United States Patent [19]

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[45] **June 10, 1975**

[54] **TELEPHONE SYSTEMS WITH REDUCED ACOUSTIC FEEDBACK**

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[21] Appl. No.: **315,807**

Related U.S. Application Data

[63] Continuation of Ser. No. 1,743, Jan. 9, 1970, abandoned.

[30] **Foreign Application Priority Data**

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Feb. 4, 1969 United Kingdom 6009/69

[52] **U.S. Cl.** ..... **179/1 FS;** 179/1 HF
[51] **Int. Cl.** **H04m 1/22**
[58] **Field of Search** ..... 179/1 HF, 1 FS, 100 L, 179/81 B, 1 E, 115.5 DV

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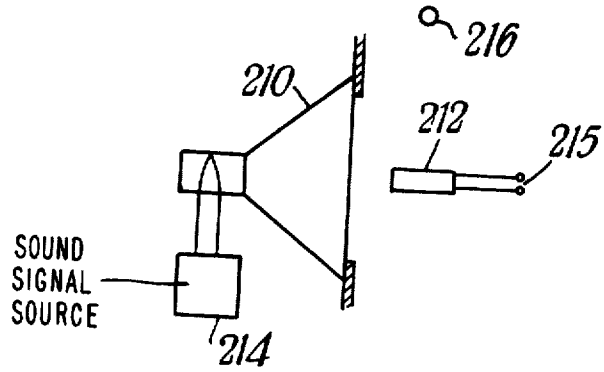
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[57] **ABSTRACT**

Feedback in an electro-acoustic transducer unit for connection into a two-way communication system is reduced or eliminated by acoustic means dependent on relative positioning of loudspeaker and one or more microphones, or electrically, by cancellation of signals due to unwanted sound components derived from a pair of microphones. The operation of the microphone and loudspeaker can be alternated at an ultrasonic frequency or a single transducer can be used as microphone and loudspeaker alternately at such a frequency. A transducer having a pair of speech coils in push-pull formation is described, as well as a laminated structure for use in the housing of the apparatus.

