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(54) **Loudspeaker line examination system**

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Description

5 **[0001]** This invention relates to a public address system having a loudspeaker line examination system for examining whether there are any problems such as line breakage or short-circuiting in loudspeaker lines in the public address system built in a building or the like.

10 **[0002]** An example of prior examination systems of the above-described type is disclosed in Patent Literature 1. In a public address system according to Patent Literature 1, a plurality of loudspeakers are connected to a loudspeaker line in parallel with each other, and a power amplifier is connected to the loudspeaker line. An audio signal and a test signal are combined in a stage preceding a power amplifier, and the power amplifier amplifies the resultant composite signal and applies it to the loudspeaker line. The test signal is a signal at a constant voltage. A detecting circuit is disposed in the output of the power amplifier, which includes a filter deriving test signal current flowing to respective loudspeakers through the loudspeaker line. Since the voltage of the test signal is constant, an output signal of the filter represents a composite impedance of the loudspeaker line and the respective loudspeakers. In the loudspeaker line examination system disclosed in Patent Literature 1, the value of the output signal of the filter is compared with a threshold value for use in detecting line breakage and a threshold value for use in detecting short-circuiting, to judge whether line breakage or short-circuiting has occurred. The examination system uses, as a reference value, the value of the filter output signal developed when the loudspeaker line operates properly, and uses a value resulting from adding a first predetermined value to the reference value as the line breakage detection threshold value, and a value resulting from subtracting a second predetermined value from the reference value as the short-circuiting detection threshold value.

20 Patent Literature 1: JP 2007-37024 A

25 **[0003]** As described, the background art examination system determines the two threshold values, using the value of the output signal of the filter developed when the loudspeaker line is in the proper operating state, and, therefore, in order to detect line breakage and short-circuiting with high accuracy, these threshold values must be set accurately. However, sometimes there is a large difference between the output signal value measured by the described examination system for determination of the threshold values, and the output signal value measured thereafter in the normal operating state in which there is no loudspeaker line breakage or short-circuiting occurred. For example, there may be a difference between the output signal value measured when only the test signal is supplied to the loudspeaker line, and the output signal value measured in the normal use of the public address system in which the audio signal at various frequencies and the test signal are supplied to the loudspeaker. The difference in value is significant when the level of the audio signal is larger than the level of the test signal. Accordingly, the examination system of the background art may make an erroneous judgment as if there were line breakage or short-circuiting, while the loudspeaker line is in the proper operating conditions, which erroneous judgment is caused by accurate setting of the first and second values.

30 **[0004]** An object of the present invention, therefore, is to provide an examination system which can make accurate detection of line breakage or impedance decrease in a loudspeaker line, with such erroneous judgment minimized as much as possible.

35 **[0005]** According to the present invention there is provided a public address system according to claim 1. The test signal may be an analog signal, or an analog signal resulting from converting a digital signal by a digital-to-analog converter. The impedance determining means can determine the impedances by deriving a voltage and current of the test signal contained in the amplifier output. Alternatively, the impedance determining means may perform frequency analysis of the amplifier output as described later, to derive frequency components of the test signal, to thereby determine impedances corresponding to the frequency of the test signal. When the ratio of the resultant composite signal to the test signal is larger than a predetermined value, and the resultant composite signal is increasing, threshold revising means revises the threshold values in the direction to lower the degree of accuracy of judgment made in the judging means. The threshold values are set based on the impedances measured, while only the test signal is being supplied from the amplifier to the loudspeaker line.

40 **[0006]** The ratio of the composite signal to the test signal being large means that the proportion of the audio signal in the composite signal is large, and that the impedances of the loudspeaker line and the loudspeakers are under the influence of the audio signal. Therefore, erroneous judgment may result if the current threshold value is used, which is the reason why the threshold value is revised.

45 **[0007]** When the tendency of the composite signal to increase changes to the tendency to decrease, the threshold revising means may raise the degree of judgment accuracy which was lowered when the composite signal was increasing. In this case, the rate of change in the direction to lower the judgment accuracy is larger, and the rate of change in the direction to raise the judgment accuracy is smaller.

50 **[0008]** When the impedance of the loudspeaker line and the loudspeakers changes due to, for example, increase of the level of the audio signal, some time period may be necessary for the impedance to return to the original level from the level to which they changed, even when the level of the audio signal decreases. In order to cope with such situation, a smaller rate of change in the direction to raise the degree of judgment accuracy is employed.

55 **[0009]** Since the test signal contains different frequency components, and the impedances are determined based on

these two frequency components, with these impedances being compared with the threshold values, it is possible to judge, with a higher degree of accuracy, at least one of open-circuiting of the loudspeaker line and the loudspeakers and impedance decrease.

[0010] In the above-described embodiment, the impedance determining means may determine the impedances in a time period during which the audio signal source stops operating. In such case, threshold setting means sets the threshold values based on the determined impedances.

[0011] The impedances of the loudspeaker line and loudspeakers change with time. Accordingly, if the threshold values set on the basis of the impedances of the loudspeaker line and loudspeakers determined at a certain time is continuously used, a difference may be arisen between the actual impedances of the loudspeaker line and loudspeakers and the impedance of the loudspeaker line and loudspeakers determined for use in determining the threshold values. Therefore the impedance of the loudspeaker line and loudspeakers is determined during a time period during which no audio signal is supplied, and the threshold values are set on the basis of the thus determined impedance, in order to avoid erroneous judgment. Furthermore, by judging whether the thus determined impedance Z is within the allowable range or not, it is possible to know when the loudspeakers should be replaced.

[0012] The impedance determining means may include current detecting means for detecting current flowing through the loudspeaker line, and voltage detecting means for detecting a voltage applied to the loudspeaker line. In such case, frequency component detecting means detects the frequency components of the test signal contained in the detected current and in the detected voltage. The detection of the frequency components may be done by the cross-spectrum analysis of the detected current and voltage, for example. Operating means computes the impedance from the detected test signal frequency components.

[0013] Since the impedance of the loudspeaker line and loudspeakers is measured based on the test signal components as described above, the impedance of the loudspeaker line and loudspeakers can be measured without being affected by the audio signal.

[0014] In order that the invention may be well understood, there will now be described an embodiment thereof, given by way of example, reference being made to the accompanying drawings, in which:

FIGURE 1 is a block diagram of a public address system with a loudspeaker examination system according to a first embodiment of the invention.

FIGURE 2 is a flow chart of frequency analyzing processing performed by a DSP of the examination system of FIGURE 1.

FIGURE 3 is a flow chart of root-mean-square value measuring processing performed by the DSP of the examination system of FIGURE 1.

FIGURE 4 is a flow chart of short-circuiting, line breakage and impedance increase judging processing performed by the DSP of the examination system of FIGURE 1.

FIGURE 5 is a flow chart of threshold revising processing performed by the DSP of the examination system of FIGURE 1.

FIGURE 6 is a detailed flow chart of Zopen and Zinc revising processing in the threshold revising processing of FIGURE 5.

FIGURE 7 is an illustration of change a degree of measurement accuracy R_a as revised according to the processing of FIGURE 6.

FIGURE 8 is a detailed flow chart of Z1open and Z1inc computation in the Zopen and Zinc revising processing of FIGURE 6.

FIGURE 9 is a flow chart of aging judging processing performed by the DSP of the examination system of FIGURE 1.

[0015] An examination system according to one embodiment of the present invention is embodied in a public address system like the one shown in FIGURE 1. The public address system is a system for announcing in various places in, for example, a large-scale store. The public address system includes a signal source 2 providing an audio signal. The signal source 2 may be, for example, a sound source for providing background music over the store, or a microphone through which information about the store and emergency announcement is given. The audio signal from the signal source 2 is applied through a notch filter 3 to an amplifier, e.g. a power amplifier 4, where the audio signal is amplified, and applied to a plurality of loudspeakers 8 through a loudspeaker line 6 connected to the output of the power amplifier 4. The notch filter 3 is used to attenuate those frequency components of the audio signal which are the same as frequency components of a later-described test signal for the purpose of avoiding interference with the test signal. Accordingly, a circuit arrangement may be employed in which the audio signal is inputted to the amplifier through the notch filter 3 only when the test signal is being outputted, and is inputted to the amplifier without passing through the notch filter 3 while the test signal is not being outputted. In place of the notch filter 3, a low-pass filter and/or a high-pass filter may be used. The loudspeakers are disposed at various locations in the store. In FIGURE 1, although only one loudspeaker line 6 is shown, the loudspeaker line 6 is actually composed of a pair of lines. The loudspeakers 8 are actually connected between

the pair of loudspeaker lines 6 in parallel with each other.

