

[54] **COMMUNICATION SOUND SYSTEM  
CONTINUOUSLY MONITORED**

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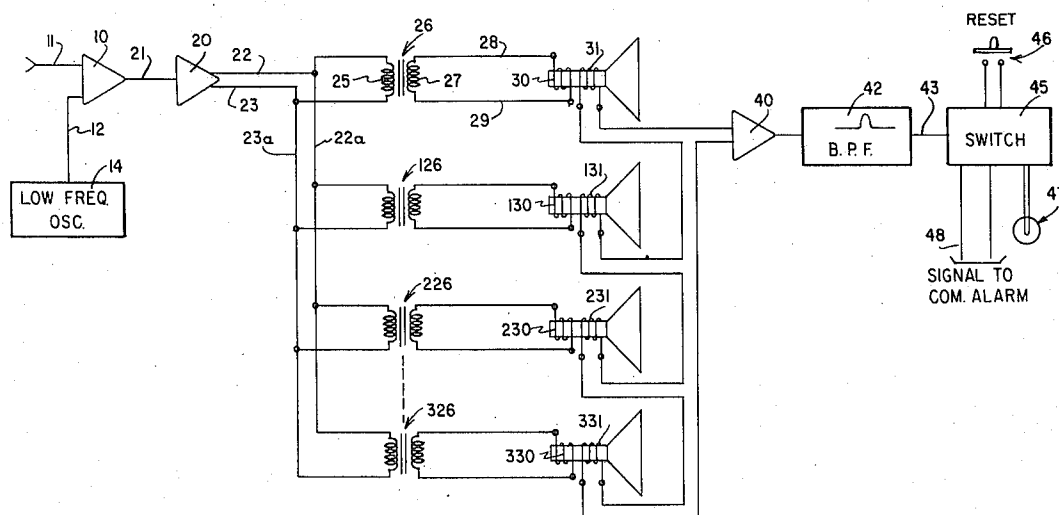
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[57] **ABSTRACT**

A communication sound system has at least one channel terminating in a dynamic type loudspeaker, a monitoring frequency is introduced into the sound system at a relatively low energy level, at least about 10 dB below normal communication level, the frequency being near or below the lower end of the sound frequency range in the system, as for example about 27 Hz. The speaker diaphragm is maintained in continuous oscillation at the monitoring frequency as well as at audible frequencies incident to sound system operation.

The energy level of the monitoring frequency is low enough so that speaker operation is not changed appreciably as far as audible speaker output is concerned. A sensing coil electrically separate from but mechanically coupled to the voice coil of the speaker cooperates with the magnetic air gap of the speaker to generate a voltage which is amplified, passed through a band pass filter to provide a monitor frequency at the filter output so long as the monitor frequency is present in the channel. The filter output is applied to an alarm which is responsive to the presence of the monitor frequency voltages (or currents) and will indicate an alarm condition if the monitor frequency in the channel is absent.

**5 Claims, 2 Drawing Figures**





## COMMUNICATION SOUND SYSTEM CONTINUOUSLY MONITORED

### INTRODUCTION

This invention relates to a sound alarm system with continuous monitor supervisory means and in general relates to a communication sound system which is continuously monitored for operability so that an operator will know that a warning during emergencies will be transmitted from a central station to branch stations. In many structures and installations, where a large grouping of people may be present, such as for example in highrise, commercial or residential structures, large buildings having remote offices and the like, it is desirable and even necessary to provide a communication system controllable from a central station for warning of danger and ordering people within hearing range of the system to evacuate the premises or to move to a different location.

In systems of the above character, there are long periods of time when the warning part of the system may not be used. In instances of this character, it has occurred that the system, for some reason or other, has been found to be inoperative at the time when an emergency occurs. Communication systems may be of various types, such as for example a local switchboard with an operator who can talk to remote telephone extensions. Other sound systems may include intercom systems wherein master or remote stations may initiate calls to other stations or may be called from other stations such as a central master station. In still other systems, an intercom arrangement may provide a master station and a plurality of remote stations, the latter remote stations being able to talk back to a calling master but otherwise not being able to initiate a call from a branch. The variety and number of different sound systems can be quite large depending upon the needs of and control which can be exercised from a central location such as in a main office of a building to any desired number of sub-stations.

In all such sound systems, speakers at all stations are provided. Communication involves transmission over one or more channels to speakers, a channel including transformers.