10 Claims, 14 Drawing Figures



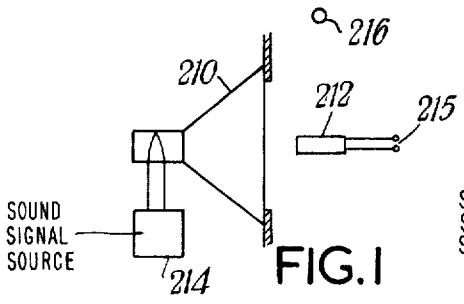


FIG.1

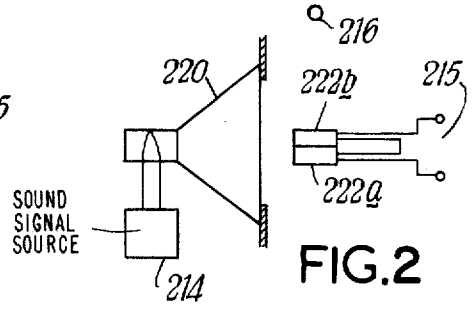


FIG.2

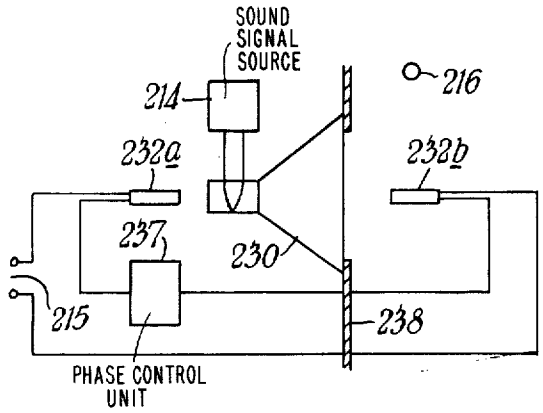


FIG.3

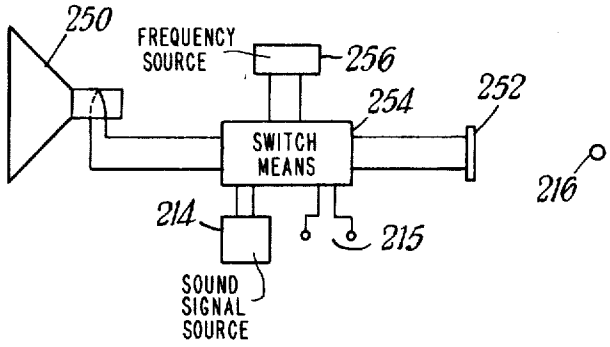


FIG.7

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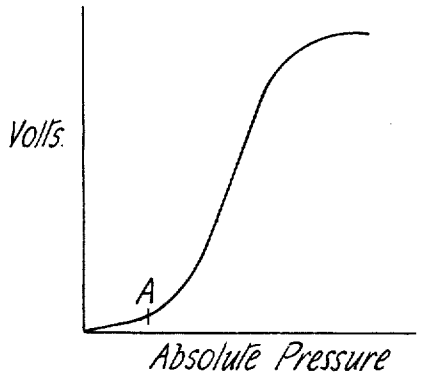


FIG. 4

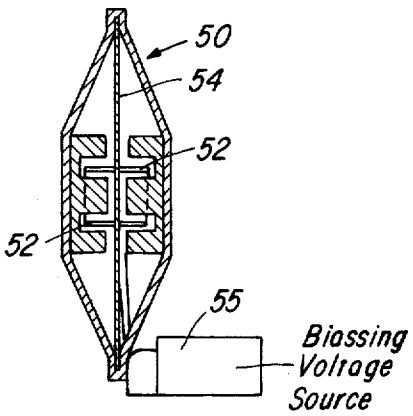


FIG. 6

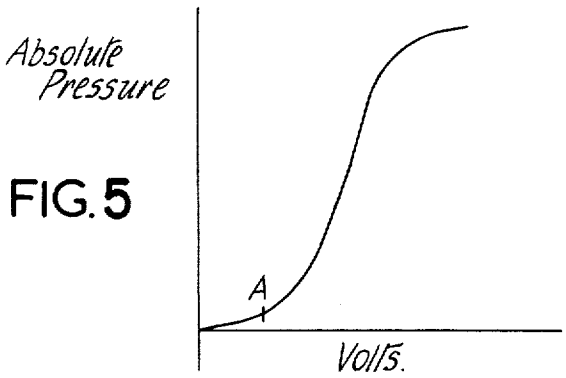


FIG. 5

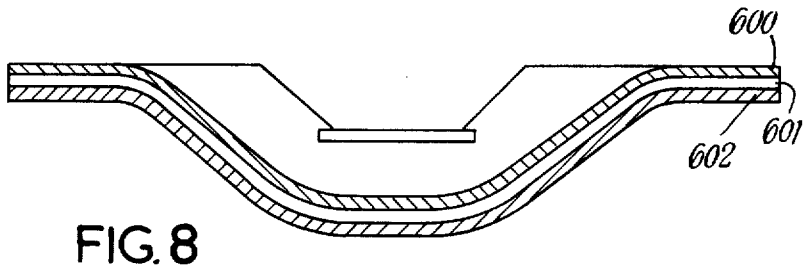


FIG. 8

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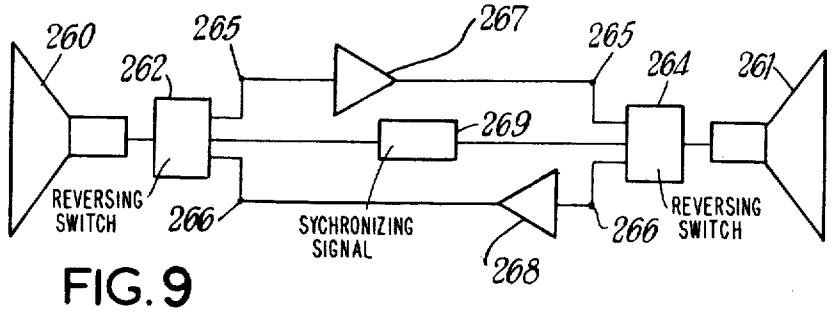