[0016] The examination system includes a DSP (digital signal processor) 10 functioning as a signal source of the test signal at an inaudible frequency. The DSP 10 provides a digital test signal as the test signal. The digital test signal is converted to an analog test signal in a D/A (digital-to-analog) converter 12. The analog test signal and the audio signal from the signal source 2 are combined in a combiner 13. The resultant composite signal from the combiner 13 is applied to the power amplifier 4. The analog test signal is a signal containing two frequency components at, for example, 40 Hz and 20 KHz, and has a constant voltage value. Generally, the human audio frequency band is from 20 Hz to 20 KHz. The loudspeakers 8 are so designed as to give optimum sound in this human audio frequency band. The test signal is used for the purpose of measuring a composite impedance of the loudspeaker line and loudspeakers 8 connected in parallel to the loudspeaker line. Accordingly, although the frequency of the test signal desirably is within the audio frequency band, it is not desirable for the test signal components in the resultant signal, which results from combining the test signal with the audio signal, to be delivered as noise to human ears. Then, the frequency of the test signal uses both of a frequency near the lowest frequency and a frequency near the highest frequency within the audio frequency band which is or are hard for human ears to sense. The loudspeakers 8 are supplied with the audio signal and the test signal as amplified in the power amplifier 4. The test signal is continuously supplied to the combiner 13 from the D/A converter 12. The audio signal is not supplied to the combiner 13 when it is not required. Alternatively, the audio signal from the signal source 2 may be A/D (analog-to-digital) converted before being combined with the test signal. In such case, the resultant composite signal is applied to the D/A converter 12.

[0017] A current detecting circuit 14 is connected in series in the output of the power amplifier 4. The current detecting circuit 14 detects the output current supplied from the power amplifier 4 to the loudspeaker line 6. Also, a voltage detecting circuit 16 is disposed in parallel in the output of the power amplifier 4. The voltage detecting circuit 16 detects the output voltage applied from the power amplifier 4 to the loudspeaker line 6.

[0018] The output signal of the current detecting circuit 14 and the output signal of the voltage detecting circuit 16 are digitized in A/D converters 18 and 20, respectively, before being applied to the DSP 10. Hereinafter, the digitized version of the output signal of the current detecting circuit 14 is referred to as a digital current detection signal, and the digitized version of the output signal of the voltage detecting circuit 16 is referred to as a digital voltage detection signal.

[0019] The DSP 10 processes the digital current detection signal, the digital voltage detection signal and the digital test signal, and judges whether the respective loudspeakers 8 and the loudspeaker line 6 are broken or short-circuited, or whether the impedance of the loudspeakers 8 and the loudspeaker line 6 have significantly decreased. The result of judgment is notified by a notification device 28. The notification device may be, for example, a display device, on which the result of judgment is displayed.

[0020] In the DSP 10, each time the successively supplied digital current detection and digital voltage detection signals are inputted to the DSP 10, the frequency analyzing processing shown in FIGURE 2 is performed.

[0021] In the frequency analyzing processing, noise frequency components are first removed from the digital current detection and digital voltage detection signals in a band-pass filter (Step S2). Then, the digital current detection and digital voltage detection signals from which noise frequency components have been removed are averaged (Step S4). Specifically, the DSP 10 is provided therein with memories equal in number to the digital current detection and digital voltage detection signals in one cycle of the test signal, and each time the digital current detection and digital voltage detection signals are supplied to the DSP 10 from the band-pass filter, they are stored in the corresponding memories over a plurality of cycles. The stored values in the memories are divided by the number of the plural cycles. The thus averaged digital current detection and digital voltage detection signals are subjected to cross-spectrum analysis to determine the correlation between the test signals contained in the digital current detection and digital voltage detection signals, and an impedance Z1 at the frequency of 20 KHz, an impedance Z2 at the frequency of 40 Hz, and the coherence of the digital current detection and digital voltage detection signals in the test signal are computed (Step S6). It should be noted that when the DSP 10 has high processing ability, Steps S2 and S4 may be skipped, and only the cross-spectrum analysis in Step S6 is sufficient.

[0022] If it is determined from the coherence that there are many frequency components other than the test signal frequency components, the DSP 10 raises the voltage of the constant-voltage test signal.

[0023] Subsequent to the processing shown in FIGURE 2, the root-mean-square values V_{rms} and I_{rms} of the digital voltage detection and digital current detection signals are computed as shown in FIGURE 3 (Step S8).

[0024] Next, as shown in FIGURE 4, using the impedances Z1 and Z2 obtained by the above-described cross-spectrum analysis and the root-mean-square value I_{rms} of the digital current detection signal, judgment is made as to whether any one of short-circuiting, decrease in impedance (increase of output current of the power amplifier 4) and open-circuiting has occurred in the loudspeaker line 6 and the loudspeakers 8.

[0025] First, judgment is made as to whether the root-mean-square value I_{rms} of the digital current detection signal is larger than a predetermined threshold value, e.g. a short-circuiting current value I_{sl} of the loudspeaker line, or whether the measured impedance Z1 is smaller than a predetermined threshold value, e.g. a short-circuiting impedance $Z1_{sl}$ at 20 KHz of the loudspeaker line 6 and the loudspeakers 8, and, at the same time, the measured impedance Z2 is larger

than a predetermined threshold value, e.g. a short-circuiting impedance Z_{2sl} at 40 Hz of the loudspeaker line 6 and the loudspeakers 8 (Step S14). The short-circuiting current I_{sl} and the short-circuiting impedances Z_{1sl} and Z_{2sl} are predetermined in view of the protection of the loudspeaker line 6 and the loudspeakers 8. If the answer to the query in Step S14 is YES, from which it is judged that there is short-circuiting in the loudspeaker line 6 etc., such short-circuiting is indicated on the display device (Step S16), and this judgment processing is ended.

[0026] When the answer to the query in Step S14 is NO, judgment is made as to whether the measured impedance Z_1 is smaller than the lower limit value Z_{1inc} for 20 KHz or whether the impedance Z_2 is smaller than the lower limit value Z_{2inc} for 40 Hz (Step S18). The lower limit values Z_{1inc} and Z_{2inc} are explained later. When the answer to the query in Step S18 is YES, which means that, while the loudspeaker line current has not yet increased to the value indicating short-circuiting, the output current from the power amplifier 4 has increased to some extent and requires some caution, current increase is displayed (Step S20), and this judgment is ended.

[0027] If the answer to the query in Step S18 is NO, judgment is made as to whether the measured impedance Z_1 is larger than the upper limit value Z_{1open} for 20 KHz or whether the impedance Z_2 is larger than the upper limit value Z_{2open} for 40 Hz (Step S22). The upper limit values Z_{1open} and Z_{2open} are explained later. When the answer to the query in Step S22 is YES, from which it is judged that open-circuiting has happened in the loudspeaker line 6 and the loudspeakers 8, open-circuiting is displayed (Step S24), and this judgment is ended.

[0028] In making the above-described judgments, the upper limit values Z_{1open} and Z_{2open} and the lower limit values Z_{1inc} and Z_{2inc} are used. These values are determined, based on a reference impedance Z_{1ave} at 20 KHz and a reference impedance Z_{2ave} at 40 Hz of the loudspeaker line 6 and loudspeakers 8, respectively. The reference impedances Z_{1ave} and Z_{2ave} are set by a worker when the worker initializes the public address system on the first use after its installation, or are set by the worker when the public address system is re-initialized for some reason. Sometimes, however, it may happen that there are large differences between these reference impedances Z_{1ave} and Z_{2ave} and the impedances Z_1 and Z_2 measured afterwards in a normal condition where there is no line breakage or short-circuiting in the loudspeaker line 6 and loudspeakers 8. For example, if the impedances Z_1 and Z_2 are measured during the usual operation of the public address system, with an audio signal having various frequencies and the test signal being supplied to the loudspeaker line 6, there is a possibility that the measured impedance Z_1 is different from the reference impedance Z_{1ave} and the impedance Z_2 is different from the reference impedance Z_{2ave} . The differences in value are significant particularly when the level of the audio signal is larger than that of the test signal. Then, as shown in FIGURE 5, after the above-described judgment is done, the upper limit values Z_{1open} and Z_{2open} and the lower limit values Z_{1inc} and Z_{2inc} , which are prepared based on the reference impedances Z_{1ave} and Z_{2ave} , are subjected to revising processing.

[0029] In the revising processing, judgment is first made as to whether the root-mean-square value V_{rms} of the digital voltage detection signal is larger, by a predetermined factor, e.g. 1.2, or more, than the root-mean-square voltage value V_{test} of the digital test signal (Step S26). If the answer is YES, it is judged that many components at the same frequencies as the test signal are contained in the audio signal. Then, the computation processing for revising the upper limit values Z_{1open} and Z_{2open} and the lower limit values Z_{1inc} and Z_{2inc} is executed (Step S28). It should be noted that the predetermined factor is not limited to 1.2.

