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(54) **SWITCHED SIGNAL PROCESSING CIRCUIT**

FOREIGN PATENT DOCUMENTS

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Related U.S. Patent Documents

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H04H 20/48 (2006.01)
H03G 7/00 (2006.01)

(52) **U.S. Cl.** **381/13; 381/106**

(58) **Field of Classification Search** **381/15, 381/11, 13, 106**

See application file for complete search history.

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(57) **ABSTRACT**

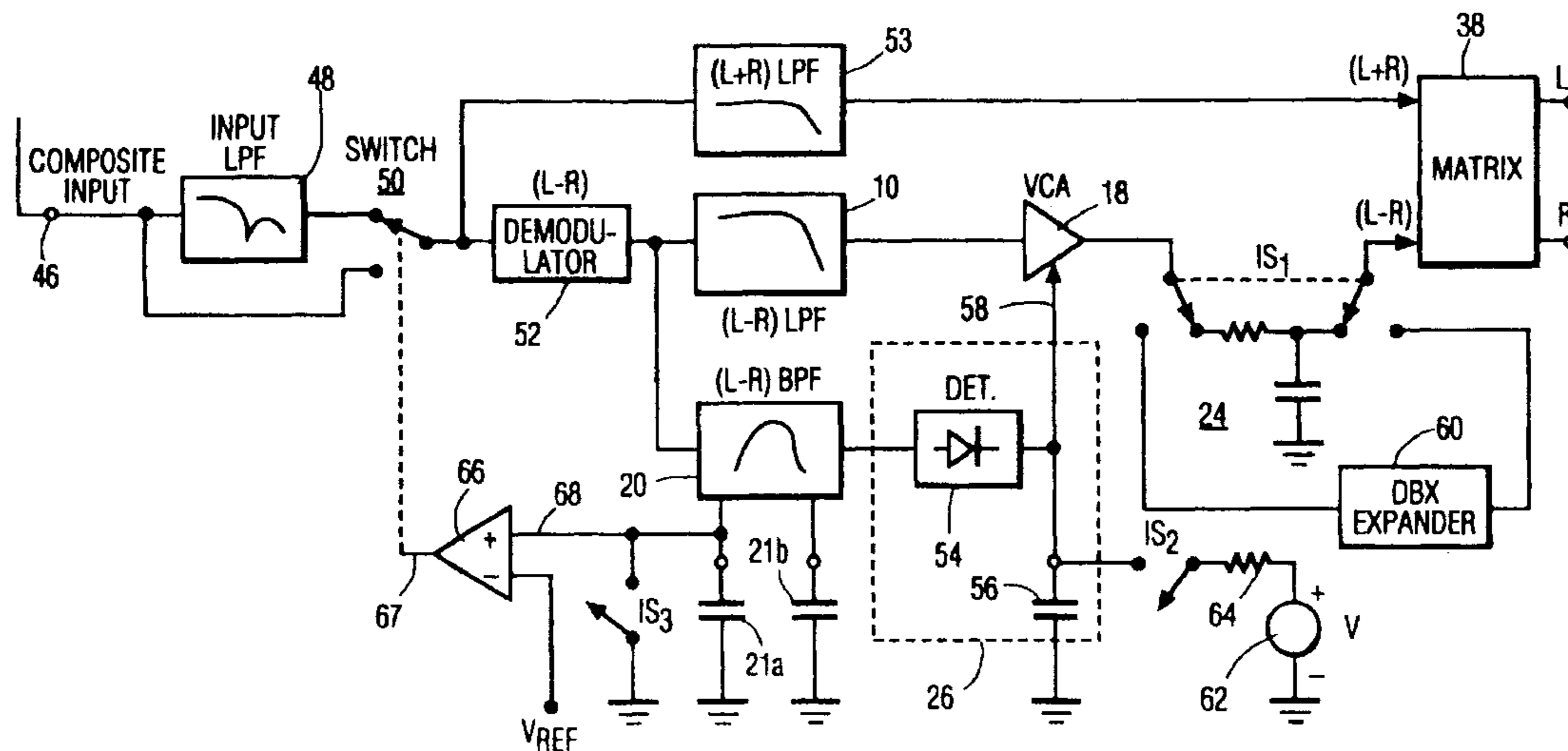
An expander circuit for decoding audio signals which were encoded in accordance with the BTSC multichannel sound system standard including DBX commanding is presented. A wideband expander circuit is utilized and a DBX expander can be accommodated. The wideband expander circuit is provided with a signal path having an input LPF (low pass filter), a stereo difference signal (L-R) demodulator, a second LPF, and a voltage controlled amplifier (VCA), the gain of which is controlled by a control signal derived from the demodulated difference signal which has been operated on by a bandpass filter (BPF) and an integrating peak detector. The output of the VCA is provided to a deemphasis network before being fed to a decoder matrix for combining with the sum stereo signal (L+R) for reconstructing the original L and R signals. When a DBX expander is connected, the DBX expander is substituted in place of the deemphasis network, the VCA control signal, which provides the wideband expansion, is overridden by a predetermined voltage, the bandpass filtering characteristic of the BPF is disabled, and the input is switched to bypass the input LPF. According to aspects of the present invention, the disablement of the BPF bandpass filtering characteristic actuates the switching of the input to bypass the input LPF.