Attempts have been made to monitor such sound systems and have for the most part been fruitless due to practical difficulties in monitoring the condition of speakers. In practically all such installations, the speakers have been and still are usually of the permanent magnet or electromagnetic type wherein a voice coil on a bobbin moves axially within an annular magnetic air gap, said voice coil being attached to the small end of a cone diaphragm. Voice currents in the voice coil result in sound generation. The operativeness of such a speaker is dependent at all times upon the continuity of an electrical circuit involving the voice coil of a speaker at one end at least of a communication channel which usually includes audio frequency transformers and back to a particular station, which for practical purposes in an emergency may be considered as a source of sound energy. The communication system may include, as a part thereof, suitable switching means which may permit the entire sound system, including any desired number of channels, to be arranged for simultaneous or individual use in any desired manner such as conventional telephone switchboard to remote stations or one or more master stations to other master

or remote stations as desired. Such switching means may include means for hooking up desired communication channels from one particular station to many branch stations so that the entire communication system may be put in a state of readiness to function as a warning system for dissemination of alarm from a central station to remote stations.

One known monitor system involves the application of DC through the wiring of the sound system. Transformers are eliminated. This simply indicates continuity of wiring and involves circuits which are primitive and inefficient.

Another known monitoring system relates to a bridge arrangement in the communication channel proper, the bridge being so arranged and balanced that so long as the loudspeaker portion of the system is electrically complete, the bridge should remain balanced. Such a system is not reliable because the small difference in impedance seen from the bridge between operative and inoperative conditions may result in no alarm when needed.

Apart from above, attempts have been made to insure reliable operation by duplication of systems or system elements. This involves extra equipment, greatly increases the cost and simply spreads the risk over a larger than normal number of elements.

### THE INVENTION GENERALLY

The invention hereinafter disclosed involves the transmission of a signal frequency over a sound system, including speakers, and applying a derived signal for monitoring the system, the signal frequency not being used for other than monitor purposes and not interfering with normal use for transmission of voice or music. The signal frequency may be below the range of frequencies normally used in the sound system but the frequency may also be above the limit of audibility, although this may not be as desirable for engineering reasons. At the output end of the sound channel going in the direction from channel input to channel output for normal warning operation, the signal frequency is used to energize the monitoring portion of the entire system. In a practical application of the invention, a signal frequency of the order of about 27 Hz. may be used and impressed at one end of the channel. The presence of such signal frequency may be used at the other end of the channel for indicating that the operativeness of the sound channel including speakers is unimpaired. The sound channel including transformers and speakers will be monitored as being operative and usable. The absence of a signal frequency will indicate an inoperative voice channel. The signal frequency may be any frequency below the lower limit of the useful voice range and is preferably somewhat different than a submultiple of any frequency defining such lower range. In many systems, 30 cycles or 60 cycles may be used as the lower limit of audibility, depending upon the quality of transmission to be achieved. This particular frequency, 27 Hz., is neither a submultiple of any strong frequency which may be present in the channel and may be generated by suitable means. The signal frequency is preferably introduced at the input end of the voice channel, this being the end where warning voice currents are introduced, the other end being where the warning voice currents are transformed into audible energy to be heard.

The signal frequency is introduced as electric potentials or currents in the voice channel at one end thereof or near one end thereof and such signal frequencies are transmitted generally in conventional fashion along the channel through switching means and particularly through transformers into the sound generating portion of the loudspeaker. The transmission at a satisfactory level of a signal frequency will indicate not only that the metallic circuit is complete but also that the transformers are functioning and that the speaker proper, particularly the voice coil portion thereof, is also functioning properly.

In general, the application of the invention to a sound system having at least one or more voice channels requires the use of a dynamic speaker having two electrically separate coils operating in the air gap of the magnetic portion of the system of the speaker. These two coils, one a voice coil and the other a sensing coil, must each be located within the annular magnetic air gap so that the voice coil may function as usual for diaphragm operation and create sound. The sensing coil must be able to have a voltage generated therein during diaphragm motion. Except for the speaker double coil arrangement, a system embodying the present invention uses conventional components readily available in the market. The signal frequency, which is preferably below the limit of audibility is introduced into the voice channel at a relatively low energy level so that no interference with speech or music frequencies will occur.

The signal frequency passes along the communication channel and functions to maintain the speaker diaphragm vibrating at signal frequency. The continuous oscillation of the voice coil in the speaker causes the sensing coil to be vibrated in the magnetic air gap and function as a voltage generator. The sensing coil is connected to a monitor system, which can indicate a normal, operating condition for the sound system so long as the signal frequency is present in the channel and speaker voice coil or will indicate an abnormal condition in the system which may prevent operation of the sound system.

Apart from the frequency of the signal, the energy level of such signal frequency is normally so low, compared to speech and/or music frequencies that when reproduced at a speaker, the signal will be substantially inaudible.

