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Selected US specifications from IPC sub-class
H04R

(54) Monitoring loudspeakers

(57) The operation of a remote loudspeaker 10 is monitored by injecting a control signal on to the audio pair 11 feeding the loudspeaker, the presence of that signal being detected by a receiver 12 which then opens a gate 15. The loudspeaker audio output is detected by a sensor 16, the conditioned output of which is fed back on to the audio pair 11 driving the loudspeaker when the gate 15 is opened. Analysis at a remote control point of the conditioned sensor output fed on to the audio pair allows determination of adequate loudspeaker operation.

By coding the control signal, a plurality of remote loudspeakers may selectively be monitored, one at a time,by arranging for each loudspeaker to respond to one particular coded control signal, individual to that loudspeaker.

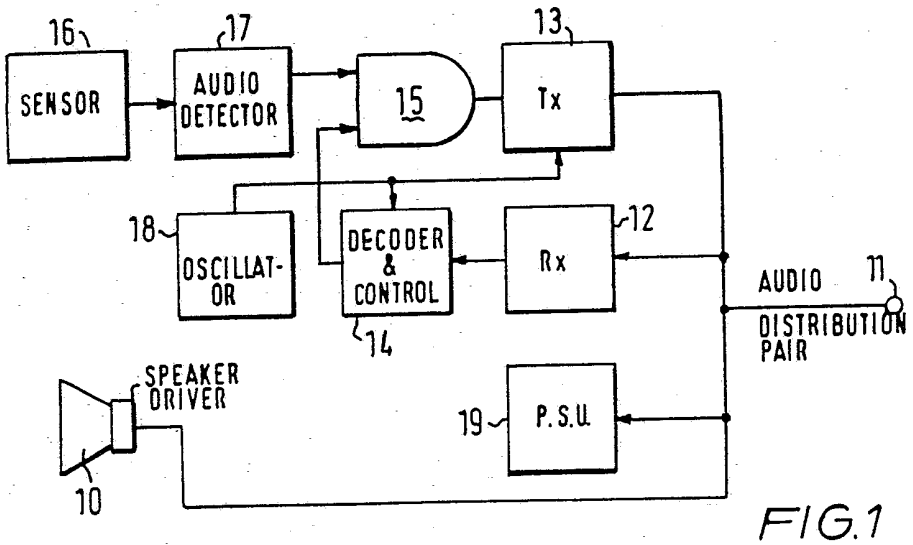

FIG.1

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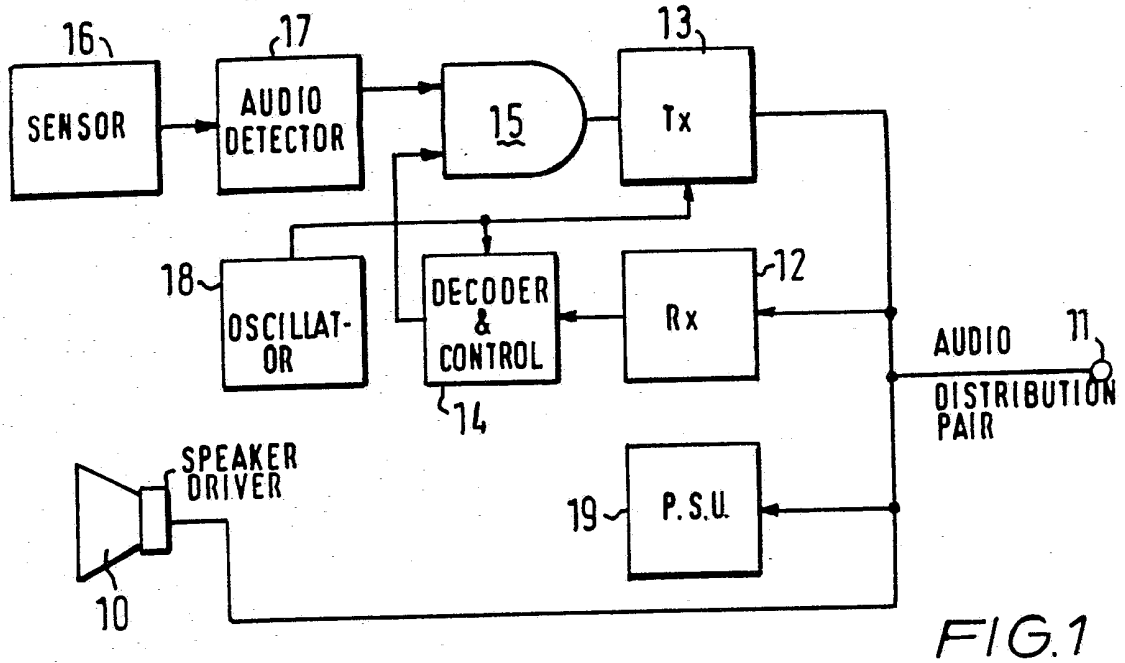

