has for
its object the provision of two-way amplified
communication service between two or more
locations by means of microphones and loud
speakers, together with associated equipment,
with the primary purpose in mind of providing
such service without the usual requirement of
holding a conventional telephone instrument in
hand while using such a system.

I am aware that numerous methods have been
employed for the purpose of obtaining commu-
nication between two or more locations by means
of microphones and loud speakers.

Telephone systems, using batteries or equiva-
lent as a source of power, have often been
equipped with "sensitive" transmitters or micro-
phones and sensitive "loud speaking" receivers
or loud speakers and it is possible for two persons
to carry on a conversation between two locations
without either person being required to hold a
conventional telephone receiver or handset in
hand; however, it is usually necessary for persons
using the system to speak within six inches of
their respective instruments to accomplish in-
telligible conversation. Such systems are usually
used in apartment houses to provide communica-
tion between the various apartments and the
vestibule and are limited as to volume of repro-
duction and sensitivity of pick-up because acous-
tic feedback or howling occurs when an attempt
is made to obtain the amplification necessary for
easy conversation.

Other telephone systems are in common use
wherein one person to a conversation must hold
a telephone receiver to his ear, thus reducing
the tendency to acoustic feedback, allowing
greater amplification, and consequently the other
party to the conversation may listen and talk
without holding a conventional telephone instru-
ment in hand.

Loudspeaker communication systems, using in
various combinations a speaker-microphone at
each desired station, a single channel audio-
amplifier and a reversing switch associated with
the amplifier, are in common use but are limited
to communication in one direction only at any
instant, depending on position of the reversing
switch, usually marked "press down to talk, re-
lease to listen", which must be continually op-
erated by at least one party during a conversa-
tion. The continuous operation of this switch
is objectionable, inconvenient, requires a certain

amount of skill, and renders a conversation un-
natural, as the person listening is unable to in-
terrupt the person operating the reversing switch.

My invention has been designed to overcome
the foregoing described difficulties and has for
an object; to provide a practical, efficient and
modern method of inter-communication between
two or more locations.

A further object is to allow conversations be-
tween two or more persons in remote locations in
a manner which closely approaches the ideal con-
dition, i. e., conversation between two persons
face to face.

A further object is to provide amplified tele-
phone service between two or more locations by
means of microphones and loud speakers in a
manner wherein persons conversing may speak
and listen at a distance from the apparatus with-
out holding or manipulating any associated ap-
paratus.

A further object is to meet a definite demand
for an inter-office loudspeaking telephone sys-
tem which will allow a person in any office to
establish communication with a person in any
other office and thereafter converse in normal
manner without either party being required to
hold, touch, or otherwise manually control any
apparatus associated with the system during the
course of a conversation.

A further object is to meet a definite demand
for an apartment house two-way loudspeaking
telephone system for communication between any
apartment and the vestibule or lobby, in which
the volume of reproduction and sensitivity of
pick-up will be greatly superior to conventional
equipment and entirely adequate for this type
of service.

The above objects are accomplished by certain
novel acoustically balanced combinations of
loudspeakers, microphones, and amplifiers,
wherein electrical currents in the output circuit
of an audio amplifier are converted into sound
energy by means of one or more loudspeakers
operated in acoustically balanced relation with
one or more microphones connected to the input
circuit of an audio amplifier in such a manner
that the loss or attenuation between amplifier
output and input circuits is substantially greater
than would be possible if said acoustically bal-
anced combinations were not employed.

Reference will now be made to the drawings
for a more detailed description of this invention,
in which the principles thereof are more fully
explained.

Fig. 1 is a diagrammatic view of a two station

communication system embodying the invention.

Fig. 2 is a diagrammatic view of a two station communication system embodying the invention, modified to require only one audio amplifier.

Fig. 3 is a perspective view of a suitable loudspeaking telephone station, including a suitable cabinet.

Fig. 4 is a sectional view taken on line IV—IV of Fig. 2.

Fig. 5 illustrates diagrammatically another form of the invention, including series connection of loudspeakers.

Fig. 6 illustrates diagrammatically another form of the invention, in which a group of loudspeakers is symmetrically located with respect to a microphone.