[0030] In the revising computation processing in Step S28, a degree of measurement accuracy R_a of the measured impedances Z_1 and Z_2 is used. The unit of the degree of measurement accuracy R_a is percent (%). The smaller the value, the degree of measurement accuracy of the impedance Z_1 , Z_2 is higher, and the larger the value, the degree of measurement accuracy R_a of the impedance Z_1 , Z_2 is lower. The degree of measurement accuracy R_a is set to the smallest value, for example, 5 %, when V_{rms} is equal to V_{test} . As shown in FIGURE 6, judgment is made, in the revision computation processing in Step S28, as to whether the digital voltage detection signal V_{rms} is larger than the digital voltage detection signal ΔV_{rms} used in the previous revision computation processing (Step S30). When the answer to the query made in Step S30 is YES, which means that audio signal components, except the test signal, at the same frequencies as the test signal, have increased from the previous revision computation processing, the value of the degree of measurement accuracy R_a must be revised to a great extent. For that purpose, computation,

$$R_a = \beta R_a + \alpha f(V_{rms}/V_{test}),$$

is carried out. In this equation, α and β are predetermined factors, and there are relationship between α and β , that $\alpha + \beta = 1$ and $\alpha > \beta$. The function $f(V_{rms}/V_{test})$ is a function with an argument V_{rms}/V_{test} , and its value increases when the value of V_{rms}/V_{test} is increasing and decreases when the value of V_{rms}/V_{test} is decreasing. Thus, since the value of V_{rms}/V_{test} is changing greatly and $\alpha > \beta$, the proportion of $\alpha f(V_{rms}/V_{test})$ in the revised degree of measurement accuracy R_a is large, and, the revised degree of measurement accuracy R_a increases rapidly when the value of V_{rms}/V_{test} is increasing, as shown in the first half portion of FIGURE 7.

[0031] When the answer to the query made in Step S30 is NO, which means that audio signal components at the

same frequencies as the test signal, except the test signal, present when the previous revision was performed, have decreased, the degree of measurement accuracy R_a is revised to have a smaller value. The rate of change in the decreasing direction, however, is smaller. For that purpose, a computation,

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$$R_a = \alpha R_a + \beta f(V_{rms}/V_{test})$$

is performed. Since the value of V_{rms}/V_{test} is smaller, $f(V_{rms}/V_{test})$ is also smaller. Since $f(V_{rms}/V_{test})$ is multiplied by β , which is smaller than α , the proportion of $\beta f(V_{rms}/V_{test})$ in the revised R_a is small, and the value of the revised R_a gradually decreases when the value of V_{rms}/V_{test} is decreasing, as is seen in the latter half portion of FIGURE 7.

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[0032] Using the thus revised degree of measurement accuracy R_a , the computations of Z_{1open} , Z_{2open} , Z_{1inc} and Z_{2inc} are performed (Step S36). For use in the next execution of Step S30, V_{rms} is memorized as ΔV_{rms} (Step S38).

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[0033] The computation of Z_{1open} and Z_{1inc} in Step S36 is done in the manner shown in FIGURE 8. First, judgment is made as to whether the degree of measurement accuracy R_a is larger than an impedance open-circuiting proportion initial value R_{ul} (Step S40). The impedance open-circuiting proportion initial value R_{ul} is expressed in percent (%), and is a proportion of the upper limit impedance to the reference impedance (Z_{1ave} , Z_{2ave}). The upper limit impedance is the impedance at which the loudspeaker line 6 etc. can be considered to have been open-circuited, with the degree of measurement accuracy R_a being highest, or, in other words, with R_a having the smallest value. The impedance open-circuiting proportion initial value R_{ul} is set by the worker at the time of initialization or re-initialization of the system, and is used for both Z_{1open} and Z_{2open} . When the answer to the query made in Step S40 is NO, it is not necessary for the degree of measurement accuracy R_a to be increased above the impedance open-circuiting proportion initial value R_{ul} , and, therefore, Z_{1open} is computed according to

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$$Z_{1open} = Z_{1ave}(1 + R_{ul}/100)$$

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(Step S42).

[0034] If the answer to the query made in Step S40 is YES, it is necessary to revise Z_{1open} based on the degree of measurement accuracy R_a , and Z_{1open} is computed (Step S44) according to

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$$Z_{1open} = Z_{1ave}(1 + R_a/100).$$

[0035] Following Step S42 or S44, judgment is made as to whether Z_{1open} is larger than an upper limit value Z_{1ul} of the impedance at 20 KHz (Step S46). The upper limit impedance value Z_{1ul} is the upper limit value of the impedance expected to actually occur at 20 KHz when the loudspeaker line 6 etc. are open-circuited. The upper limit value Z_{1ul} is manually set by the worker at the time of initialization or re-initialization of the system. Alternatively, Z_{1ave} measured by DSP 10 at the time of initialization or re-initialization of the system is multiplied by a factor greater than 1, and the resultant product is set as the upper limit value Z_{1ul} . The reason why the judgment in Step S46 is done is that it is sometimes possible for the value of Z_{1open} revised based on the degree of measurement accuracy R_a to be an impossible value. When the answer to the query made in Step S46 is YES, Z_{1open} is used as Z_{1ul} (Step S48) since it is impossible that Z_{1open} is greater than Z_{1ul} .

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[0036] Subsequent to Step S48, or when the answer to the query made in Step S46 is NO, judgment is made as to whether the degree of measurement accuracy R_a is larger than an impedance increase proportion initial value R_{II} (Step S50). The impedance increase proportion initial value R_{II} is a value resulting from subtracting 1 (unity) from the reciprocal of the proportion of the reference impedance (Z_{1ave} or Z_{2ave}) to the impedance at which the impedance of the loudspeaker line 6 and the loudspeakers 8, when the degree of measurement accuracy R_a is highest, can be considered to have decreased. The impedance increase proportion initial value R_{II} is expressed in percent (%). The impedance increase proportion initial value R_{II} is set by the worker when the system is initialized or re-initialized, and is used for both of Z_{1inc} and Z_{2inc} . If the answer to the query in Step 50 is NO, Z_{1inc} is computed (Step S52) according to

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$$Z_{1inc} = Z_{1ave}(1 + R_{II}/100)$$

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since it is not necessary to decrease the degree of measurement accuracy R_a below R_{II} .

[0037] if the answer to the query made in Step S50 is YES, it is necessary to revise Z_{1inc} according to the degree of measurement accuracy R_a , and, therefore, Z_{1inc} is computed (Step S54) according to

$$Z1inc = Z1ave/(1 + Ra/100).$$

[0038] Subsequent to Step S52 or S54, judgment is made as to whether Z1inc is smaller than a lower limit value Z1ll of the impedance Z1 at 20 KHz (Step S56). The impedance lower limit value Z1ll is the lower limit value at 20 KHz at which impedance decrease is expected to actually occur while no short-circuiting has occurred in the loudspeaker line 6 or the loudspeakers 8. The lower limit value Z1ll is manually set by the worker at the time of initialization or re-initialization of the system. Alternatively, the product of Z1ave measured by the DSP 10 at the time of initialization or re-initialization of the system multiplied by a factor smaller than 1 (unity) is set as the lower limit value Z1ll. Step S56 is executed since Z1inc revised in Step S54 sometimes takes a value which it cannot actually take. If the answer to the query made in Step S56 is YES, Z1inc is adopted as Z1ll (Step S58) since it is impossible for Z1inc to be smaller than Z1ll. When the execution of Step S58 is finished or if the answer to the query made in Step S56 is NO, the processing for computing Z1open and Z2open is ended.

[0039] By the processing similar to the ones described above, Z2open and Z2inc are computed, using the impedance open-circuiting proportion initial value Rul, the impedance increase proportion initial value Rll, an upper limit value Z2ul of the impedance Z2 at 40 Hz, a lower limit value Z2ll of the impedance Z2 at 40 Hz, and the reference impedance Z2ave of the impedance Z2 at 40 Hz. Description of this processing is not made.

[0040] Let it be assumed, for example, that Z2ave is 1,000 Ω , Z2ul is 2,000 Ω , Z2ll is 500 Ω , Z2s1 is 20 Ω , Z1ave is 1,500 Ω , Z1ul is 3,000 Ω , Z1ll is 750 Ω , Z1sl is 30 Ω , Isl is 5 A, Rul is 10 %, Rll is 10 %, Ra is 5 %, and Vtest is 5 V. The Ra of 5 % is the highest degree of accuracy. A state in which Vrms is 5 V is maintained, with the above-assumed values maintained, since Ra < Rul, Z1open and Z2open are:

$$Z2open = 1,000 \Omega \times (1 + 5/100) = 1,050 \Omega$$

$$Z1open = 1,500 \Omega \times (1 + 5/100) = 1,575 \Omega$$

Also, since Ra > Rll, Z2inc and Z1inc are:

$$Z2inc = 1,000 \Omega / (1 + 5/100) = 952 \Omega$$

$$Z1inc = 1,500 \Omega / (1 + 5/100) = 1,428 \Omega$$

[0041] In this condition, if the measured impedance Z2 is 1,000 Ω and the measured impedance Z1 is 1,500 Ω , it is judged by the processing shown in FIGURE 4 that the loudspeaker line is in the proper state. Similarly, if the measured impedances Z2 and Z1 are 1,100 Ω and 1,500 Ω , respectively, it is judged by the processing shown in FIGURE 4 that open-circuiting is present. If the measured impedances Z2 and Z1 are 1,100 Ω and 1,600 Ω , respectively, it is judged by the processing shown in FIGURE 4 that open-circuiting is present. If the measured impedances Z2 and Z1 are 1,000 Ω and 1,400 Ω , respectively, it is judged by the processing shown in FIGURE 4 that increase has occurred. If the measured impedances Z2 and Z1 are 15 Ω and 10 Ω , respectively, it is judged by the processing shown in FIGURE 4 that short-circuiting has occurred.