FIG. 9

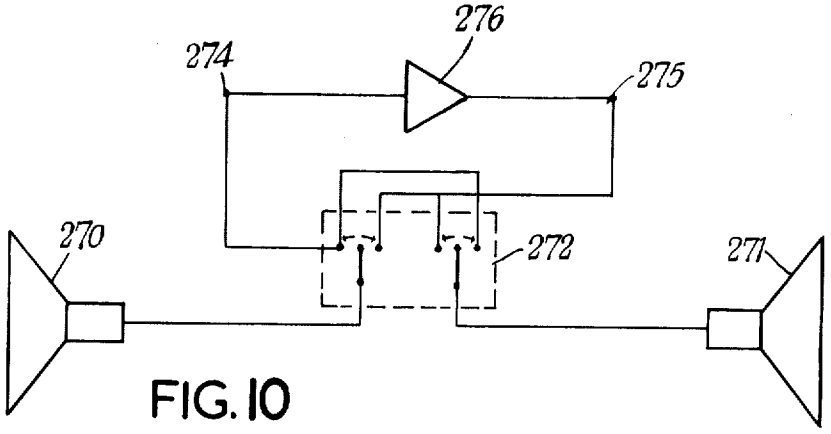


FIG. 10

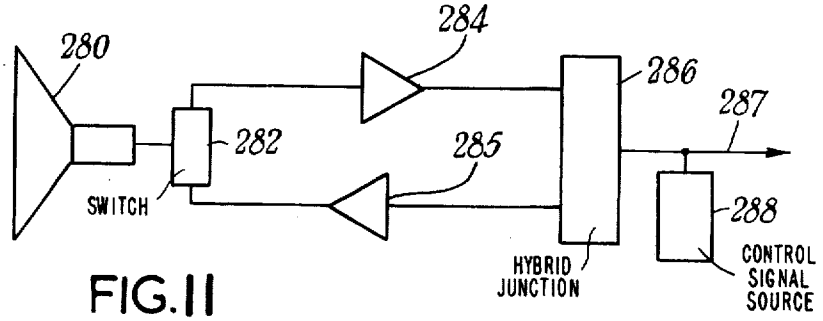


FIG. 11

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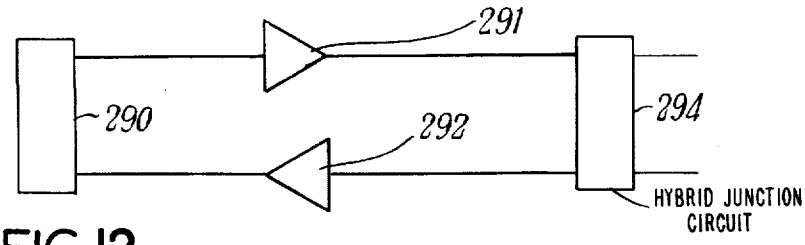