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14 Claims, 5 Drawing Sheets



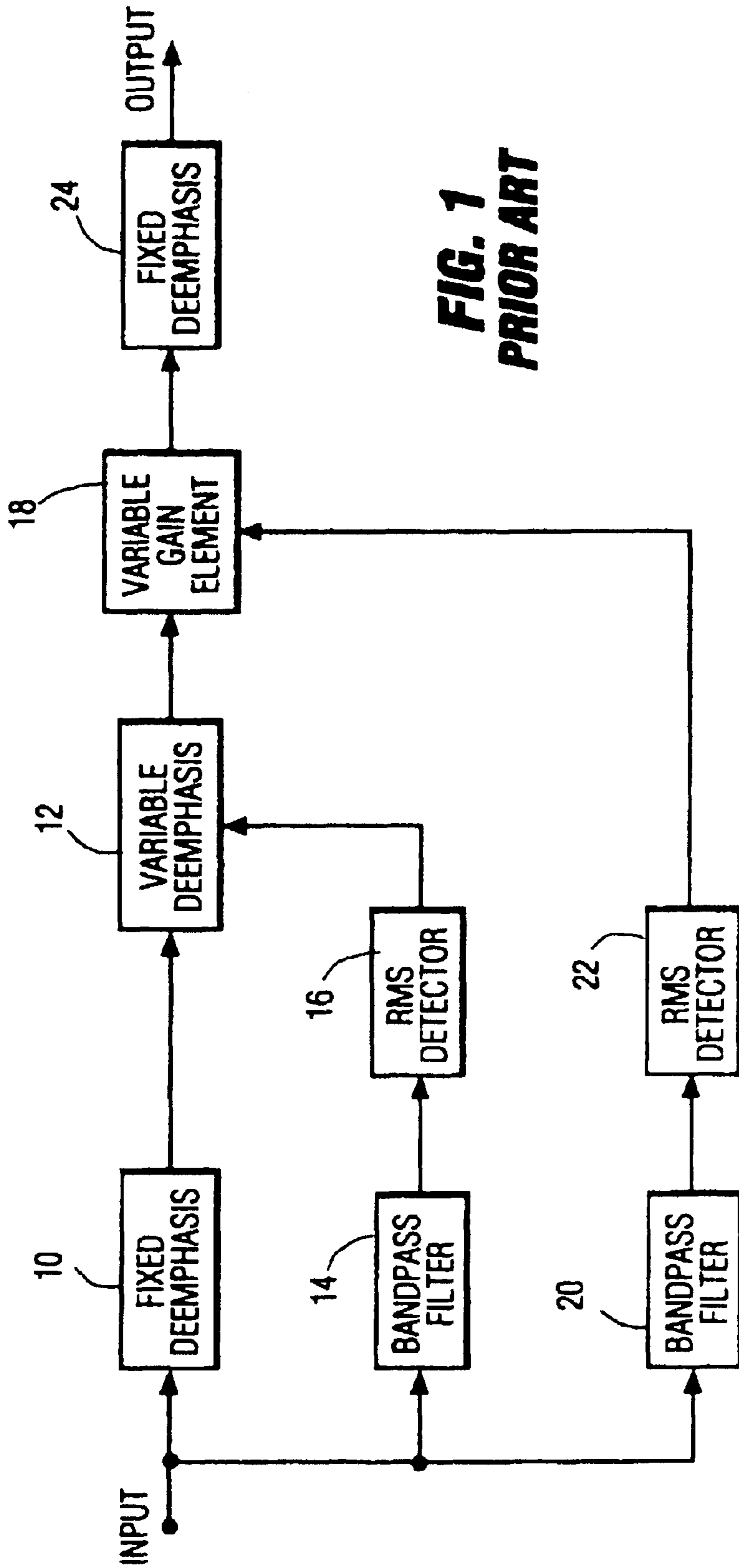