[0042] Let it be assumed that a condition in which the audio signal contains components at the same frequencies as the test signal to some extent, in addition to the test signal, and Vrms is larger than Vtest, for example, Vrms is 10 V, continues for some time, resulting in rapid increase of Ra to, for example, 50 %, due to the processing shown in FIGURE 6. Since Ra > Rul,

$$Z2open = 1,000 \Omega \times (1 + 50/100) = 1,500 \Omega$$

$$Z1open = 1,500 \Omega \times (1 + 50/100) = 2,250 \Omega$$

Also, since Ra > Rll,

$$Z2_{inc} = 1,000 \Omega / (1 + 50/100) = 667 \Omega$$

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$$Z1_{inc} = 1,500 \Omega / (1 + 50/100) = 1,000 \Omega$$

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[0043] In this condition, if the measured impedance Z2 is 1,100 Ω and the measured impedance Z1 is 1,600 Ω , it is judged by the processing shown in FIGURE 4 that the loudspeaker line is in the normal state. If the measured impedances Z2 and Z1 are 2,300 Ω and 1,000 Ω , respectively, it is judged by the processing shown in FIGURE 4 that open-circuiting has occurred. If the measured impedances Z2 and Z1 are 1,400 Ω and 600 Ω , respectively, it is judged by the processing shown in FIGURE 4 that current has increased. If the measured impedances Z2 and Z1 are 15 Ω and 10 Ω , respectively, it is judged by the processing shown in FIGURE 4 that short-circuiting has occurred.

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[0044] Let it be assumed that a condition in which the audio signal contains, in addition to the test signal, a large amount of components at the same frequencies as the test signal, and V_{rms} is significantly larger than V_{test} , for example, V_{rms} is 30 V, continues for some time, resulting in rapid increase of R_a to, for example, 300 %, due to the processing shown in FIGURE 6. Since $R_a > R_{ul}$,

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$$Z2_{open} = 1,000 \Omega \times (1 + 300/100) = 4,000 \Omega$$

$$Z1_{open} = 1,500 \Omega \times (1 + 300/100) = 6,000 \Omega$$

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However, since $Z2_{open} > Z2_{ul}$ and $Z1_{open} > Z1_{ul}$, $Z2_{open}$ and $Z1_{open}$ are changed to:

$$Z2_{open} = Z2_{ul} = 2,000 \Omega$$

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$$Z1_{open} = Z1_{ul} = 3,000 \Omega$$

Also, since $R_a > R_{II}$,

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$$Z2_{inc} = 1,000 \Omega / (1 + 300/100) = 250 \Omega$$

$$Z1_{inc} = 1,500 \Omega / (1 + 300/100) = 375 \Omega$$

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Since $Z2_{inc} < Z2_{II}$ and $Z1_{inc} < Z1_{II}$, $Z2_{inc}$ and $Z1_{inc}$ are changed to:

$$Z2_{inc} = Z2_{II} = 500 \Omega$$

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$$Z1_{inc} = Z1_{II} = 750 \Omega$$

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[0045] In this condition, if the measured impedance Z2 is 1,000 Ω and the measured impedance Z1 is 1,600 Ω , it is judged by the processing shown in FIGURE 4 that the loudspeaker line is normal. If the measured impedances Z2 and Z1 are 2,500 Ω and 2,800 Ω , respectively, it is judged by the processing shown in FIGURE 4 that open-circuiting has occurred. If the measured impedances Z2 and Z1 are 400 Ω and 1,000 Ω , respectively, it is judged by the processing shown in FIGURE 4 that current has increased. If the measured impedances Z2 and Z1 are 15 Ω and 10 Ω , respectively, it is judged by the processing shown in FIGURE 4 that short-circuiting has occurred.

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[0046] Even if the state in which V_{rms} is 30 V returns to the state in which V_{rms} is 10 V, for example, R_a does not change to 50 %, but only decreases slightly, due to the processing of Step S34 in FIGURE 6. Accordingly, $Z2_{open}$ slightly decreases from 4,000 Ω , $Z1_{open}$ slightly decreases from 6,000 Ω , $Z2_{inc}$ slightly increases from 500 Ω , and $Z1_{inc}$ slightly increases from 750 Ω . With this arrangement, if, for example, the loudspeakers 8 generate heat due to a

large value of V_{rms} , and it takes a long time for the temperature of the loudspeakers 8 to return to the temperature before they began to generate heat, erroneous judgment can be avoided since it takes a long time for Z_{1open} , Z_{2open} , Z_{1inc} and Z_{2inc} to return to their values before the heat generation occurred.

[0047] In this examination system, the reference impedances Z_{1ave} and Z_{2ave} at 20 KHz and 40 Hz of the loudspeaker line 6 and the loudspeakers 8 are measured prior to the application of the audio signal, and judgment is made as to whether the reference impedance Z_{1ave} is between predetermined allowable aging upper and lower limit values Z_{1UL} and Z_{1LL} for 20 KHz, or whether the reference impedance Z_{2ave} is between predetermined allowable aging upper and lower limit values Z_{2UL} and Z_{2LL} for 40 Hz. Specifically, as the public address system is operated for a long time, the impedance of the loudspeakers 8 changes due to aging, and the reference impedances Z_{1ave} and Z_{2ave} also change as the impedance of the loudspeakers 8 changes. Judgment is made as to whether the reference impedance Z_{1ave} is within an allowable range defined by the allowable upper limit Z_{1UL} and the allowable lower limit Z_{1LL} , which are the limits for 20 KHz indicating the necessity for replacement of the loudspeakers, or whether the reference impedance Z_{2ave} is within an allowable range defined by the allowable upper limit Z_{2UL} and the allowable lower limit Z_{2LL} , which are the limits for 40 Hz indicating the necessity for replacement of the loudspeakers. If the reference impedance Z_{1ave} is outside the allowable range defined by the allowable upper limit Z_{1UL} and the allowable lower limit Z_{1LL} , or if the reference impedance Z_{2ave} is outside the allowable range defined by the allowable upper limit Z_{2UL} and the allowable lower limit Z_{2LL} , an indication to recommend the replacement of loudspeakers is displayed on the notification device 28. Such judgment is made at a time when the public address system is not in use. For example, if the public address system is installed in a store, the judgment is made everyday at a given time within a time period after the store is closed and before the store is opened.

[0048] As shown in FIGURE 9, whether the time for examination comes or not is judged (Step S60). If the answer to the query made in Step S60 is NO, the processing is ended. If the answer is YES, the DSP 10 provides the test signal (Step S62). Then, the reference impedances Z_{1ave} and Z_{2ave} are measured in the manner described with reference to FIGURE2 (Step S64). Judgment is made as to whether Z_{1ave} is within the above-described allowable range defined by Z_{1UL} and Z_{1LL} and, at the same time, whether Z_{2ave} is within the above-described allowable range defined by Z_{2UL} and Z_{2LL} (Step S66). If the answer to the query made in Step S66 is NO, an error notification is displayed on the notification device 28 (Step S68) to recommend replacement of a loudspeaker. If the answer is YES, the measured Z_{1ave} and Z_{2ave} are stored (Step S70). The execution of the processing of Step S70 renews Z_{1ave} and Z_{2ave} for use in computing Z_{1open} , Z_{2open} , Z_{1inc} and Z_{2inc} in the processing shown in FIGURE 8 in later stages. This prevents erroneous judgment which would be caused by influence given by changes in impedance caused by aging.

[0049] According to the described embodiment, cross-spectrum analysis is used to determine the impedances Z_1 , Z_2 , Z_{1ave} and Z_{2ave} , but the impedances may be determined by using a band-pass filter having a narrow band capable of deriving the test signal to derive current and voltage of the test signal, and determine the impedances from the derived current and voltage, for example. Also, according to the described embodiment, the test signal has frequencies of 40 Hz and 20 KHz. Further, according to the described embodiment, the digital test signal from the DSP 10 is digital-to-analog converted and the resultant analog test signal is applied to the combiner 13. Instead, an analog test signal source is additionally used and a test signal from this analog test signal source may be applied to the combiner 13. In such case, the analog test signal is analog-to-digital converted and the resultant digital signal is applied to the DSP 10. According to the described embodiment, open-circuiting and decrease in impedance of the loudspeaker line and loudspeakers are determined, but only one of them may be determined, instead.