Fig. 7 illustrates diagrammatically another form of the invention, in which two microphones are symmetrically located with respect to a loudspeaker.

Fig. 8 illustrates diagrammatically another form of the invention, in which two loudspeakers and two microphones are arranged in acoustically balanced relation.

In Fig. 1:—1 is a microphone, connected to the input of audio amplifier 2, the output of which is connected to loudspeakers 3 and 4. Similarly, 5 is a microphone, connected to the input of audio amplifier 6, the output of which is connected to loudspeakers 7 and 8.

In this figure, and throughout the drawings, block figures have been used to indicate audio amplifiers and arrows have been drawn thereon to indicate the direction of amplification, that is, arrows point toward amplifier output circuits and away from amplifier input circuits. It is believed that in this manner the invention may be more easily explained. Furthermore, audio amplifiers are in common use and no claim as to invention is made regarding these well known circuits, except as to their particular functions with respect to this invention as a whole.

To facilitate identification, microphones wherever indicated in the drawings are marked with the letter M and loudspeakers with the letter S.

Loudspeakers and microphones may be of the permanent magnet dynamic type, or any other types with suitable characteristics. Suitable permanent magnet dynamic speakers are available in the open market and similar units may be used as microphones. In practice, microphones having six or eight inch diameter cones, together with loudspeakers having three to five inch diameter cones have proven satisfactory, although proper operation is not limited to such combinations only.

In Fig. 1, loudspeakers 7 and 8 and microphone 1 are enclosed by dotted lines and represent one station of a two station communication system, which will hereinafter be referred to as Station A. Loudspeakers 3 and 4 and microphone 5 are also enclosed by dotted lines and represent the other station, remotely located, which will hereinafter be referred to as Station B.

In Fig. 1, loudspeakers 7 and 8 are symmetrically located with respect to microphone 1 and are connected in parallel and out of phase with respect to each other, that is, if at any instant the cone of loudspeaker 7 is moving in one direction, the cone of loudspeaker 8 is moving in the reverse direction. Under these instantaneous conditions, if the cone of loudspeaker 7 is moving outward, causing a wave of increased air pressure to be created, then the cone of loudspeaker 8 is moving inward, causing a wave of decreased air

pressure to be created. These waves of increased air pressure and decreased air pressure constitute sound waves and expand in more or less uniform patterns through the air surrounding loudspeakers 7 and 8.

Since loudspeakers 7 and 8 generate identical sound waves, approximately 180 degrees out of phase with respect to each other, it is apparent that at a point of plane midway between them these equal and opposite waves must meet and cancel each other. If microphone 1 is symmetrically placed midway between loudspeakers 7 and 8, it is apparent that if, at any instant a sound wave of increased air pressure is impressed on its cone from loudspeaker 7, there will be an equal and opposite sound wave of decreased air pressure impressed on its cone from loudspeaker 8.

If a perfect balance could be obtained, sound waves originating from loudspeakers 7 and 8 would cause no net movement of the cone of microphone 1. In practice, a perfect balance cannot be obtained and throughout this specification and the claims, wherever the words "acoustically balanced", "cancellation of opposing forces", or other similar phrases are used, this practical limitation is a limiting factor. However, a considerable amount of acoustical cancellation can easily be accomplished, resulting in greatly improved performance of communication systems embodying this principle of preventing acoustic feedback or howling.

Loudspeakers 3 and 4 of Station B, Fig. 1, are also connected out of phase with respect to each other and acoustically balanced with respect to microphone 5. In this figure and in other figures of the drawings, wherever two or more loudspeakers or microphones are connected out of phase with respect to each other, they are marked arbitrarily plus and minus as an indication that their respective cones operate approximately 180 degrees out of phase with respect to each other, or, in the case of microphones, that the electromotive forces generated, because of simultaneous motion of their respective cones, are approximately 180 degrees out of phase with respect to each other.

It is desirable to adjust the overall frequency response of amplifiers 2 and 6 so that frequencies below approximately 400 cycles per second and above approximately 4000 cycles per second are attenuated. Such restriction in overall frequency response does not seriously impair speech intelligibility and makes it possible to secure a more accurate acoustical balance. These modifications in amplifier characteristics are well known to those skilled in the art and a more detailed description is not thought necessary.