FIG. 12

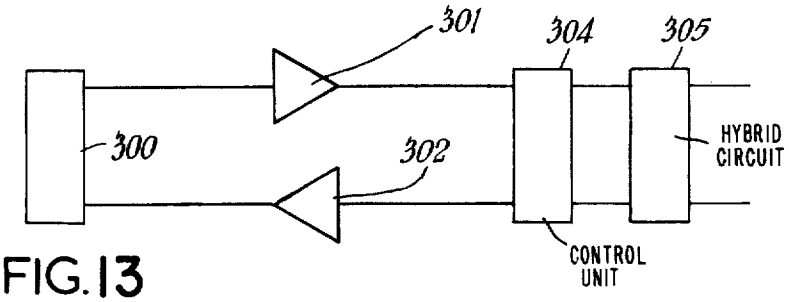


FIG. 13

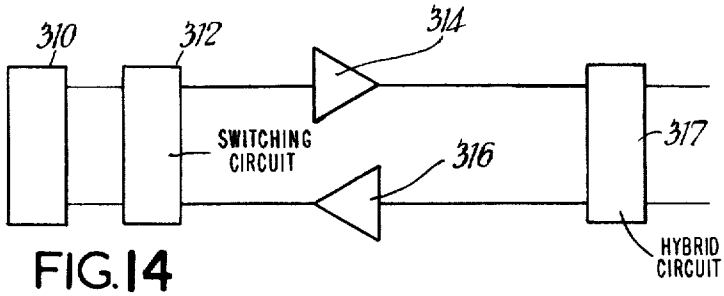


FIG. 14

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TELEPHONE SYSTEMS WITH REDUCED ACOUSTIC FEEDBACK

This is a continuation of application Ser. No. 1,743, filed Jan. 9, 1970 now abandoned.

The invention relates to the elimination or reduction of feedback in electro-acoustic transducer apparatus for connection into a two-way communication system, for example, a loudspeaking telephone apparatus.

Feedback between the loudspeaker and the microphone is propagated in three ways, namely by direct radiation, by reflection from the inside surface of the casing enclosing the loudspeaker and/or microphone and by conduction through the walls of the casing.

It is accordingly an object of the present invention to provide an electro-acoustic transducer apparatus in which the effects of feedback are reduced or eliminated.

According to one aspect of the invention, the apparatus comprises a first transducer means for producing a sound signal in response to an electrical input, a second transducer means for providing an electrical output from sound waves incident thereon, housing means for said first and second transducer means, and means mounting said first and second transducer means in adjacency in said housing means so that the electrical output from the second transducer means due to sound waves incident thereon from the first transducer means is zero, said housing means and mounting means being adapted to limit sound conduction from the first transducer means to the second transducer means.

According to another aspect of the invention, the apparatus comprises loudspeaker means, two microphone means, housing means, means mounting said loudspeaker means and at least one of said microphone means within said housing means, the microphone means being located symmetrically with respect to the axis of movement of the diaphragm of the loudspeaker means, and means connecting the outputs of said two microphone means in reverse phase, whereby said connecting means provides an output in which components due to sounds waves from the loudspeaker means and incident on the microphone means are cancelled.

The invention also provides an electro-acoustic transducer apparatus, the apparatus comprising a housing means mounting first and second electro-acoustic transducer means so that two sides of diaphragm means of one of the transducer means are substantially equally and directly coupled to the other transducer means, whereby the electrical output from either transducer means due to the sound waves from the other transducer means is substantially zero.

The invention will be better understood from the following illustrative description and from the accompanying drawings in which:

FIGS. **1**, **2** and **3** each schematically show a respective arrangement of a loudspeaker means and microphone means for electro-acoustic transducer apparatus;

FIGS. **4** and **5** are graphs showing the relationship between the absolute pressure applied to the diaphragm of a transducer and the voltage in the coil thereof;

FIG. **6** schematically shows a transducer having a pair of speech coils in push-pull formation;

FIG. **7** shows a circuit for a further form of transducer apparatus, in schematic block diagram form;

FIG. **8** is a schematic sectional view of a wall of a housing for a transducer unit; and

FIGS. **9–14** each show in schematic block diagram form a respective circuit for an electro-acoustic apparatus.

Referring to FIG. **1**, a loudspeaker **210** functions as the reproduction unit and is so positioned with respect to a microphone **212** constituting the production unit that the diaphragm of the latter receives the same sound vibrations from the loudspeaker on one side as on the other. The loudspeaker **210** is fed with an electrical signal corresponding to an unwanted sound, for example, background music from a source **214.** The effect of the sound vibrations from the loudspeaker **210** on the electrical output of the microphone **212** is consequently zero. The location of the microphone **212** and the loudspeaker **210** is at the same time such that the microphone receives, effectively the wanted sound signal, for example, speech, from a sound source **216** which is consequently responsible for all or substantially all of the electrical output of the microphone appearing across output terminals **215.** The arrangements for example can coveniently be such that the axis of the loudspeaker diaphragm lies on a diameter of the microphone diaphragm, where this is circular, as shown.