Claims

1. A public address system comprising:

a signal source (2) of an audio signal;
 an amplifier (4) for amplifying said audio signal;
 a loudspeaker line (6) through which an output signal of said amplifier (4) is transmitted;
 a plurality of loudspeakers (8) connected in parallel with each other to said loudspeaker line (6); and
 a loudspeaker line examination system for examining said loudspeaker line, said loudspeaker line examination system comprising:

a source of a test signal containing both of a first frequency component near a lowest frequency of a human audio frequency band and a second frequency component near a highest frequency of the human audio frequency band;
 a combiner (13) for combining said test signal with said audio signal and applying a resultant signal to said amplifier (4);

impedance determining means for deriving said first and second frequency components of said test signal contained in an output signal of said amplifier (4) and determining, from said derived first frequency component, a first impedance (Z1) viewed from the output of said amplifier toward said plurality of loudspeakers at said first frequency component, and determining, from said derived second frequency component, a second impedance (Z2) viewed from the output of said amplifier toward said plurality of loudspeakers at said second frequency component; and

judging means for comparing said first and second impedances (Z1, Z2) with first and second predetermined upper limit threshold values (Z1open, Z2open), respectively, for use in detecting open-circuiting of said loudspeaker line (6) and loudspeakers (8) at said first and second frequency components, and/or comparing said first and second impedances (Z1, Z2) with first and second predetermined lower limit threshold values (Z1inc, Z2inc), respectively, for use in detecting decrease in impedance of said loudspeaker line (6) and loudspeakers (8) at said first and second frequency components to thereby judge whether said first impedance (Z1) is larger than the first predetermined upper limit threshold value (Z1open) at said first frequency component for use in detecting open-circuiting of said loudspeaker line (6) and plurality of loudspeakers (8), or whether said second impedance (Z2) is larger than the second predetermined upper limit threshold value (Z2open) at said second frequency component for use in detecting open-circuiting of said loudspeaker line (6) and plurality of loudspeakers (8), and determining the open-circuiting of said loudspeaker line (6) and plurality of loudspeakers (8) if said judgment is affirmative, and/or to judge whether said first impedance (Z1) is smaller than the first predetermined lower limit threshold value (Z1inc) at said first frequency component for use in detecting decrease of impedance of said loudspeaker line (6) and plurality of loudspeakers (8), or whether said second impedance (Z2) is smaller than the second predetermined lower limit threshold value (Z2inc) at said second frequency component for use in detecting decrease of impedance of said loudspeaker line (6) and plurality of loudspeakers (8), and determining that the impedance of said loudspeaker line (6) and plurality of loudspeakers (8) has decreased if said judgment is affirmative;

said public address system further comprising filter means for supplying, to said combiner (13), said audio signal from said audio signal source having its frequency components same as the frequency components of said test signal attenuated, only while said test signal source is outputting said test signal.

Patentansprüche

1. Ein öffentliches Adresssystem, umfassend:

einer Signalquelle (2) eines Audiosignals;
 einem Verstärker (4) zur Verstärkung des Audiosignals;
 einer Lautsprecherleitung (6), durch die ein Ausgangssignal an den Verstärker (4) übermittelt wird;
 mehreren Lautsprechern (8), die parallel zueinander mit der Lautsprecherleitung (6) verbunden sind; und
 einem Lautsprecherleitungsprüfsystem zur Prüfung der Lautsprecherleitung, das Lautsprecherleitungsprüfsystem umfassend:

einer Testsignalquelle, die sowohl eine erste Frequenzkomponente im Bereich der niedrigsten Frequenz der menschlichen Audiofrequenzbandbreite, und eine zweite Frequenzkomponente im Bereich der höchsten Frequenz der menschlichen Audiofrequenzbandbreite enthält;

einem Kombinator (13) zur Kombination des Testsignals und der Übertragung eines daraus entstehenden Signals an den Verstärker (4) ;

Möglichkeiten zur Bestimmung der Impedanz, um die erste und zweite Frequenzkomponente des in einem Ausgangssignal enthaltenem Prüfsignals von dem Verstärker (4) zu bereinigen, und zur Bestimmung einer ersten errechneten Impedanz (Z1) aus der bereinigten ersten Frequenzkomponente, betrachtet von der Ausgabe der Lautsprecher bei der ersten Frequenzkomponente und der Bestimmung einer zweiten errechneten Impedanz (Z2) aus der bereinigten zweiten Frequenzkomponente, betrachtet von der Ausgabe der Lautsprecher bei der zweiten Frequenzkomponente; und

Beurteilungsmöglichkeiten zum Vergleich der ersten und zweiten Impedanzen (Z1, Z2) mit dem jeweils ersten und zweiten vorbestimmten oberen Grenzwerten (Z1offen, Z2offen), zur Verwendung bei der Erkennung von Unterbrechungen der Lautsprecherleitung (6) und den Lautsprechern (8) bei den ersten und zweiten Frequenzkomponenten, und/oder zum Vergleich der ersten und zweiten Impedanzen (Z1, Z2) mit den jeweils ersten und zweiten vorbestimmten unteren Grenzwerten (Z1inc, Z2inc), zur Verwendung für die Erkennung von Impedanzabnahmen der Lautsprecherleitung (6) und der Lautsprecher (8) bei den

ersten und zweiten Frequenzkomponenten, um so zu beurteilen, ob die erste Impedanz (Z1) größer ist als der erste vorbestimmte obere Grenzwert (Z1offen) der ersten Frequenzkomponente, um Unterbrechungen der Lautsprecherleitung (6) und Lautsprecher (8) zu erkennen, oder ob die zweite Impedanz (Z2) größer ist als der zweite vorbestimmte obere Grenzwert (Z2offen) der zweiten Frequenzkomponente, um Unterbrechungen der Lautsprecherleitung (6) und Lautsprecher (8) zu erkennen und die Unterbrechungen der Lautsprecherleitung (6) und Lautsprecher (8) bei positiver Beurteilung zu bewerten, und/oder um zu beurteilen, ob die erste Impedanz (Z1) kleiner ist als der erste vorbestimmte untere Grenzwert (Z1inc) der ersten Frequenzkomponente, um Impedanzabnahmen der Lautsprecherleitung (6) und Lautsprecher (8) zu erkennen, oder ob die zweite Impedanz (Z2) kleiner ist als der zweite vorbestimmte untere Grenzwert (Z2inc) der ersten Frequenzkomponente, um Unterbrechungen der Lautsprecherleitung (6) und der Lautsprecher (8) zu erkennen und die Unterbrechungen der Lautsprecherleitung (6) und Lautsprecher (8) bei positiver Beurteilung zu bewerten;

das öffentliche Adresssystem, ferner umfassend Filtermöglichkeiten für die Zuführung an den Kombinator (13) des Audiosignals aus der Audiosignalquelle, deren Frequenzkomponenten, nur während die Prüfsignalquelle das Prüfsignal ausgibt, entsprechend den Frequenzkomponenten des Prüfsignals gedämpft sind.

Revendications

1. Système de diffusion publique comprenant :

une source de signal (2) d'un signal audio ;
 un amplificateur (4) afin d'amplifier ledit signal audio ;
 une ligne de haut-parleur (6) à travers laquelle est transmis un signal de sortie dudit amplificateur (4) ;
 une pluralité de haut-parleurs (8) connectés les uns aux autres en parallèle à ladite ligne de haut-parleur (6) ; et
 un système d'inspection de lignes de haut-parleurs pour examiner ladite ligne de haut-parleur, ledit système d'inspection de lignes de haut-parleurs comprenant :

une source d'un signal d'essai contenant à la fois une première composante de fréquence proche de la plus basse fréquence d'une bande de fréquence audio humaine et une deuxième composante de fréquence proche de la fréquence la plus élevée de la bande de fréquence audio humaine ;

un combineur (13) pour combiner ledit signal d'essai avec ledit signal audio et appliquer un signal résultant audit amplificateur (4) ;

un moyen de détermination d'impédance pour dériver lesdites première et deuxième composantes de fréquence dudit signal d'essai contenu dans un signal de sortie dudit amplificateur (4) et la détermination, à partir de ladite première composante de fréquence dérivée, d'une première impédance (Z1) constatée depuis la sortie dudit amplificateur vers ladite pluralité de haut-parleurs à ladite première composante de fréquence, et la détermination, à partir de ladite deuxième composante de fréquence dérivée, d'une deuxième impédance (Z2) constatée depuis la sortie dudit amplificateur vers ladite pluralité de haut-parleurs au niveau de ladite deuxième composante de fréquence ; et

un moyen de jugement pour la comparaison desdites première et deuxième impédances (Z1, Z2) avec les première et deuxième valeurs seuils prédéterminées de limite supérieure (Z1ouvert, Z2ouvert), respectivement, dans le but de détecter un circuit ouvert de ladite ligne de haut-parleur (6) et des haut-parleurs (8) au niveau desdites première et deuxième composantes de fréquence, et/ou la comparaison desdites première et deuxième impédances (Z1, Z2) avec les première et deuxième valeurs seuils prédéterminées de limite inférieure (Z1inc, Z2inc), respectivement, dans le but de détecter une diminution d'impédance de ladite ligne de haut-parleur (6) et des haut-parleurs (8) au niveau desdites première et deuxième composantes de fréquence pour ainsi juger si ladite première impédance (Z1) est supérieure à la première valeur seuil prédéterminée de limite supérieure (Z1ouvert) à ladite première composante de fréquence dans le but de détecter un circuit ouvert de ladite ligne de haut-parleur (6) et de la pluralité de haut-parleurs (8), ou si ladite deuxième impédance (Z2) est supérieure à la deuxième valeur seuil prédéterminée de limite supérieure (Z2ouvert) au niveau de ladite deuxième composante de fréquence dans le but de détecter un circuit ouvert de ladite ligne de haut-parleur (6) et de la pluralité de haut-parleurs (8), et la détermination du circuit ouvert de ladite ligne de haut-parleur (6) et la pluralité de haut-parleurs (8) si ledit jugement est affirmatif, et/ou pour juger si ladite première impédance (Z1) est inférieure à la première valeur seuil prédéterminée de limite inférieure (Z1inc) à ladite première composante de fréquence dans le but de détecter une diminution d'impédance de ladite ligne de haut-parleur (6) et de la pluralité de haut-parleurs (8), ou si ladite deuxième impédance (Z2) est inférieure à la deuxième valeur seuil prédéterminée de limite inférieure

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(Z2inc) au niveau de ladite deuxième composante de fréquence dans le but de détecter une diminution d'impédance de ladite ligne de haut-parleur (6) et de la pluralité de haut-parleurs (8), et la détermination que l'impédance de ladite ligne de haut-parleur (6) et de la pluralité de haut-parleurs (8) a diminué si ledit jugement est affirmatif ;

5 ledit système de diffusion publique comprenant en outre un moyen de filtrage pour alimenter, audit combineur (13), ledit signal audio à partir de ladite source de signal audio ayant ses composantes de fréquence identiques aux composantes de fréquence dudit signal d'essai atténué, seulement pendant que ladite source de signal d'essai émet ledit signal d'essai.