Thus a novel loudspeaking communication system has been described wherein a person's voice at Station A is picked up by microphone 1 and reproduced by loudspeakers 3 and 4 at Station B. Voice at Station B is picked up by microphone 5 and reproduced by loudspeakers 7 and 8 at Station A.

Due to acoustical balancing of loudspeakers and microphones, considerable amplification may be utilized without causing feedback or howling, and in practice it is possible for two persons to converse in a normal manner, even though each person may be ten feet or more distant from their respective stations.

If loudspeakers 4 and 8 were not included in the system illustrated in Fig. 1, howling due to feedback of sound energy between loudspeakers and microphones, would limit the overall ampli-

fication to such an extent that the system would have little practical use.

Fig. 2 is a modification of Fig. 1, requiring only one audio amplifier. Microphones 9 and 10 are connected to the input of audio amplifier 11, the output of which is connected to loudspeakers 12, 13, 14 and 15. Microphone 9 is mounted in acoustically balanced relation to loudspeakers 12 and 13, which are connected out of phase with respect to each other. Microphone 9 and loudspeakers 12 and 13 are enclosed by dotted lines and will be referred to as Station A'. Similarly, microphone 10 is mounted in acoustically balanced relation to loudspeakers 14 and 15, which are connected out of phase with respect to each other. Microphone 10 and loudspeakers 14 and 15 are enclosed by dotted lines and will be referred to as Station B'.

In operation, a person's voice at Station A' is picked up by microphone 9, amplified by amplifier 11 and reproduced by loudspeakers 14 and 15 at Station B'. The voice is also reproduced by loudspeakers 12 and 13 at Station A', but as reproduction coincides closely with the spoken voice, the effect is not objectionable. A person's voice at Station B' is picked up by microphone 10, amplified by amplifier 11 and reproduced by loudspeakers 12 and 13 at Station A' and also by loudspeakers 14 and 15 at Station B'.

Thus a person at Station A' may converse with a person at Station B' in a manner which closely approaches face to face conversation. Although the overall sensitivity of pick-up and volume of reproduction is not as great as may be obtained with the arrangement of Fig. 1, the Fig. 2 modification is entirely adequate for most loudspeaking communication system requirements. An advantage of this arrangement is that all stations connect to the same amplifier input and output circuits and therefore switching circuits and associated apparatus for intercommunicating systems of more than two stations are greatly simplified.

To make up a practical system as illustrated in Fig. 1 or Fig. 2, it is advisable to mount associated loudspeakers and microphones in suitable cabinets and provide each station with a control switch to turn the system on whenever it is needed.

Three or more such stations may be provided with the necessary switching devices, to make up a complete intercommunicating system. For instance, ten stations may be included in one system, and control switches provided so that any station may communicate with any other station. Such circuits are well known to those skilled in the art and it is not thought necessary to describe them in detail.

Fig. 3 illustrates a suitable desk type cabinet 16, which contains a microphone 17 and two loudspeakers 18 and 19. Panel 20 is provided for mounting the necessary controls.

Fig. 4 is a sectional view along lines IV-IV of Fig. 3. Cabinet 16 encloses the rear of loudspeakers 18 and 19 and microphone 17 completely. The remaining space in each enclosure is partly filled with sound absorbant material 21. In this manner, backside radiation of sound from loudspeakers 18 and 19 is largely absorbed, backside pick-up of sound by microphone 17 is reduced and a better acoustic balance may be obtained.

The cabinet design of Fig. 3 is illustrative only, and other variations may be used equally as well. Loudspeakers 18 and 19 may be mount-

ed at various angles with respect to each other and to microphone 17. It is only necessary that a symmetrical placement be maintained.

Although Figures 1, 2, 3 and 4 illustrate a preferred combination, wherein each station includes two loudspeakers in balanced acoustical arrangement with one microphone, there are other ways in which the principle of the invention may be applied. To simplify further explanation, Figures 5, 6, 7 and 8 of the drawings will represent changes in arrangement of Station A of Fig. 1. Station B may be assumed to retain the arrangement shown in Figs. 1, 3 and 4. Any of the following acoustically balanced combinations of loudspeakers and microphones may be substituted for Station A' or Station B' of Fig. 2.