FIG.1

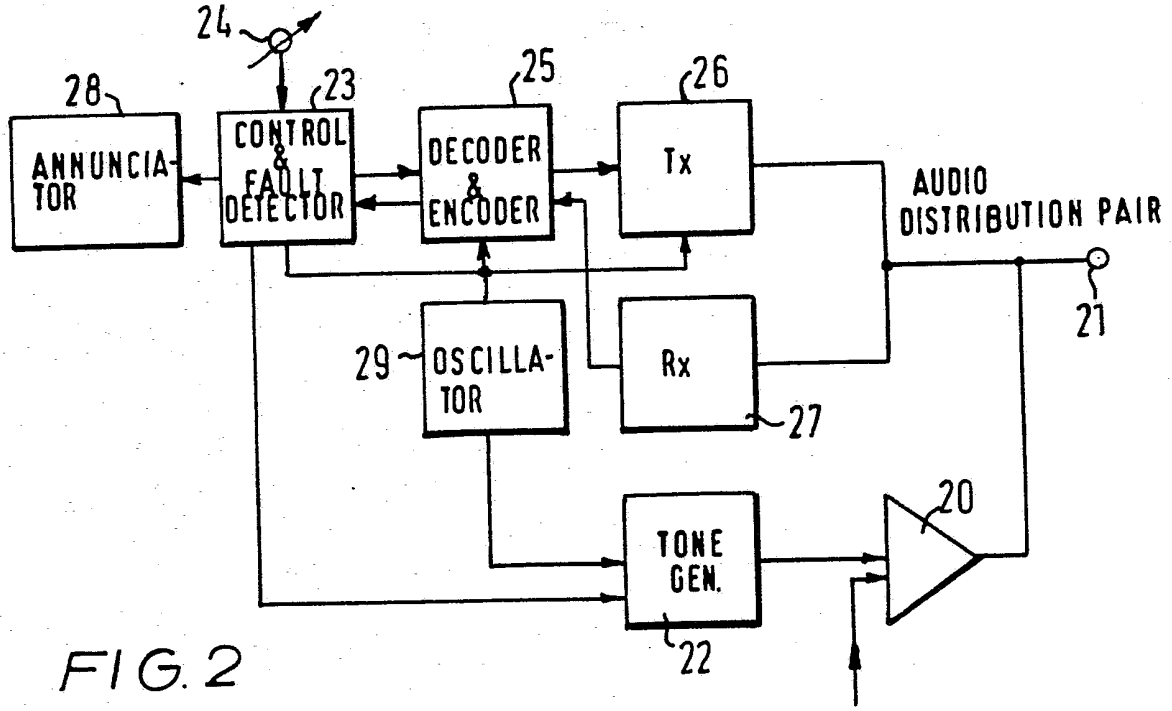

FIG.2

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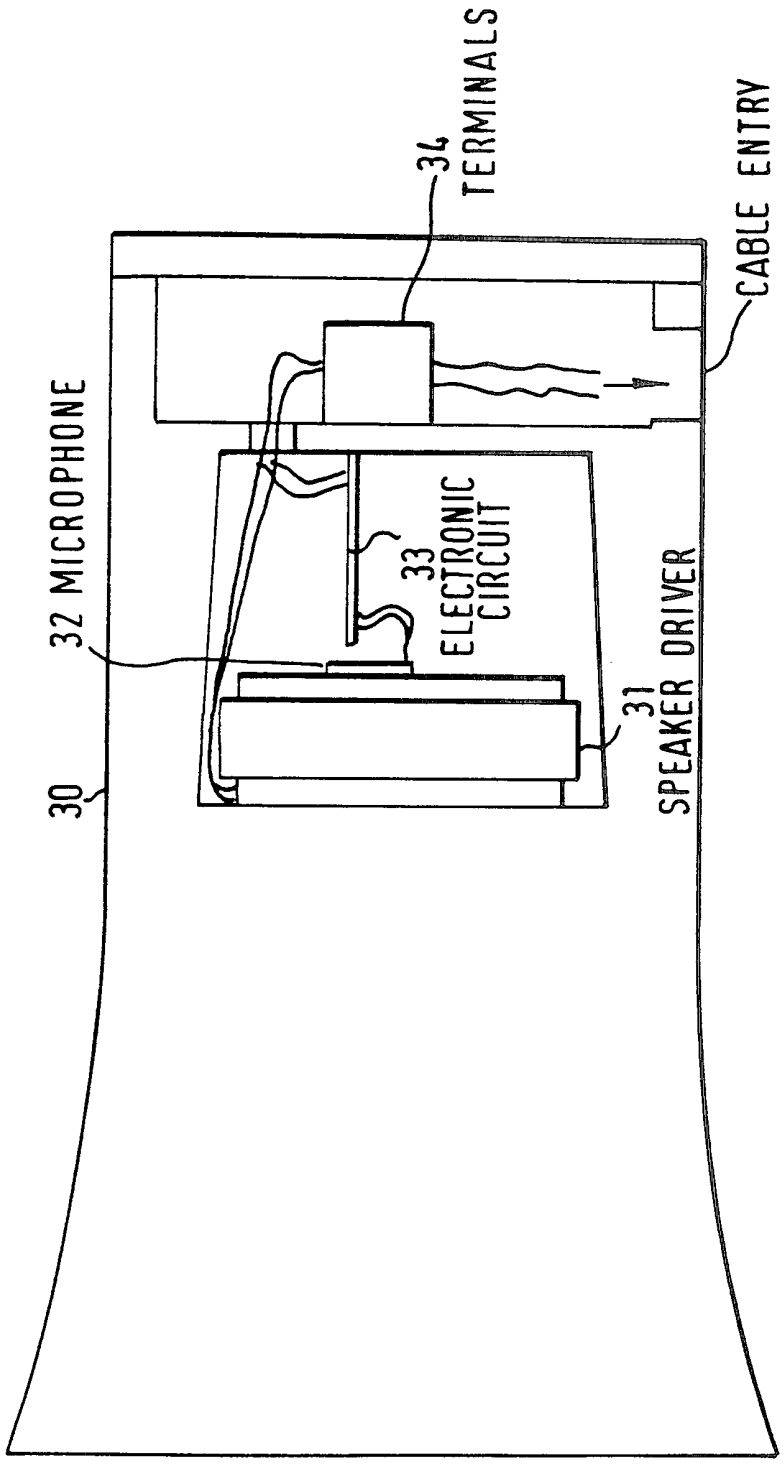

FIG. 3

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LOUDSPEAKERS

This invention concerns loudspeakers, and in particular relates to a method of remotely monitoring the operation of a loudspeaker, as well as to a loudspeaker arranged to permit the remote monitoring of the performance thereof.

Public address loudspeaker systems usually have a plurality of separate loudspeaker units arranged at various required locations, all of the loudspeakers being driven by a common signal provided by a suitable amplifier and distributed to all of the loudspeaker units via an audio distribution line which feeds all of the loudspeakers in parallel. There are various standards for such loudspeaker systems - for example, the amplifier may supply the audio signal at substantially 100V rms, each loudspeaker being connected to this line and having a transformer adapted to match the impedance of the loudspeaker to that of the 100V line.