#### DESCRIPTION OF THE DRAWINGS

The invention will now be disclosed in connection with the drawings wherein:

FIG. 1 is a block diagram of a system embodying the present invention; and

FIG. 2 is a simplified view illustrating a loudspeaker having both voice coil and sensing coil used in connection with the invention.

#### DESCRIPTION OF A PREFERRED SPECIES

Referring first to FIG. 1, a generally conventional amplifier 10 is shown in diagrammatic form. This amplifier may either be a single stage or a number of stages for handling low power audio frequencies. The amplifier may be of the vacuum tube variety or preferably may be transistorized and has a conventional audio frequency input channel 11 which may be the output from a microphone, phonograph, or any other source of audio frequencies ranging up to a desired top limit, such as up to about 10 or 15 kHz. In addition to input

11 for voice or music currents, amplifier 10 has input channel 12 to which is supplied signal frequency voltages from source 14. Source 14 may consist of an oscillator for generating a signal frequency such as about 27 Hz. as an example. This signal frequency may be obtained from an R-C type of oscillator or any other convenient source. Preferably the signal wave is substantially sinusoidal to avoid the presence of harmonics.

It is preferred to have the signal voltage level fed into input 12 at a low level. The relative energy levels between the signal frequency and the normal sound voltages may be obtained in a variety of ways. As one example, the signal frequency may be introduced into the sound system channel at a later stage in the amplification portion of the entire system or the input level of the signal frequency may be set to be low enough with reference to the input along channel 11 so that the desired relative values of voltages will be as desired. The objective is to have the amplitude of signal frequency voltages low enough to be substantially inaudible at a speaker not merely because of the low frequency (if so) but because of the low energy level of operation as compared to the normal level of operation of the sound system as a whole.

Since the inputs along channels 11 and 12 are both generally in about the same broad range, the mixing thereof in an amplifier is simple. Thus, many audio frequency accessories such as microphone mixers, mixers for combining a microphone and tape recorder input or other accessories available on the market may be utilized. See for example, page 414 — mixing circuits, pads of The Electronic Engineering Handbook by Batchner and Moulic, pub. by Electronic Development Associates of N.Y., N.Y. in 1944. It is understood that channels 11 and 12 in practice will have a high potential wire and a ground wire in each of these channels.

The output of amplifier 10 is fed into audio frequency power amplifier 20. Again, as with amplifier 10, channel 21 between amplifiers 10 and 20 will in practice comprise at least two wires. Power amplifier 20 may be of the vacuum tube variety or may be transistorized, both such types of amplifiers being readily available. As a rule, power amplifier 20 is a current amplifier and will provide sufficient power in its output to operate a sound system. The output of amplifier 20 will be fed to wires 22 and 23 forming part of a communication channel. It is of course possible for power amplifier 20 to be of the push-pull variety in which case the channel there would have three wires, wires 22 and 23 being oppositely poled with a neutral wire provided. Inasmuch as such arrangements are well known, no detailed description thereof is deemed to be necessary.

Wires 22 and 23 terminate in primary winding 25 of audio frequency transformer 26. Such audio frequency transformers are well known and available. Other coupling means may also be used. Sometimes an audio frequency transformer or coupling may have a cut off at the lower end of its audio frequency range which cut off may be relied upon for signal frequency attenuation and this characteristic may be relied on at least in part for maintaining the signal frequency at a relatively low level with regard to the audio frequencies to be used in the normal sound system. Such audio frequency range may go up to any top limit such as 15 or 20 KHz and may extend down to the lowest range which may be about 30 Hz. or something more or less than this. In any

event, transformer 26 will usually be of the iron core variety. Transformer 26 has its secondary 27 connected by wires 28 and 29 to the terminals of voice coil 30 of a dynamic type loudspeaker 30a. An example of a loudspeaker which may be used is disclosed on page 408 FIG. B of the previously identified Handbook.

In accordance with the invention, a speaker forming part of the sound system so far described will have sensing winding 31 on the same bobbin 30b as voice coil 30, illustrated in FIG. 2. The voice and sensing coils can be wound on bobbin 30b in side-by-side relation to form one layer or may be in bifilar relation or in two layers or more on the bobbin or in any other relation providing that both the voice coil and the sensing coil can both operate within the magnetic field in the annular air gap. Sensing coil 31 must retain its cooperating relationship with magnetic field at least for small excursions of the bobbin from either direction of its normal rest position. The voice coil 30 functions in customary manner over the maximum amplitude range for the speaker.