In Fig. 1, parallel connections are shown where loudspeakers are connected out of phase with respect to each other. Series connections may be utilized equally as well. In Fig. 5, loudspeakers 22 and 23 are connected in series with the output of amplifier 6. It should be understood that, throughout the specification and drawings, wherever two or more loudspeakers or microphones are connected together, either series or parallel connections, or a combination of both, may be utilized regardless of which method is used for purpose of explanation.

Fig. 6 is a front view of four loudspeakers, 24, 25, 26 and 27, and one microphone 28. Loudspeakers 24 and 25 are connected in phase with respect to each other and out of phase with respect to loudspeakers 26 and 27. As microphone 28 is symmetrically located with respect to loudspeakers 24, 25, 26 and 27, acoustical cancellation is obtained because of equal and opposing forces on the diaphragm of microphone 28, as explained above in detail with reference to Fig. 1.

Fig. 7 is a variation of the above combinations, in that two microphones 29 and 30 are mounted in acoustically balanced relation with loudspeaker 31. Microphones 29 and 30 are connected together and out of phase with respect to each other, and may be considered as one unit with two independent diaphragms. If equal forces are applied to these diaphragms at the same instant, causing each diaphragm to move in the same direction, then each microphone will generate an electro-motive force, which forces are equal, but oppose each other due to out of phase connection, and will cancel each other, and cause amplifier 2 to be unaffected thereby.

In operation, sounds from loudspeaker 31 actuate microphones 29 and 30 equally and in phase, but amplifier 2 is largely unaffected because of acoustical balancing of microphones 29 and 30 with respect to loudspeaker 31.

Sounds not originating from loudspeaker 31 will be amplified by amplifier 2, depending on the phase relationship and relative intensity of sounds actuating microphones 29 and 30. The resulting partial cancellation of sounds not originating from loudspeaker 31 may prove objectionable in some cases.

Fig. 8 illustrates a modification in which only one microphone and one loudspeaker is used for each station and acoustical balancing is provided through the use of another microphone and loudspeaker, which may be remotely located and entirely enclosed. Loudspeaker 32 and microphone 33 are mounted in a desk station cabinet 34 (sectional view) and padding 35 is provided to absorb back-side radiation of sound from loudspeaker 32. Similarly, loudspeaker 36 and micro-

phone 37 are mounted in a cabinet 38 (sectional view), including padding 39. Cabinet 38 may be provided with a cover 40, thus totally enclosing loudspeaker 36 and microphone 37. Padding 41 is provided to absorb and prevent direct reflection of sound from loudspeaker 36.

Microphones 33 and 37 are connected together and in phase with respect to each other and may be considered as one unit. Loudspeakers 32 and 36 are connected together and out of phase with respect to each other. If at any instant, microphone 33 is responding to a wave of increased air pressure from loudspeaker 32, then microphone 37 is responding to a wave of decreased air pressure from loudspeaker 36. Since the forces actuating each microphone are equal and approximately 180 degrees out of phase with respect to each other, each microphone will generate an electro-motive force approximately 180 degrees out of phase with the other. These equal and opposing forces will cancel, thus rendering amplifier 2 unaffected by sounds from loudspeakers 32 and 36.

It is evident that loudspeakers 32 and 36 may be connected together in phase with respect to each other, and microphones 33 and 37 out of phase with each other. In this case, if at any instant, microphone 33 is responding to a wave of increased air pressure from loudspeaker 32, then microphone 37 is also responding to a wave of increased air pressure from loudspeaker 36. Since the forces actuating each microphone are equal, each microphone will generate an electro-motive force equal and in phase with respect to the other. These electro-motive forces will cancel, thus rendering amplifier 2 unaffected by sounds from loudspeakers 32 and 36.

The equipment herein described may be modified and altered in many ways, for instance, switches, controls, microphones and loudspeakers may be added to make up a complete inter-communicating system of any size required. Special equipment may be added, such as handset telephones for use in noisy locations, telephone receivers for use when secrecy is desired, bells or other signals, for special duties, etc. Such modifications are believed to be within the purview of this invention.