An operator of a public address loudspeaker system as described above is unable to tell whether all of the loudspeaker units connected to the system are operating correctly. Whilst sometimes this may not be particularly important, in other circumstances it may be essential that each loudspeaker unit connected to the public address system operates with total reliability. For example, a public address loudspeaker system often

is installed in a chemical processing plant or other industrial installation where dangerous materials are handled in order that safety or emergency messages may be passed to workers - and the failure of a loudspeaker may have serious or even disastrous consequences, for personnel. Similarly, loudspeaker systems are installed on boats and aircraft for use in an emergency and though the system may be used only rarely, if ever, it is essential that all the loudspeakers will operate when required.

In order to ensure that all of the loudspeakers connected to a public address system are operating correctly, it is known to feed at regular intervals a relatively short audio signal into the audio distribution line, so that personnel may hear for themselves that the loudspeaker nearest them is operating correctly - and if it does not operate correctly, the matter may immediately be reported. Such a technique requires an intrusive audio signal to be emitted by all of the loudspeakers at regular intervals, and moreover relies on personnel reacting to the non-operation of a loudspeaker. It is therefore a principal aim of the present invention to provide a method of monitoring the operation of a loudspeaker which method does not require the intervention of personnel close to the loudspeaker. A further aim is to provide a loudspeaker suitable for use with such a monitoring method.

Accordingly, one aspect of the present invention provides a method of monitoring from a control point the operation of a remote loudspeaker having a drive unit and having sensor means arranged directly or indirectly to detect drive unit operation, the sensor means producing an electrical output dependent thereon, in which method an activating signal is supplied from the control point to the loudspeaker to activate the sensor means, an audio signal is supplied to the loudspeaker to operate the drive unit, and the consequent sensor means output is fed back to the control point for analysis to indicate loudspeaker operation.

It will be appreciated that in the method of the present invention, remote monitoring of the operation of a loudspeaker becomes possible, without involving extra wiring between the loudspeaker and the control point. All that is necessary to initiate a monitoring operation is for the activating signal to be supplied to the loudspeaker, accompanied by an audio signal which operates the loudspeaker drive unit. Use may be made of an already-present audio signal, or the control point may generate a special audio signal for this purpose. Such an audio signal may be of a very low power so as to minimise the intrusion of the loudspeaker audio output on personnel working in the vicinity of the loudspeaker. The return signal from the loudspeaker must then be detected at the control point, and analysed to determine

whether the remote loudspeaker has operated correctly.

In the case of a public address system having a plurality of loudspeakers, it is preferred for the activating signal supplied from the control point to be at a frequency higher than the audio signal and to be coded, and for each loudspeaker to be arranged to respond to a activating signal coded in a manner individual to that loudspeaker. In this way, the performance of each loudspeaker of the public address system may separately and individually be monitored, by performing a number of monitoring operations one after the other, each using a different coded activating signal. An alternative would be for a single activiating signal to be supplied to all of the loudspeakers, each loudspeaker including a timing arrangement so that its return signal is fed on to the audio distribution line at a known time after the activating signal, each loudspeaker transmitting its return signal at a different time from all the others.

When coding of the activating signal is used, that may be achieved in any suitable manner, provided that each loudspeaker has means adapted to decode that signal. For example, the activating signal may be frequency-encoded, and so consist of a plurality of sequential tones. Another possibility is for the activating signal to be digitally encoded, by keying that signal on and off in a particular pattern.

Preferably, the activating signal is transmitted

at a frequency above the highest frequency at which the overall loudspeaker installation is designed to operate. Since many public address systems intended primarily for use with speech may have cut off frequencies as low as 7 kHz, or even lower, the activating signal may have a relatively low frequency as compared to the overall audio spectrum - typically 10 kHz or so. The transmission of such an activating signal on the audio distribution line will not therefore be audible.

In performing the method of this invention, the sensor means of the loudspeaker may operate either directly on the loudspeaker drive unit, or indirectly, to detect sound generated by the drive unit. For example, the sensor means may include a microphone which responds to the sound pressure generated by the loudspeaker drive unit. Alternatively, the sensor means may include a sensor directly detecting movement of the loudspeaker drive unit diaphragm, or may detect current flowing through the loudspeaker voice coil, or the voltage across the voice coil. Though any of the foregoing techniques may be employed, a microphone detecting the sound pressure generated by the drive unit is the most preferred arrangement, for this checks that actual sound is being produced.