It will be appreciated that the microphone and loudspeaker will normally be housed in a suitable cabinet, which may incorporate associated equipment to provide all the facilities necessary to a complex communication system. In the present instance the axes of the loudspeaker and microphone can both be horizontal, with the latter axis directed towards the expected position of a sound source to be monitored or recorded.

Instead of employing acoustic cancellation, electric signal cancellation can be used by the provision of two microphones. Thus, as shown in FIG. **2**, two identical microphones **222***a* and **222***b* are placed with respect to a loudspeaker **220**, so as to produce identical electrical signals from the unwanted sound they receive from it, one microphone **222***a* being completely or nearly completely shielded from the wanted sound and the other microphone **222***b* being exposed to it. In this arrangement also the axis of the loudspeaker **220** and the common axes of the microphone **222***a*, **222***b* at right angles thereto are all most conveniently arranged in a horizontal plane, with the microphone **222***b* orientated to receive the incoming wanted sound signal from the source **216.**

In the alternative arrangement of FIG. **3**, which again employs two microphones **232***a* and **232***b*, the microphone **232***a* to be shielded from the wanted sound source is placed within a cabinet **238** housing a loudspeaker **230** so as to receive the sound produced from the diaphragm. The other microphone **232***b* is positioned externally of the housing in the same relationship to the loudspeaker **230** as the microphone **212** is to the loudspeaker **210** in FIG. **1.** The microphone output signals are combined out of phase as shown so that the electric signal components due to the sound from the loudspeaker **230** are cancelled. The signal component due to the wanted sound from the source **216** is available terminals **235** without or substantially without the addition of a signal due to the loudspeaker reproduction. The circuit arrangements associated with the microphones can include where appropriate a phase control unit **237**, that is, a unit of a known kind, for relatively adjusting the phases of the microphone outputs.

The effect of the feedback due to all three of the above mentioned causes is reduced by shifting the op-

erating point of the transducer, whether the microphone or the loudspeaker, on the power (response curve). FIGS. 4 and 5 show the curves for the microphone and loudspeaker respectively. By shifting the operating point from A to B on each of these curves, a greater voltage output to absolute pressure ratio in the case of the microphone and a greater absolute pressure output to voltage input ratio are obtained. The actual voice signal is greater than the feedback signal and, therefore, due to the shift on the curve, the difference between the reproduced voice signal and the reproduced feedback signal is even greater and the effect of the feedback signal is lessened.

The shifting of the operating point may be carried out as shown in FIG. 6 by fitting the transducer **50** with identical coils **52** on either side of the diaphragm **54** and applying a D.C. biassing voltage to the coils as from a source **55.** The coils **52** may be the actual speech coils or alternately separate biassing coils may be provided. The use of the two speech coils with the transducer increases the output by at least twice; by using special magnets, a further increase is possible. The fact that the output from the transducer is doubled means that the overall gain of the amplifier systems can be reduced and therefore the stability of the circuit would be increased.

A further reduction of feedback is produced by operating the arrangements of FIGS. **1, 2** and **3** so that the microphone and loudspeaker are active alternately by providing a suitable high-speed switching system. The effect of this is that a closed circuit between microphone and loudspeaker is never formed as the loudspeaker never operates at the same time as the microphone. Also, spurious signal reflection effects from the transducer enclosure are reduced.

Alternatively, as illustrated in FIG. **7,** operation of a microphone **252** for receiving the wanted sound interrupted at a high frequency and a loudspeaker **250** operated only when the microphone is inoperative. The frequency at which the operation of the two transducers is alternated or interruptions are made is variable and may, for example, by 15,000 or 16,000 per second.