FIG. 1
PRIOR ART

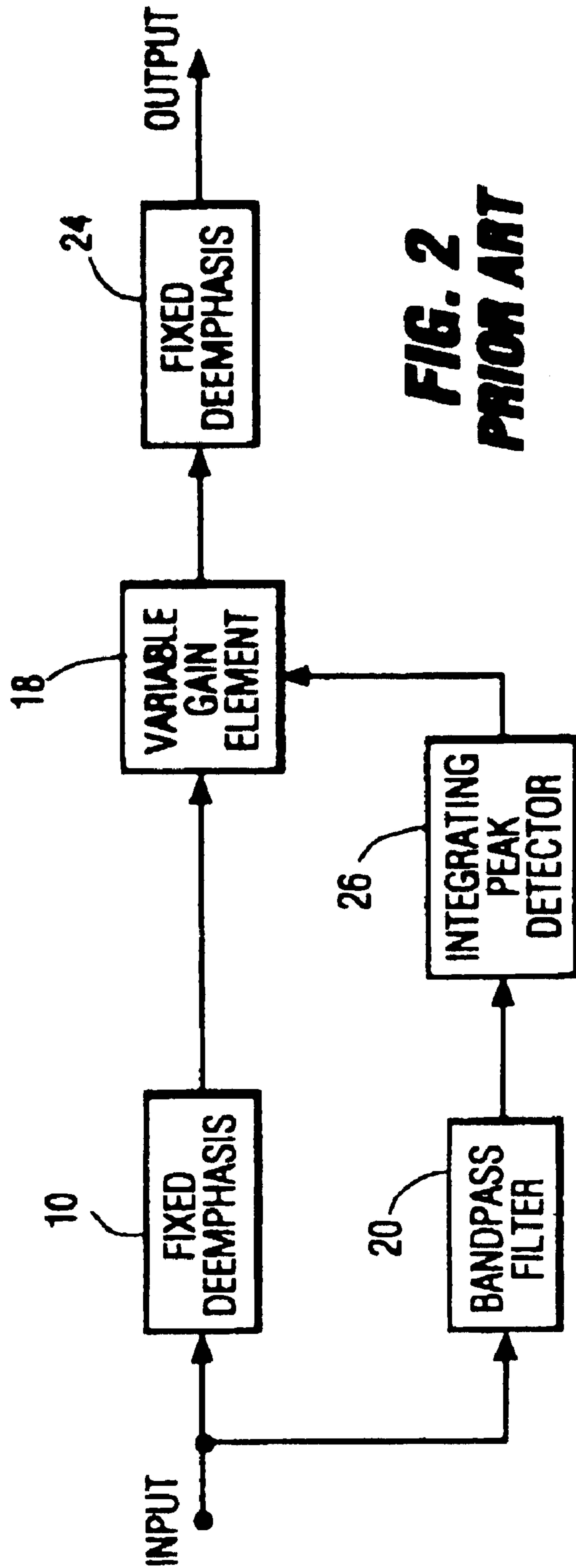
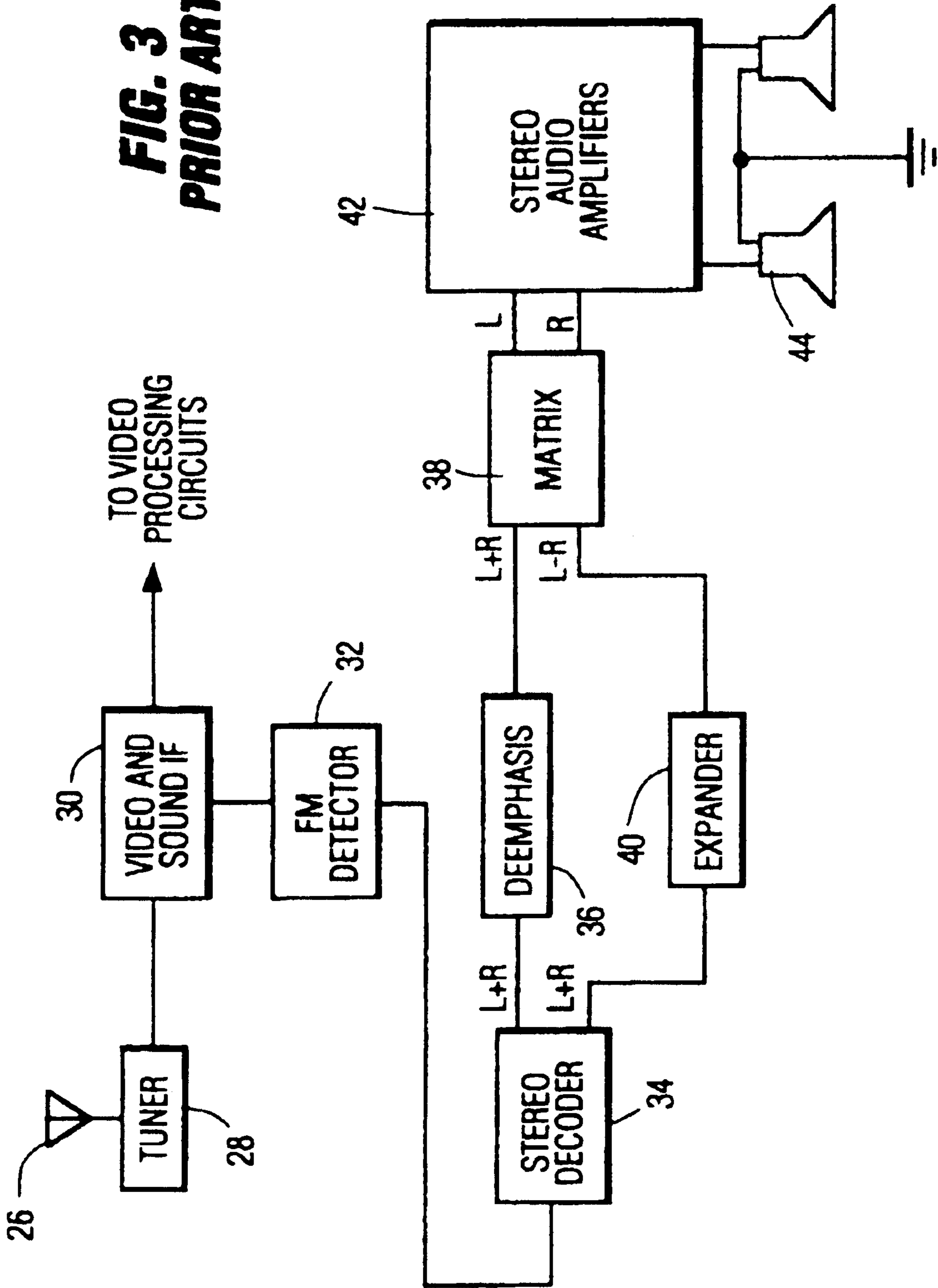