According to a second aspect of this invention, there is provided a loudspeaker having an enclosure in which is mounted a loudspeaker drive unit and sensor

means adapted to monitor the operation of the loudspeaker drive unit, which sensor means comprises a sensor arranged directly or indirectly to detect drive unit operation upon the supply of an audio signal on an audio line connected to the loudspeaker, the sensor providing an output dependent upon detected drive unit operation, a transmitter arranged to inject an operation signal on the audio line dependent upon the sensor output, and a receiver adapted to detect the presence of an activating signal on the audio line and to enable the operation of the sensor means and/or transmitter.

A loudspeaker of this invention is suitable for use in a public address system adapted to perform the monitoring method also of this invention, as described above. To complete such an installation, a control unit should be provided which control unit includes an activating signal generator to produce an activating signal for a remote loudspeaker sensor means, a transmitter to inject that activating signal on to the audio distribution line connecting the audio amplifier and the remote loudspeaker, a receiver for an operation signal transmitted by the loudspeaker and an analyser for operating on the receiver output, so as to produce an indication of the operation of the remote loudspeaker.

Most preferably, the control unit includes means to encode the activating signal, and the sensor means of each loudspeaker includes a decoder arranged to

determine whether a received activating signal is encoded to match a pre-set code within that loudspeaker. The loudspeaker preferably also includes an electronic gate, which gate is opened upon detection of an activating signal encoded to match that pre-set within the loudspeaker, so as thereafter to allow the loudspeaker transmitter to inject on to the audio distribution line a signal dependent upon the sensor output. Such a signal should be at a frequency above the audio frequency at which the system is designed to operate. The transmitted signal may be a simple signal, merely to indicate that the loudspeaker operation is sufficient, or may be a more complex signal carrying information concerning the actual performance of the loudspeaker.

It will be further appreciated that the monitoring system of this invention may be used to check the integrity of a complete loudspeaker installation, including the wiring between the power amplifier and the loudspeakers, as well as the amplifier itself. Moreover suitable analysis of the received signals from the loudspeakers, at least some fault diagnosis also may be achieved.

By way of example only, one specific embodiment of a loudspeaker system arranged for performing the method of this invention, and also a loudspeaker for use in such a system, will now be described in detail,

reference being made to the accompanying drawings, in which:-

Figure 1 is a block diagram of a loudspeaker for use in performing the monitoring method of this invention;

Figure 2 is a block diagram of a control unit for use with the loudspeaker of Figure 1; and

Figure 3 is a diagrammatic cross-section through a loudspeaker constructed in accordance the invention.

Referring initially to Figure 1, there is shown the block diagram of a loudspeaker adapted for use in performing the remote performance monitoring method of this invention. The loudspeaker includes an enclosure (not shown) within which is mounted a loudspeaker drive unit 10 connected to terminals 11 so that the drive unit may directly be supplied with current from an audio distribution line (not shown). If necessary transformer may be provided between the terminals 11 and the drive unit 10, to match the impedance of the loudspeaker to that of the distribution line. Also connected to the terminals 11 are a receiver 12 and a transmitter 13. The receiver 12 is tuned to a frequency outside the normal audio frequency range supplied to the drive unit 10 and provides an output should a signal of that tuned frequency appear on the audio distribution line. The output of the receiver is fed to a decoder and control block 14, the output of which is connected to one terminal of an AND gate 15. The decoder and control block 14 allows the pre-setting of a particular code

pattern for that loudspeaker, and will supply a signal to the gate 15 only if a received signal is suitably encoded to match the pre-set code within the control block 14.

The loudspeaker further includes a sensor 16 suitably mounted within the enclosure of the loudspeaker, to detect sound pressure generated by the drive unit 10. The sensor output is fed to an audio detector 17, which provides a signal to the other input of AND gate 15 if the sensor output falls within a pre-set range. Provided that there are signals on both imputs to gate 15, the transmitter 13 is activated, so as to inject a signal on to the audio distribution line, via terminals 13. The loudspeaker also includes an oscillator 18, for controlling the operation of the decoder and control block 14, as well as of the transmitter 13.