This aspect of the invention can be conveniently carried into effect by electronic, for example transistorized, switch means **254** operated at the required frequency under control of a frequency source **256.** The switch means **254** acts to cut off the loudspeaker **250** from the electric signal source **214,** at the same time connecting the microphone **252** to the associated output terminal **215,** and then to connect the loudspeaker and source at the same time connecting the microphone to the terminals, this cycle being repeated. In an alternative arrangement of this general kind, a receiver amplifier and a separate microphone amplifier are energised from a single source alternatively as by an alternating square wave, so that only one of the amplifiers is working at any instant.

Due to the mechanical inertia of the microphone and loudspeaker, this alternate activation is not apparent to the user of the station. However, provided a suitable rate of alternation is chosen, echos from the surroundings of the transducers used are reduced.

The feedback due to conduction through the casing is reduced by the type of casing used. A preferred type of casing construction is shown in FIG. **8** and consists of a rigid layer **600,** an air gap **601** and a soft layer **602.** Further rigid and soft layers separated by an air gap may be used, the greater the number of layers, the greater the reduction of conducted feedback.

In the further embodiments of the invention illustrated in FIGS. **9** and **10,** the functions of the first and second transducer means are performed by a single transducer means alternately. The transducer means, which as before may comprise one or more actual transducer units, is thus arranged to operate as a microphone for an instant, and as a loudspeaker during a following instant. The frequency at which these functions alternate is again advantageously at least 10,000 cycles per second and preferably greater than 15,000 c.p.s.

Both FIGS. **8** and **9** schematically illustrate complete communication systems. The system of FIG. **8** has one transducer means **260, 261** at each of a pair of stations. Each station is further provided with a reversing switch **262, 264** which can be incorporated in the body of the associated transducer operable to connect this transducer with either of a pair of lines **265, 266** including amplifiers **267, 268** respectively. The switches **262, 264** are arranged to alternate connection of both transducers **260** with the line **265,** when the transducer **260** acts as a microphone and the transducer **261** acts as a loudspeaker with connection of both transducers to the line **266,** when the functions of the two transducers are interchanged. The positions of the switches **262, 264** must of course be co-ordinated, as by means of a co-ordinating or synchronising signal supplied to the switches **262, 264** from a suitable source **269.** Alternatively, the two switches can be operated independently at very different frequencies, for example 10,000 and 30,000 c.p.s., generated randomly, so that the connections required are obtained during a sufficient part of the time for communication to be effected.

In the alternative arrangement shown in FIG. **10** only a single amplifier is used. The two stations of the system illustrated include respective electro-acoustic transducer means **270, 271** connected to a switch means **272.** The switch means is arranged to alternate connections of the transducer **270, 271** to the input terminal **274** and the output terminals **275** of an amplifier **276.** In one position of the switch means, the transducer **270** is connected to the input terminal **274** and functions as a microphone whilst the other transducer **271** is connected to the output terminal **275** and functions as a loudspeaker. In the other position the connections and functions of the two transducers are interchanged.

It will be understood that the switch means **272** although represented as a two pole, two way mechanical switch is preferably constituted as an electronic switch, such as a transistorised switch, as are the switch means **262, 264** of FIG. **9.**

The arrangements illustrated in FIGS. **11–14** each comprise a single instrument or station for incorporation in a conventional single line telephone system. In FIG. **11,** the instrument comprises a single transducer means **280,** a switch means **282** and amplifiers **284, 285** connected by a hybrid junction **286** for transmission into the single output line **287.** This arrangement permits signal controlling the alternating function of the transducer means **280** to be fed from a source **288** into the line **287** at any convenient point on its length. The need to connect the synchronizing signal source **269** of FIG. **9** to both switch means **262, 264** by a separate line is thus eliminated.

In FIG. **12,** a transducer apparatus **290** is provided which can comprise any one of the arrangements de-

scribed above with reference to FIGS. **1–3.** The two transducer means of the apparatus **290** are connected to respective amplifiers **291, 292.** The amplifier outputs are taken to a hybrid junction circuit **294.** It will be evident that in the apparatus of FIG. **12,** both transducers function continuously, the elimination from the electrical output of a component due to unwanted sound being effected by electrical or acoustic cancellation.