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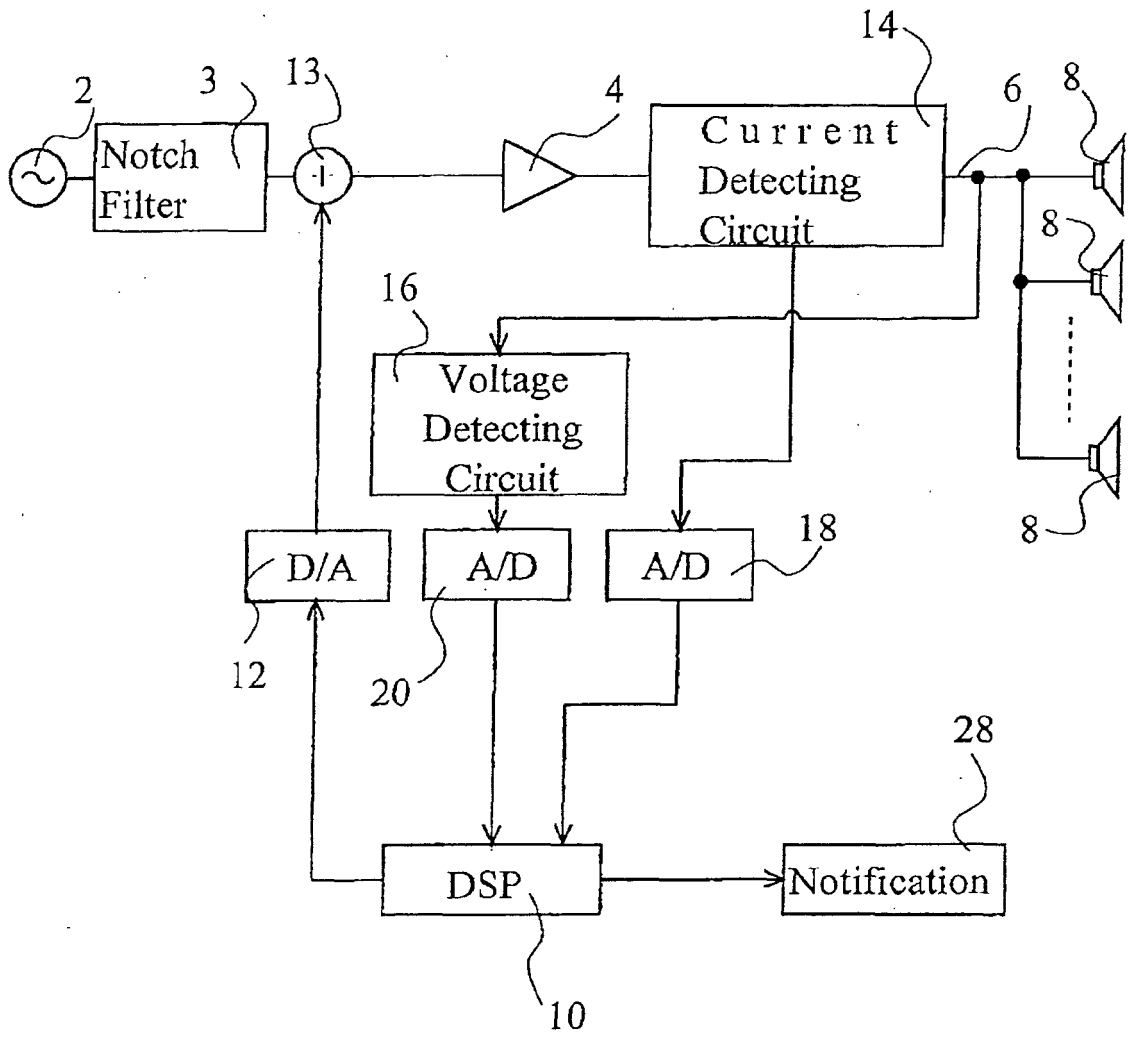