A power supply unit 19 is connected to the terminals 11, to serve as a low voltage DC source for supplying power to the various monitoring components 12, 13, 14, 15 17 and 18, described above. Such electrical power is obtained by rectifying a small part of the overall current supplied to the loudspeaker - but in view of the relatively small power requirements of the various components, this will not adversely affect the overall operation of the loudspeaker.

The loudspeaker described above should be used

with a control unit associated with an audio power amplifier which drives the overall loudspeaker installation; such a control unit is shown in Figure 2. An audio power amplifier 20 supplies current to terminals 21, for feeding to an audio distribution line, leading to each loudspeaker to be driven. The amplifier 20 may be driven by a conventional audio signal source, or by a tone generator 22, for a purpose to be described below.

The control unit includes a control and fault detector block 23, provided with a manual test control 24. Whilst the system normally will operate fully automatically, at preset time intervals, operation may be triggered by control 24. Upon operation, a signal is supplied to a decoder and encoder block 25, which in turn supplies an encoded signal to a transmitter 26, arranged to inject a signal on to the audio distribution line, via terminals 21. Also connected to those terminals is a receiver 27 tuned to a particular frequency and which, on detecting the presence of that frequency on the audio distribution line, provides a signal to the decoder and encoder block 25. In turn, dependent upon the decoded output, a signal is fed to the control and fault detector block 23, which is arranged to drive a display device 28. An oscillator 29 provides signals to certain of the circuit elements, as shown in Figure 2.

The loudspeaker and control unit described above

together operate in the following manner. When a test is initiated by block 23 to monitor the performance of the loudspeakers, signals are supplied to the decoder and encoder block 25, which supplies an encoded signal to the transmitter 26. Using the signal generated by the oscillator 29, a modulated and encoded signal is fed to the audio distribution line by the transmitter, at a frequency above the normal operating bandwidth of the amplifier 20.

The presence of that transmitted signal is detected by the receiver 12 of each loudspeaker connected to the audio distribution line, but the encoded signal will match that pre-set in the decoder and control block 14 of only one of the loudspeakers. In that loudspeaker, a high level signal will thus be fed to gate 15.

Immediately before the tranmission of the encoded signal by the control unit, the tone generator 22 is caused to operate and so to feed an audio signal to the amplifier 20. This signal will drive all of the loudspeaker drive units connected to the audio distribution line, and the operation of those drive units will be sensed by the associated sensors 16 and, provided that the sensed sound pressure falls within a pre-determined range, all of the audio detetors 17 will respond, to supply a high level signal to the associated inputs of the several gates 15. However, an activating

signal will be supplied only to that transmitter 13 of the loudspeaker which responded to the original signal transmitted by the control unit. If the performance of that loudspeaker has been satisfactory, the transmitter 13 of that loudspeaker will then inject a signal on to the audio distribution line, possibly at a frequency different from that produced by the transmitter 26 of the control unit, but at a frequency above the normal operating range of the amplifier 20.

The receiver 27 of the control unit responds to such an injected signal, and that signal is decoded and then supplied to the control and fault detector block 23. If the received signal indicates the loudspeaker has operated satisfactorily, then a suitable indication of this may be given on the display device 28. Block 23 then initiates the testing of the next loudspeaker. On the other hand, if the receiver 27 detects no transmitted signal from the loudspeaker, then the control and fault detector block 23 may respond appropriately, to give and indication of this on the display device 28.

It will be appreciated that all of the loudspeakers in an installation will automatically be polled one at a time, in order to test the performance of each loudspeaker separately. Moreover, the transmitted signal from each loudspeaker may suitably be encoded to give more information regarding the detected sound output from the drive unit, such a signal being decoded

in the control unit to permit a display of the loudspeaker performance.

Figure 3 illustrates a loudspeaker constructed in accordance with this invention. The loudspeaker has a horn-type enclosure 30 in which is mounted a moving coil drive unit 31. A microphone 32 is attached to the drive unit 31 so as to detect the sound generated by the drive unit, the microphone being connected to an electronic circuit provided on a circuit board 33. Within the enclosure 30, there are provided terminals 34 to permit the connection of the loudspeaker to an audio distribution line. The loudspeaker drive unit 31 and the circuit board 33 are connected by means of suitable wires to those terminals, to permit an audio signal supplied to the loud speaker to operate the loudspeaker drive unit and the electronic circuit, and to permit an output from the electronic circuit to be injected on to the audio distribution line.