FIG. 2
PRIOR ART

FIG. 3
PRIOR ART



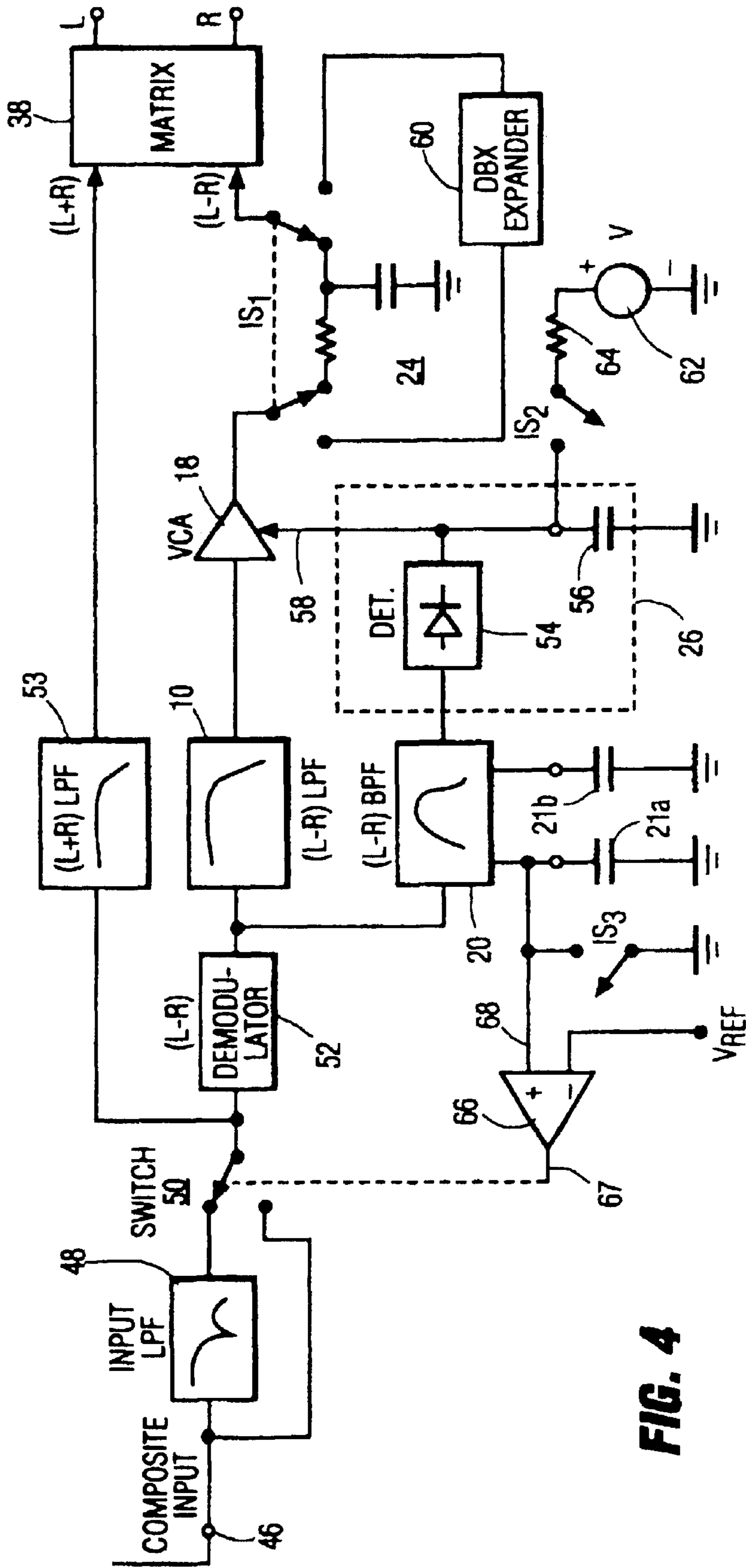


FIG. 4

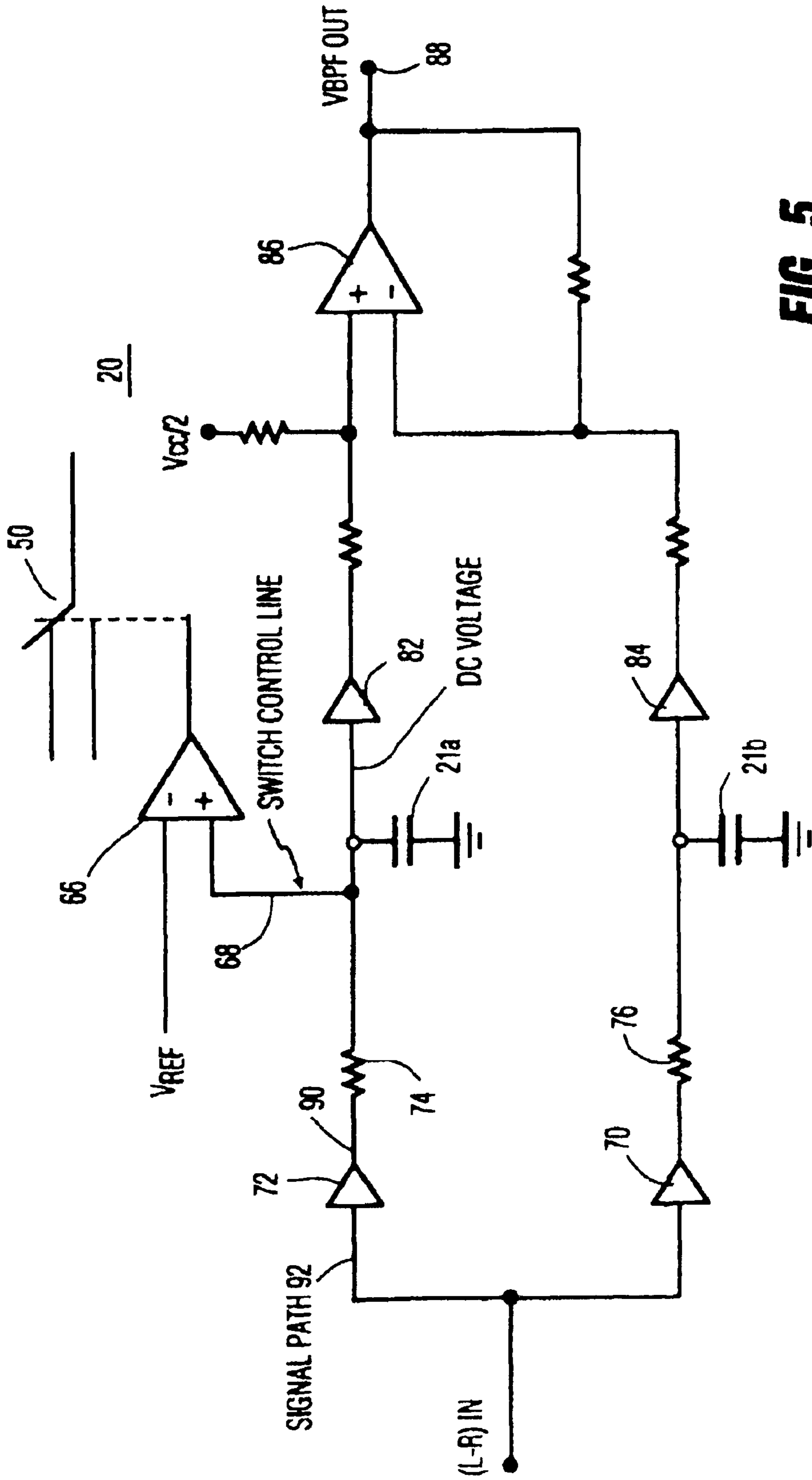


FIG. 5

SWITCHED SIGNAL PROCESSING CIRCUIT

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

FIELD OF THE INVENTION

The present application concerns television receivers having signal processing circuitry for decoding stereo signals which were encoded in accordance with the DBX® format.