Fig.1

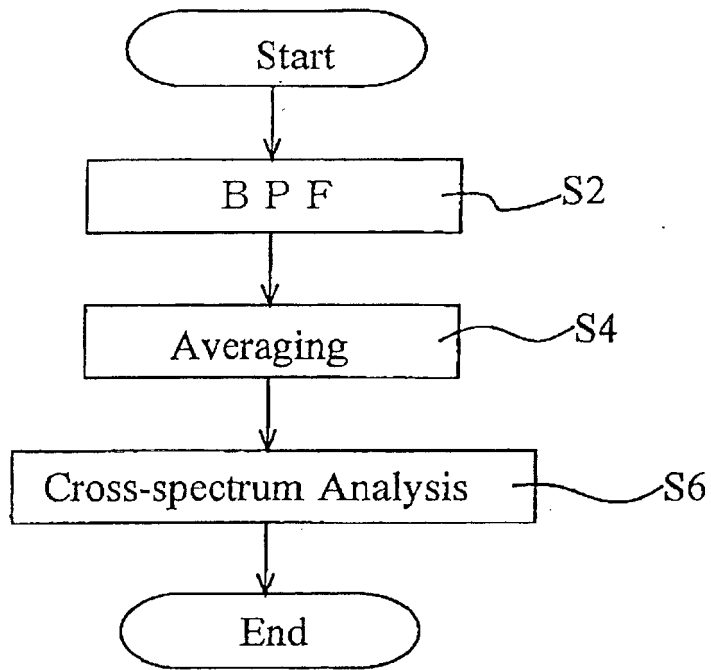


Fig.2

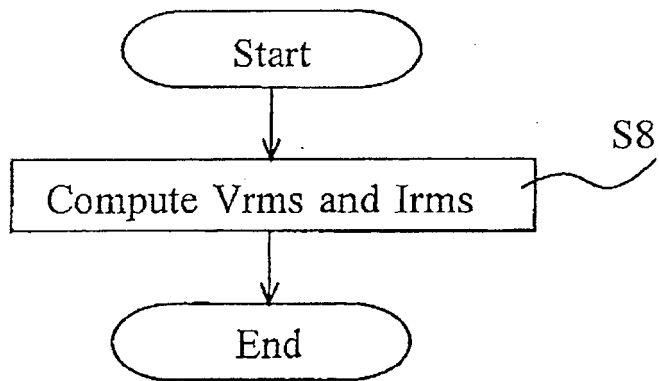


Fig.3

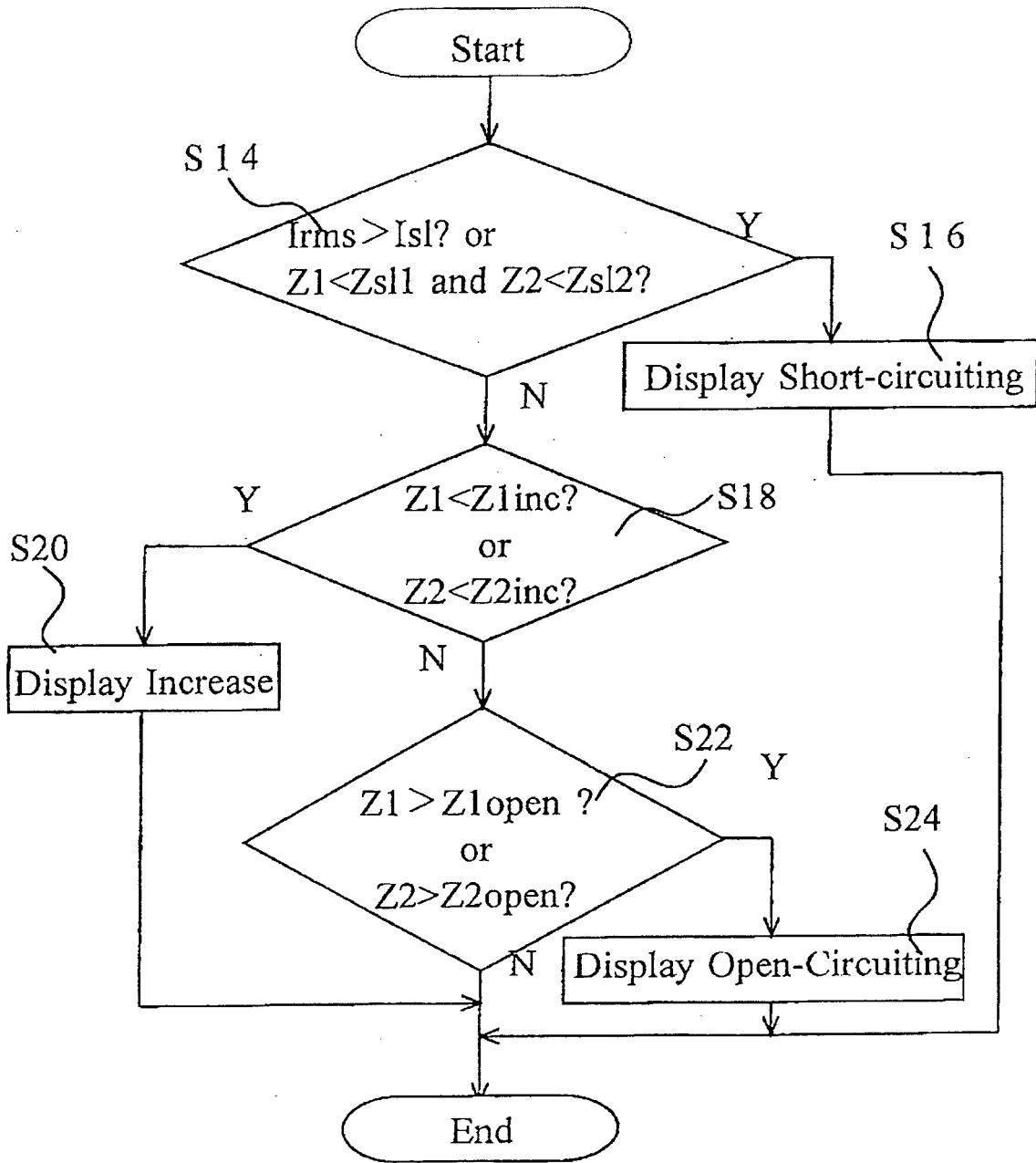


Fig.4

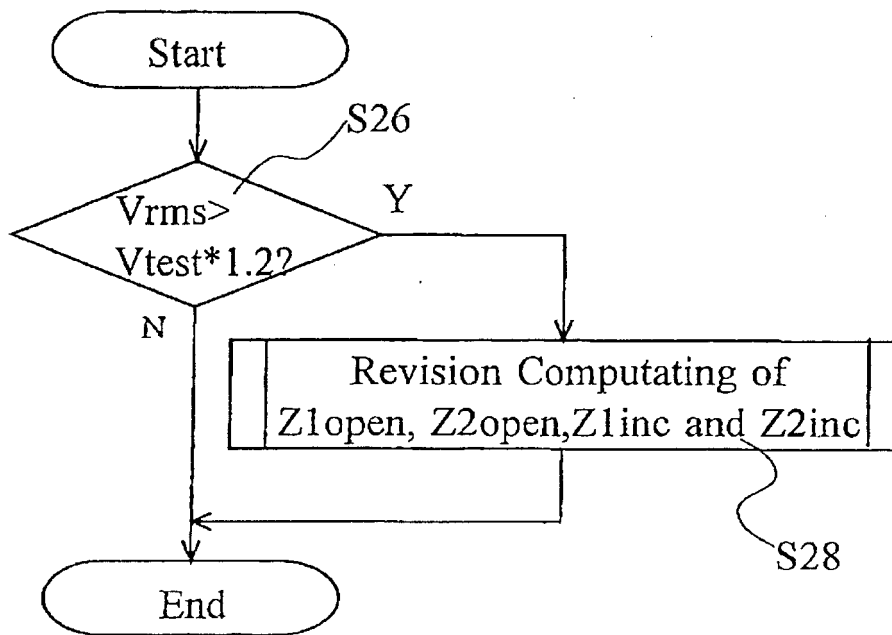


Fig.5

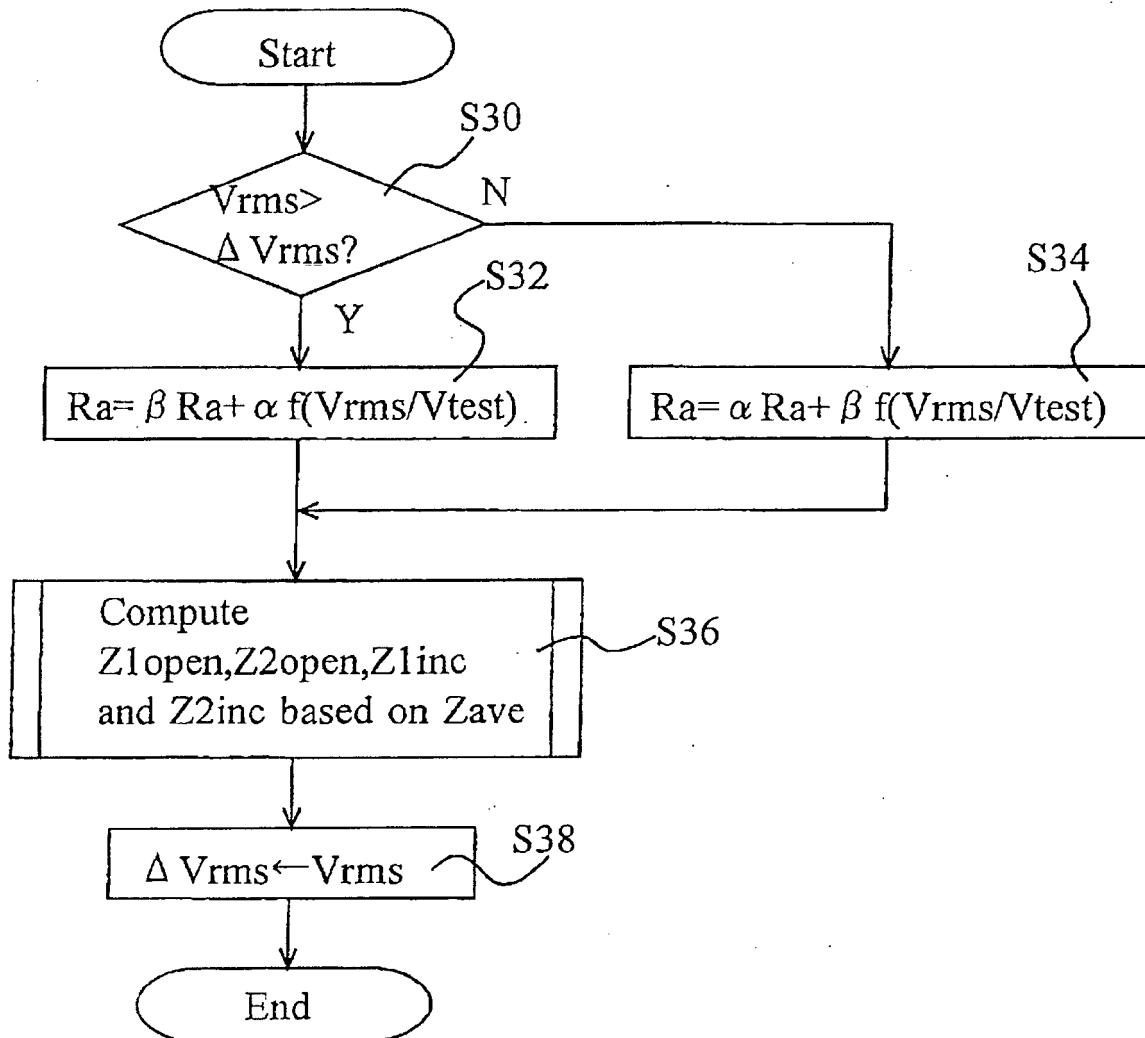