Thus it will be seen that this invention makes possible a new and useful system of communication, wherein sensitive microphones and loudspeakers are employed for pick-up and reproduction of sounds, and is the means whereby acoustical feedback, which would otherwise prevent successful operation, is practically eliminated.

In my co-pending patent application entitled "Communication system", mailed to the Commissioner of Patents on October 10, 1938, I have described certain novel two-way loudspeaking communication systems, dependent for proper operation on an improved audio amplifier system, including amplifier gain control devices responsive to sound energy. A further advantage may be obtained through combination of my improved amplifier system, as previously disclosed, with the acoustically balanced loudspeaker-microphone combinations described herein.

It will be understood that changes and modifications in the form, construction, arrangement and combinations of the several parts of this invention may be made and substituted for those herein shown and described without departing from the nature and principle of the invention. It is not intended to limit this invention by the

specific discussion in the foregoing, but only by such limitations as are expressed in the claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. In a communication system of the character described, the combination of a microphone mounted adjacent and responsive to a loudspeaker, with a remotely located and similarly disposed microphone and loudspeaker, said microphones and loudspeakers being connected respectively to amplifier input and output circuits in electro-acoustically balanced manner, all substantially as described.

2. A communication system of the character described, comprising in combination two independent audio channels, each channel including an audio-amplifier, a microphone and two loudspeakers, wherein the microphone of each audio channel is mounted in acoustically balanced manner with respect to the loudspeakers of the other audio channel.

3. A communication system, of the character described, comprising in combination two independent audio channels, each channel including an audio amplifier, a loudspeaker and two microphones, wherein the loudspeaker of each audio channel is mounted in acoustically balanced manner with respect to the microphone of the other audio channel.

4. The combination, in a communication system of the character described, of a one-way audio amplifier, with two groups of microphones and loudspeakers symmetrically arranged in acoustically balanced relationship, wherein said microphones are electrically connected to the input circuit of said audio amplifier and said loudspeakers are electrically connected to the output circuit of said audio amplifier.

5. In a communication system, of the character described, a cabinet, comprising housing means for one microphone and two loudspeakers symmetrically arranged in acoustically balanced relationship, and sound absorption means for prevention of backside radiation from said loudspeakers and backside pick-up by said microphone.

6. In a communication system of the character described, means for acoustical balancing of loudspeakers and microphones, comprising means for causing loudspeakers to operate in fixed phase relation to each other and cabinet means for housing said microphones and loudspeakers in fixed relation to each other.

7. The combination, in a communication system, of the character described, of a microphone, electrically connected to the input circuit of an audio amplifier, with two loudspeakers electrically connected to the output circuit of another audio amplifier, said microphone and said loudspeakers arranged in acoustically balanced relation, wherein said microphone is substantially unaffected by sounds from said loudspeakers.

8. In a communication system of the character described, means for electro-acoustic balancing of one loudspeaker and two microphones, said microphones being electrically connected 180 degrees out of phase with respect to each other and to a common input circuit, wherein the electro-motive forces generated by each said microphone, due to sound energy from said loudspeaker, are of substantially the same character and magnitude but 180 degrees out of phase with respect to each other, thus substantially effecting cancellation of said electro-motive forces in said input circuit.

9. In an apparatus of the character described, the method of acoustical balancing comprising means for symmetrical arrangement of one microphone and two loudspeakers, said loudspeakers being electrically connected to a common energy source but 180 degrees out of phase with respect to each other.

10. The combination of a microphone with two loudspeakers, arranged in acoustically balanced relation, wherein said microphone is substantially unaffected by sounds from said loudspeakers.

11. The combination of a microphone with a plurality of loudspeakers, arranged in acoustically balanced relation, wherein said microphone is substantially unaffected by sounds from said loudspeakers.

12. A multi-station inter-communication system, comprising electro-acoustically balanced means for pick-up and reproduction of sounds at each station, and audio amplifier means cooperating with said means for pick-up and reproduction of sounds, all substantially as described.

LENNART G. ERICKSON.