BACKGROUND OF THE INVENTION

The present application relates to wide band expansion of stereophonic signals as discussed in U.S. Pat. No. 5,091,957 of Anderson et al. The teaching of the '957 patent is expressly incorporated by reference herein. The '957 patent disclosed a wideband expander, and recognized that for practical purposes, satisfactory restoration of an (L-R) audio difference signal compressed according to the DBX format can be achieved without spectral expansion. A decoder according to '957 provides a modified fixed deemphasis and wideband expansion of the received compressed L-R audio signal, but does not provide spectral expansion. Additionally, it was further recognized in '957 that the relatively complex RMS detectors of the DBX system can be replaced with simpler, lower cost integrating peak detectors.

It is desirable to design and build television receivers wherein different decoders can be used depending upon model and options.

SUMMARY OF THE INVENTION

Briefly, the present invention concerns an expander circuit for decoding audio signals which were encoded in accordance with the BTSC multichannel sound system standard including DBX companding. A wideband expander circuit is utilized and a DBX expander can be accommodated. The wideband expander circuit is provided with a signal path having an input LPF (low pass filter), a stereo difference signal (L-R) demodulator, a second LPF, and a voltage controlled amplifier (VCA), the gain of which is controlled by a control signal derived from the demodulated difference signal which has been operated on by a bandpass filter (BPF) and an integrating peak detector. The output of the VCA is provided to a deemphasis network before being fed to a decoder matrix for combining with the sum stereo signal (L+R) for reconstructing the original L and R signals. When a DBX expander is connected, the DBX expander is substituted in place of the deemphasis network, the VCA control signal, which provides the wideband expansion, is overridden by a predetermined voltage, the bandpass filtering characteristic of the BPF is disabled, and the input is switched to bypass the input LPF. According to aspects of the present invention, the disablement of the bandpass filtering characteristic of the BPF actuates the switching of the input to bypass the input LPF.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a block diagram of a DBX expander as known in the prior art.

FIG. 2 shows a block diagram of a wideband expander.

FIG. 3 show a block diagram of a television receiver having BTSC multichannel sound capability.

FIG. 4 shows a block diagram of a stereophonic difference signal processor according to aspects of the present invention.

FIG. 5 is a block diagram showing details of the bandpass filter and switching apparatus of FIG. 4.

DETAILED DESCRIPTION OF THE EMBODIMENT

In the DBX system of FIG. 1, a fixed deemphasis is applied to the incoming (L-R) stereo difference signal, by fixed deemphasis unit 10. A spectral expansion is applied to the deemphasized audio signal by variable deemphasis unit 12 in response to a control signal developed by bandpass filter 14 and RMS detector 16. Amplitude expansion is applied to the audio signal by variable gain element 18 in response to a control signal developed by bandpass filter 20 and RMS detector 22. A fixed deemphasis (i.e., a fixed amount of low pass filtering) is applied to the expanded audio signal by fixed deemphasis unit 24 in order to attenuate high frequency products which may have been generated in the expansion process.

FIG. 2 shows a wideband expander. The units of FIG. 2 having the same numerical designation as corresponding units of the decoder of FIG. 1, perform the same function as their counterparts. The wideband expansion provided by variable gain element 18 of FIG. 2 in response to control signals developed by units 20 and 26, substantially restores the dynamic range of the original signal.

Discussion of the significant differences between the arrangements of FIGS. 1 and 2 are stated in the '957 patent. Briefly, these differences are: 1) that the spectral expansion of the compressed DBX audio signal is not necessary for the reproduction of an acceptable stereo signal. Accordingly, the variable deemphasis unit 12, its associated control path filter 14, and its associated RMS detector 16 were completely eliminated from the arrangement of FIG. 2; 2) that the rolloff frequency of the fixed deemphasis networks had been changed to compensate for some of the lost variable deemphasis caused by elimination of the spectral expansion elements, and 3) that the RMS detector 22 was replaced by a much lower cost and more simply constructed integrating peak detector 26.

The expanders of FIGS. 1 and 2 have been used in television receivers known in the prior art. FIG. 3 shows such a television receiver having BTSC multichannel television sound (MTS) capability. Broadcast television signals are received by an antenna 26 (or coupled to the receiver via a cable television system) and applied to a tuner 28 for channel selection. Tuner 28 converts a selected one of a plurality of received television signals from its respective broadcast frequency to a common intermediate frequency (IF). The IF frequency television signal is applied to a video and sound IF unit 30 which produces a baseband video signal and a frequency modulated (FM) sound carrier. The video and audio signals are separated, and the video signals are applied to video signal processing circuitry, (not shown).

As shown in FIG. 3, a composite multichannel sound audio signal is detected from the FM sound carrier by an FM detector 32 and applied to a stereo decoder 34. Stereo decoder 34 provides an (L+R) stereo sum signal and an (L-R) stereo difference signal. The (L+R) stereo sum signal is deemphasized in a deemphasis unit 36 (i.e., a low pass filter having the appropriate time constant) and applied, to one input of a stereo matrixing unit 38 in which the original left (L) and right (R) stereo signals are reconstructed. The (L-R) stereo difference signal from stereo decoder unit 34 is applied to expander unit 40. Expander unit 40 can correspond to a full DBX expander as shown in FIG. 1 or to a wideband expander as shown in FIG. 2. The expanded (L-R)

stereo difference signal is applied to the other input of stereo matrix unit **38**. The reconstructed left (L) and right (R) stereo signals are applied to stereo audio amplifier unit **42** for amplification and ultimate reproduction in a dual speaker unit **44**.