Fig.6

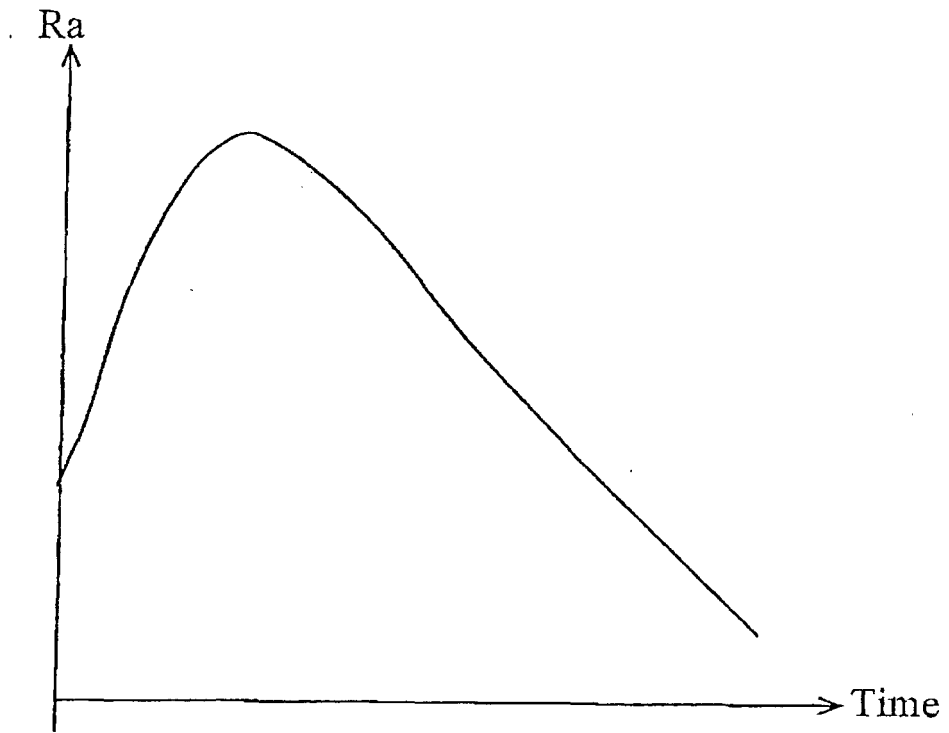


Fig.7

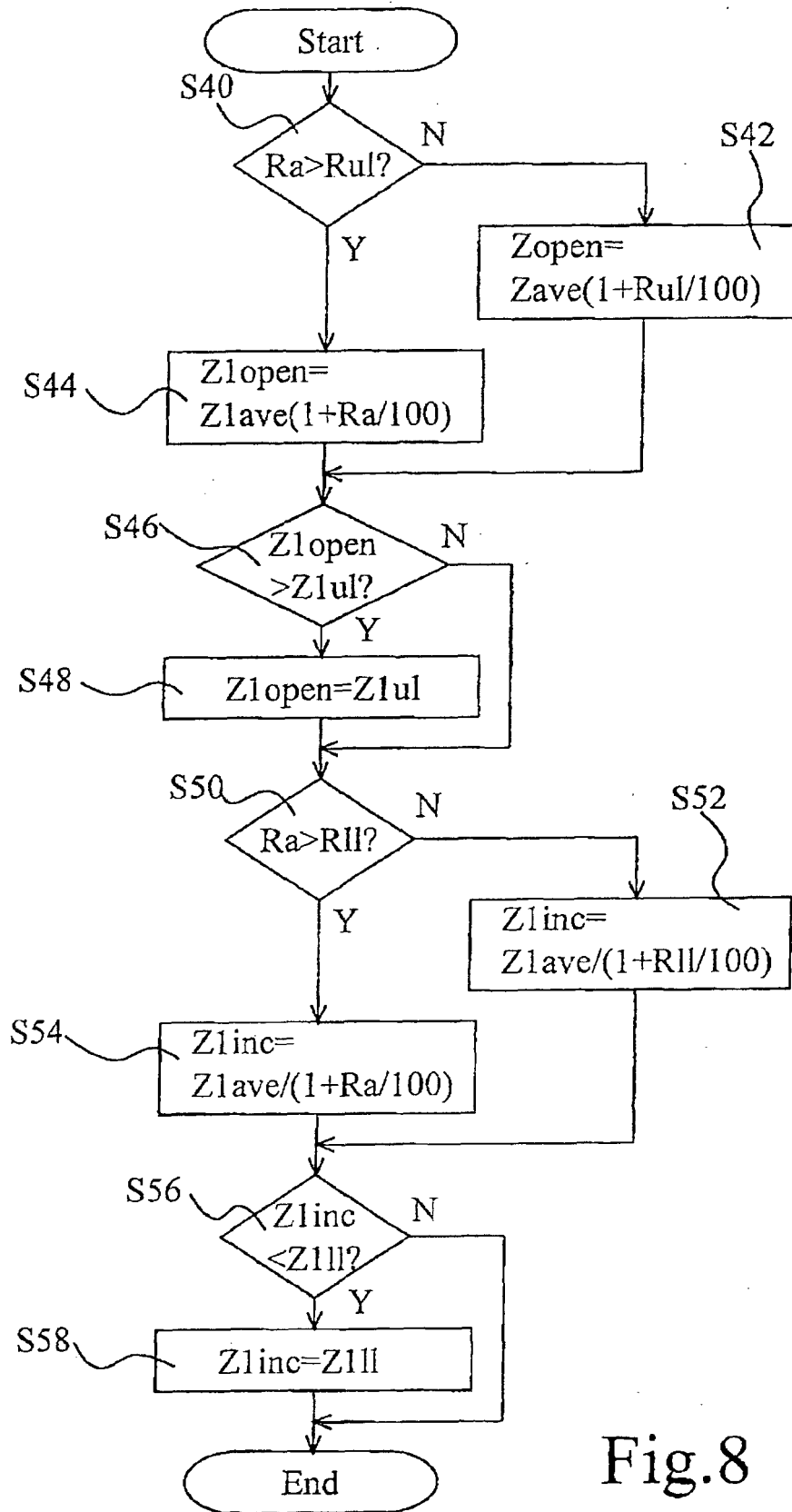


Fig.8

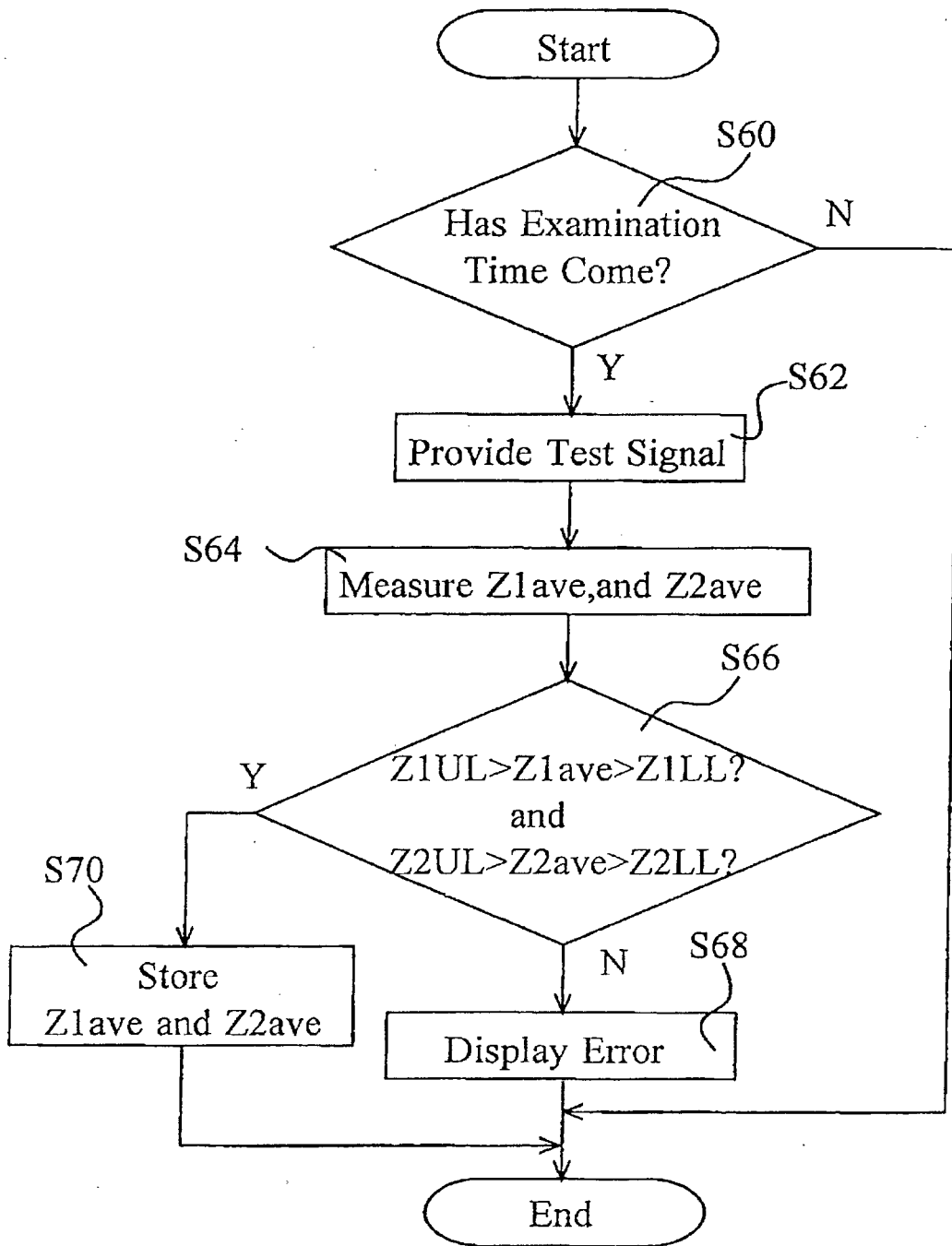


Fig.9

REFERENCES CITED IN THE DESCRIPTION

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