CLAIMS

1. A method of monitoring from a control point the operation of a remote loudspeaker having a drive unit and having sensor means arranged directly or indirectly to detect drive unit operation, the sensor means producing an electrical output dependent thereon, in which method an activating signal is supplied from the control point to the loudspeaker to activate the sensor means, an audio signal is supplied to the loudspeaker to operate the drive unit, and the consequent sensor means output is fed back to the control point for analysis to indicate loudspeaker operation.

2. A method according to claim 1, in which the audio signal is a low-power signal generated at the control point for operation detection purposes.

3. A method according to claim 1 or claim 2 and for use with a public address system having a plurality of loudspeakers, in which the activating signal supplied from the control point is at a frequency higher than the audio signal and is coded, and each loudspeaker is arranged to respond to an activating signal coded in a manner individual to that loudspeaker.

4. A method according to claim 3, in which the activating signal is frequency-encoded, and consists of a plurality of sequential tones.

5. A method according to claim 3, in which the activating signal is digitally encoded, and the signal

is keyed on and off in a particular pattern.

6. A method according to claim 1 or claim 2 and for use with a public address system having a plurality of loudspeakers, in which a single activating signal is supplied to all of the loudspeakers, and each loudspeaker includes a timing arrangement adapted to feed its return signal on to the audio distribution line at a known time after receipt of the activating signal, each loudspeaker transmitting its return signal at a different time from all the others.

7. A method according to any of the preceding claims, in which the activating signal is transmitted at a frequency above the highest frequency at which the overall loudspeaker installation is designed to operate.

8. A method according to any of the preceding claims, in which the sensor means includes a microphone which responds to the sound pressure generated by the loudspeaker drive unit to provide an electrical output.

9. A method according to any of claims 1 to 7, in which the sensor is arranged directly to detect movement of the loudspeaker drive unit diaphragm.

10. A method according to claim 9, in which the sensor is arranged to detect current flowing through the loudspeaker voice coil, or the voltage across the voice coil.

11. A method of monitoring from a control point the operation of a remote loudspeaker, substantially as hereinbefore described with reference to the

accompanying drawings.

12. A loudspeaker for use in a remote operation monitoring method, which loudspeaker has an enclosure in which is mounted a loudspeaker drive unit and sensor means adapted to monitor the operation of the loudspeaker drive unit, which sensor means comprises a sensor arranged directly or indirectly to detect drive unit operation upon the supply of an audio signal on an audio line connected to the loudspeaker, the sensor providing an output dependent upon detected drive unit operation, a transmitter arranged to inject an operation signal on the audio line dependent upon the sensor output, and a receiver adapted to detect the presence of an activating signal on the audio line and to enable the operation of the sensor means and/or transmitter.

13. Apparatus for use in a remote operation monitoring method for a loudspeaker installation, which apparatus comprises a loudspeaker as claimed in claim 12, a control unit including an activating signal generator to produce an activating signal for the remote loudspeaker sensor means, a transmitter to inject said activating signal on to the audio distribution line connecting an audio amplifier and the remote loudspeaker, a receiver for an operation signal transmitted by the loudspeaker and an analyser for operating on the receiver output and producing an indication of the operation of the remote loudspeaker.

14. Apparatus according to claim 13, wherein the control unit includes means to encode the activating signal, and the sensor means of each loudspeaker includes a decoder arranged to determine whether a received activating signal is encoded to match a pre-set code within that loudspeaker.

15. Apparatus according to claim 14, wherein the loudspeaker includes an electronic gate which is opened upon detection of an activating signal encoded to match that pre-set within the loudspeaker, so as thereafter to allow the loudspeaker transmitter to inject on to the audio distribution line a signal dependent upon the sensor output.

16. Apparatus according to any of claims 13 to 15, wherein the transmitted signal carries information concerning the actual performance of the loudspeaker.

17. Apparatus according to any of claims 13 to 16 and substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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