FIG. **13** shows apparatus in which the output of a transducer apparatus **300,** the apparatus comprising an arrangement in accordance with FIGS. **1–3,** is fed to a pair of amplifiers **301, 302.** Alternate energisation of the amplifiers **301, 302** is effected by a control unit **304.** Alternatively, a control unit can be supplied which blocks the inputs alternately. The arrangement illustrated includes a hybrid circuit **305** for feeding into the line. A modification of this arrangement is shown in FIG. **14** in which alternate operation of the transducer units of the transducer arrangement **310,** which again comprises an apparatus as described in connection with FIGS. **1–3,** is effected by switching circuit **312** which can take any of the forms described in connection with the earlier Figures. A microphone amplifier **314** and a loudspeaker amplifier **316** which are both permanently energised in use are again connected at the output ends to a hybrid unit **317.**

It will be understood that although reference has been made to use of single loudspeakers and microphones in the arrangements described above, a plurality of such units can be employed in place of each if desired. The apparatus is not limited to loudspeakers and microphones of any particular kind.

The invention can thus be variously embodied to provide an electric output signal representing exclusively or nearly exclusively the wanted component of an incoming sound containing also unwanted components. The signal can be recorded for subsequent replay or fed directly to a loudspeaker when appropriate. The electrical output signal can be monitored to enable the amplitude of the cancellation signal to be adjusted to the required level.

I claim:

1. In combination, housing means, a single loudspeaker having a diaphragm having an axis of movement and an electrical input, microphone means having diaphragm means with exposed opposite sides and an electrical output, means mounting said single loudspeaker and said microphone means in close proximity in said housing means so that sound waves radiated by the loudspeaker diaphragm in response to energization of the loudspeaker travel in a direction parallel to the sides of the microphone diaphragm means directly and by a single sound path to the microphone means, the microphone diaphragm means being disposed substantially in a plane lying along the axis of movement of the loudspeaker diaphragm when the loudspeaker diaphragm moves in response to an electrical input to the loudspeaker, said opposite sides of said microphone diaphragm means being equidistant from said loudspeaker diaphragm, whereby the sound waves radiated by the loudspeaker diaphragm fall directly and substantially equally on said opposite sides of the microphone diaphragm means, so that the electrical output of the microphone means due to the sound waves from the single loudspeaker diaphragm is substantially zero.

2. The combination claimed in claim **1,** in which said microphone means comprises a pair of microphones back to back and having oppositely outwardly facing diaphragms.

3. The combination claimed in claim **2,** said microphone diaphragms being coaxial.

4. The combination claimed in claim **1,** said microphone means lying on said axis of movement of said loudspeaker diaphragm.

5. The combination claimed in claim **1** including a second microphone having a diaphragm and means mounting said second microphone in said housing means in close proximity to said loudspeaker on the side of the loudspeaker diaphragm remote from said first-mentioned microphone with the diaphragm of said second microphone disposed in a plane lying along said axis of movement of said loudspeaker diaphragm.

6. The combination claimed in claim **5** having circuit means connecting said first-mentioned and said second microphone in reverse phase to provide said common electrical output.

7. The combination claimed in claim **6** in which said circuit means includes a phase adjustment means.

8. The combination claimed in claim **1** in which said housing means includes at least one wall comprising laminations of hard and relatively soft material.

9. The combination claimed in claim **1** including electric circuit means interconnecting said microphone and said loudspeaker and adapted to operate said microphone and said loudspeaker alternately at an ultrasonic frequency.

10. The combination claimed in claim **1** including a second microphone, means mounting said second microphone in said housing means in close proximity to said loudspeaker, circuit means connecting together said first-mentioned microphone and said second microphone and providing therefor a common electrical output, and a phase adjustment means included in said circuit means.

* * * * *