Normally at lower audio frequencies, there will not be substantial transformer action between the two coils. At higher frequencies, some transformer action may occur. However, the signal frequency component in sensing coil 31 will always be present.

#### THE ALARM SYSTEM

Sensing winding coil 31 feeds its output in whole, or as illustrated in FIG. 1 and later explained, in part to low power amplifier 40 whose output 41 is fed into band pass filter 42, designed to pass the signal frequency, in this instance 27 Hz., through to filter output 43 into alarm switch 45. Alarm switch 45 is maintained in one condition (closed or open) so long as the signal frequency is present and will change its condition (to open or closed) when the signal frequency is absent. Thus, for example, alarm switch 45 may be locked into a conducting condition, as by bias, and will change to non-conducting condition in the absence of a signal frequency. Alarm switch 45 is preferably provided with manual alarm reset switch 46 for reset, alarm switch 45 preferably remaining in the tripped position due to the absence of the signal frequency even though the signal frequency is later restored. It is possible however to have alarm switch 45 of any type whatsoever so that it will change its condition in the absence of a signal frequency and restore itself or may remain tripped and require manual reset. Alarm switch 45 may also have local alarm light 47 and a signal channel 48 for remote alarm indication. Electronic switching is widely used, see Section 16-11, Switching Circuits, page 471 of Electronic Engineering by Seely, published 1956 by McGraw-Hill Book Co. Inc., New York, N.Y. This same book has a section 4-16 (page 95 and on) about Filters with cascaded amplifier stages, which can be a basis for the design of filter 42.

Insofar as the generation of a signal frequency is concerned, oscillators of the L-C type or of the R-C type are available and may be used to generate all kinds of wave shapes including sinusoidal. A signal frequency of about 27 Hz. sinusoidal wave is practical. Such a wave shape is readily handled by conventional electric filters. For example, a conventionally designed band pass filter for a mid frequency of 27 Hz. can pass a band from about 24 to about 30 Hz. The design of such filters is well within the skill of the art. Such filters may consist

of lumped inductance and/or capacitance; or may consist of resistors and capacitors and may include amplifiers of the vacuum tube or transistor variety. In practice, it is possible to use an integrated circuit containing the mixer preamplifier 10, the amplifier for low frequency oscillator 14; whatever amplifiers are necessary for filter 42 and possibly amplifier 40, depending upon the power level to be handled. As an example, amplifier type UA 741 manufactured by Signetics of Sunnyvale, Calif., is a linear integrated circuit and may be used, it being understood that external connections to utilize various functions of the integrated circuits must be made.

Referring now to alarm switch 45, this can simply be any suitable type of electronic switch which can have a normally open (or closed) condition to control the energization of an alarm circuit. Such an alarm system is preferably provided with a manual reset for the electronic switch system to restore the alarm switch system from a normal alarm indicating condition (when triggered) to an alarm sensing condition. In its simplest form, an alarm sensing means may consist of an amplifier of the vacuum tube variety or transistorized variety which may be biased to a non-conducting condition or may consist of a sensitive relay whose relay circuit may be kept open, any one of these systems being in a non-alarm condition maintained by the presence of the output of the signal frequency passed through filter 42. Alarm switch 45 in its simplest form can be a detector whose output is present only when the signal frequency is impressed thereon. In the absence of a signal frequency for any time, the alarm switch will close to actuate a visual or audible or both means, the alarm condition remaining, independently of the absence or presence of a signal frequency, until manual reset 46 is closed to lock the electronic switch or detector into normal condition. It is understood that the alarm system or detector is retained against a bias to prevent the alarm system from indicating an alarm condition. Once the alarm condition is shown, this will continue until manual reset, independently of the presence or absence of the signal frequency to the alarm switch.

Because of the low level of power generated in the sensing coil incident to the signal frequency vibration of the speaker operation, it is desirable to provide amplifiers and detectors and switch means whose sensitivity will be satisfactory for the requirements of the system. To that end, a biased multi-vibrator utilizing transistors is preferred. The arrangement is such that the multi-vibrator is maintained against this bias in a switch open position so long as a signal frequency is impressed upon the input of the vibrator. However, the absence of a signal frequency for as long a period as may be desired (from as little as one cycle to as much as several cycles of signal frequency) whereupon the multi-vibrator responds to its bias to close the electronic switch. As an example, a retriggerable monostable multi-vibrator type 9601 manufactured by Fairchild Semiconductor Corp. of Mountain View, Calif. This multi-vibrator is designated as TTL plus the remaining designations previously given and includes not only transistorized amplifiers but the multi-vibrator proper. External resistors and capacitors of suitable values are required for determining the operating characteristics of the multi-vibrator.