FIG. **4** shows a wideband expander, generally designated **44**, which according to aspects of the present invention, can be adapted so that a DBX expander can be used. A composite DBX encoded audio signal including a pilot signal is fed to the system at input terminal **46**. The composite DBX encoded audio signal is then filtered by an input low pass filter (LPF) **48**, which is a notch filter having its maximum attenuation at a frequency close to but higher than the fifth harmonic (5H) of the pilot signal. This filter is used because it is desirable to remove any SAP signal from the incoming composite signal since the SAP signal can cause interference with the operation of the (L-R) demodulator. This is because an (L-R) demodulator typically uses a phase-locked loop (PLL) and there is a possibility that the PLL will falsely lock onto the 5H center frequency of the SAP signal if the 5H signal is of sufficient amplitude.

The present LPF **48** is of a twin-T topology (not shown) with the notch tuned to a frequency higher than 5H. In such an arrangement, the SAP signal can be sufficiently attenuated via the filter skirt without requiring close tolerance components to precisely determine the notch frequency. Additionally, placing the notch above the frequency of interest permits smaller capacitance values which are more practical to integrate and assures that R/C value variations will not change the skirt attenuation if a high enough "Q" is used. The present LPF **48** uses a portion of the twin-T arrangement as part of the feedback loop for an operational amplifier for increasing the Q of the circuit.

The output signal from LPF **48** is fed to a switch **50** for switching the input terminal of the (L-R) demodulator **52** between the output of LPF **48** and input terminal **46**. In the exemplary embodiment, LPF **48** is bypassed when a DBX expander is used. When a DBX expander is used, a third order Sallen-Key LPF (not shown) can be used for providing sharper skirts at the notch frequency. The operation of switch **50** will be discussed in greater detail below.

The signal from switch **50** is fed to LPF **53** for deriving the stereo sum signal (L+R) which is subsequently fed to matrix **38**. The signal from switch **50** is also provided to demodulator **52** which is a standard demodulator according to the MTS television standard. The output signal from demodulator **52** is fed to the series coupling of LPF **10** and VCA **18**, as well as to the series coupling of BPF **20** and integrating peak detector **26**, all of which correspond to similarly designated members shown in FIG. **2**. Integrating peak detector **26** is comprised of a detector **54** and an integrating capacitor **56** for providing an integrated peak detected control signal at line **58** to VCA **18**. The expanded output signal from VCA **18** is fed to a fixed deemphasis network **24** (see FIG. **2**) which in turn is fed to a stereo matrix **38** for reconstructing the L and R signals.

The members so far described in connection with FIG. **4** for the (L-R) signal correspond with the wideband expander discussed in FIG. **2**, as shown in the '957 patent. The wideband expander of FIG. **4** provides amplitude expansion for DBX encoded signals with an expander is not a mirror image of the encoder. However, it is recognized herein that it may be desirable to use selected portions of the present expander, e.g., demodulator **52**, LPF **10**, and VCA **18**, when expansion from a DBX expander is utilized instead of wideband expansion. In such a case, some operations of the present expander

would be modified to accommodate the operation of the DBX expander. Such circuitry changes are indicated in FIG. **4** as illustrative switches IS1, IS2, and IS3. These switches are designated as "illustrative" because it is expected that in practice, that such the alternate connections would be hard wired connections.

A DBX expander **60** would be wired in place of the emphasis network **24** and such substitution is shown by switch IS1. This substitution is made because the DBX expander **60** provides its own deemphasis and thus, emphasis network **24** is not needed.

In wideband expander **40**, BPF **20** and integrating peak detector **26** provide a control voltage at line **58** to VCA **18** to provide amplitude expansion of the (L-R) signal. Since DBX expander **60** provides its own amplitude expansion of the signal, the amplitude expansion provided by the control voltage at line **58** is defeated by providing a constant predetermined voltage **62** through a resistor **64** to the output of the integrating peak detector **26** at line **58** by way of illustrative switch IS2. In this way, any changes in the control voltage at line **58** which would be caused by the (L-R) signal processing of BPF **20** and integrating peak detector **26**, are "swamped" out by constant voltage **62**. Thus, in this arrangement, VCA **18** provides a constant amplification with the amount of said amplification being predetermined by the value of the constant control voltage **62** applied at line **58**.