The use of integrated circuits is advantageous as the level of energy required for operation of the filter and alarm system is low and simplifies assembly.

It is possible to apply the invention to a single communication channel such as has been so far described. In such case, sensing coil 31 on a speaker will have its output fed into the input of amplifier 40. It is possible however to apply the invention to a multichannel sound system. The sound system depicted in FIG. 1 may, in a normal standby condition, have wires 22a and 23a connected across wires 22 and 23 for providing voice currents including relatively low level signal frequency currents to transformers 126; 226; 326 and so on, these various transformers having their primary windings connected in parallel across wires 22a and 23a. The secondaries of these transformers will be connected by wires to speakers similar to that described above wherein voice coils 130; 230; and 330 are respectively connected to the secondary output of transformers 126; 226; 326, etc. Each of the speakers is provided with its sensing coil 131; 231; 331 and so forth. The sensing coils 31 to 331 are connected in series to feed the input to amplifier 40.

As a practical matter, it is possible to have as many as about eight speakers, each one of which is similar to the speakers previously referred to, each speaker of which may be considered as a separate alarm station, all such speakers having their respective sensing coils connected in series as previously described. More than eight speakers may involve excessive potentials from the sensing coils to the input of amplifier 40, assuming that all the speakers in the group are functioning. However, as far as amplifier 40 is concerned, it is possible to utilize an amplifier having a wide range of voltage inputs. Insofar as the maximum number of remote stations is concerned, amplifiers 10 and 20 may be powerful enough to supply voice or music or signal frequencies to a large number of separate transformers similar to 26. If more than eight stations (assuming the maximum number to be handled by practical equipment is eight) then such additional stations may have their respective speaker sensing coils connected in series to the input of a different amplifier corresponding to 40 which can feed a different band pass filter, corresponding to 42, which, in turn, will feed its output to alarm systems such as has been described for filter 42. By using powerful individual speakers at stations, a wide area over which a warning may be broadcast orally is possible.

It is understood that a sound system as illustrated in FIG. 1 is shown in condition for disseminating sound or music as well as signal frequency from one station. However, complex switching facilities may provide intercommunication functions between various selected stations. In all cases, the signal frequency channel should always be functioning to provide the monitoring action. No attempt has been made to show such possible switching means, the drawing showing one or more sound channels connected to provide both sound (and music if required) transmission as well as signal fre-

quency injection and monitoring functions.

What is claimed is:

1. A system for indicating the operativeness of a sound channel including at least one speaker at an output end of said channel, said system having an input for a range of sound frequencies in the form of electric potentials, means for generating electric potentials at a signal frequency, means for introducing said signal frequency potentials into the channel to mix with potentials corresponding to sound frequencies normally transmitted along said channel to said speaker, said speaker being of the dynamic type having a voice coil movable axially in an annular magnetic air gap, said speaker normally being continuously energized by said signal frequency potentials as well as by sound frequency potentials, means for generating a potential from the vibration of said voice coil, said last named means including a sensing coil in proximity to said voice coil and vibrating therewith in said magnetic air gap, means for amplifying said generated potentials and filtering to derive signal frequency potentials when said channel is transmitting signal frequency potentials, and connections to feed such potentials to an alarm system having positions corresponding to the presence or absence of signal frequency potentials whereby the presence of signal frequency potentials generated in the sensing coil will indicate that the channel including the speaker is operative for communication purposes and said alarm system, in case of interruption of said signal frequency will indicate a fault.

2. The system according to claim 1, wherein said signal frequency potentials are introduced into the channel at a low energy level so that signal frequency reproduction is substantially inaudible.

3. The system according to claim 1, wherein a plurality of sound channels are provided, said channels having a common input and individual outputs, each channel having a speaker with its own voice coil and its own sensing coil and means for connecting the sensing coils in series to said amplifying and filtering means.

4. A method of monitoring a sound system communication channel terminating in a loudspeaker of the dynamic type having a voice coil axially movable within an annular magnetic air gap, said method comprising injecting into said channel signal currents at a fixed frequency and at a low energy level compared to sound currents at different frequencies in said channel, feeding said signal currents to said speaker to produce air waves below audibility, deriving potentials incident to voice coil motion in said speaker at frequencies of voice coil vibrations, filtering said derived potentials to suppress frequencies outside of said signal frequency and feeding such potentials to an alarm system of the type whose condition is responsive to the presence or absence of signal frequency potentials.

5. The method according to claim 4, wherein the signal frequency is below the audio frequency spectrum normally handled by the sound system.

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