As discussed above, switch **50** switches the input signal for demodulator **52** to bypass LPF **48** when a DBX expander **60** is used. In the exemplary embodiment, the switching of switch **50** is effectuated by the defeating of the bandpass operation of BPF **20**. Such an arrangement will not adversely effect the operation of the system since any control signal generated by the operation of BPF **20** (and integrating detector **26**) is rendered ineffectual by voltage source **62** and resistor **64**. The frequency selective operation of BPF **20** is provided by capacitors **21a** and **21b** which provide a frequency sensitive network, and will be more fully discussed below. In the exemplary embodiment, capacitor **21a** is coupled to a reference potential such as ground, and is provided with a DC voltage thereacross. This DC voltage is compared against a reference potential by comparator **66**, which has an output **67** to which the switch position of switch **50** is responsive. The DC voltage across capacitor **21a**, is of a value above a threshold reference voltage V_{REF} coupled to the negative terminal of comparator **66**. In such an arrangement, switch **50** is switched for receiving an input signal from LPF **48**. If the DC voltage at line **68** is below V_{REF} , the output of comparator **66** causes switch **50** to be switched for receiving the input signal from terminal **46**, bypassing LPF **48**. In the exemplary embodiment, the DC voltage across capacitor **21a** is changed by short circuiting the capacitor **21a** to ground by illustrative switch IS3. However, a resistor can be used having a low enough value sufficient to change the voltage at line **68** through V_{REF} from above V_{REF} to below V_{REF} .

The details of BPF **20** are shown in FIG. **5**. The (L-R) signal derived from the output of demodulator **52** is provided to unity amplifiers **70**, **72** and in turn is fed to a respective pair of frequency sensitive low pass filters comprised of resistors **74**, **76**, and respective capacitors **21a**, **21b** to ground for providing low pass filtering. The output signals from the low pass filters are fed to respective unity gain amplifiers **82**, **84** and subsequently to an operational amplifier **86** wherein one of the low pass filtered signals is provided to the non-inverting input terminal and the other low pass filtered signal is provided to the inverting input terminal. In such a case, when the two signals into amplifier **86** are equal, there is no

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output signal at terminal **88** of amplifier **86**. If the signal fed to the inverting terminal has a rolloff at a lower frequency than the signal to the non-inverting terminal, the subtraction process is reduced past the rolloff frequency and the signal at the non-inverting terminal will be passed through to terminal **88** until the non-inverting input signal reaches its own rolloff frequency. In this way a bandpass filter is generated.

In the exemplary embodiment, the DC voltage across capacitor **21a** at line **68** is provided from the output line **90** of amplifier **72** which is DC coupled and has a DC voltage thereat. Thus, when capacitor **21a** is shunted or short circuited to ground through illustrative switch **IS3**, the operation of that signal path **98** is defeated, and consequently, the operation of the bandpass function of BPF **20** is defeated. The change of the DC voltage at line **68** causes switch **50** to switch between input signal terminals as discussed above.

What is claimed is:

1. Switching apparatus comprising:

filter means including a frequency sensitive network for spectrally filtering [a] an encoded audio signal, said filter means having at its output an audio signal and at least one member of the frequency sensitive network having a DC voltage thereacross, wherein the filter means is a bandpass filter, and changing the DC voltage across the member of the frequency sensitive network disables the bandpass filtering characteristic of the filter means;

a comparator means having an output signal responsive to a comparison of the amplitude of the DC voltage and a threshold voltage;

switch means responsive to the output signal of the comparator means for changing the DC voltage across the member of the frequency sensitive network by shunting the frequency sensitive network, said switch means also switching between a first audio signal and a second audio signal, as the encoded audio signal, said switch

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shunting said frequency network when a DBX expander is coupled to the switching apparatus.

[2. The apparatus of claim 1 wherein the filter means is a bandpass filter.]

[3. The apparatus of claim 1 wherein the filter means is a bandpass filter, and changing the DC voltage across the member of the frequency sensitive network disables the bandpass filtering characteristic of the filter means.]

4. The apparatus of claim 1, wherein the switch means includes a switch that switches between first and second terminals to select the signal.

5. The apparatus of claim 1, wherein the switch means includes a switch.

6. The apparatus of claim 5, wherein a position of the switch is responsive to the comparator.

7. The apparatus of claim 6, wherein the switch is coupled to a demodulator.

8. The apparatus of claim 7, wherein the switch is further coupled to a filter.

9. The apparatus of claim 8, wherein the switch is further coupled to an input terminal.

10. The apparatus of claim 8, wherein the filter removes SAP signaling.

11. The apparatus of claim 7, wherein the demodulator is coupled to first and second filters.

12. The apparatus of claim 11, wherein the first and second filters are low pass filters.

13. The apparatus of claim 1, wherein the switch means comprises a switch being coupled to an input of the comparator.

14. The apparatus of claim 13, wherein the switch is further coupled to ground.

15. The apparatus of claim 14, wherein the switch is coupled in parallel with a capacitance.

16. The apparatus of claim 15, wherein the switch short-circuits the capacitance.

* * * * *