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DEVICE FOR THE STEREOPHONIC REPRODUCTION OF SIGNALS

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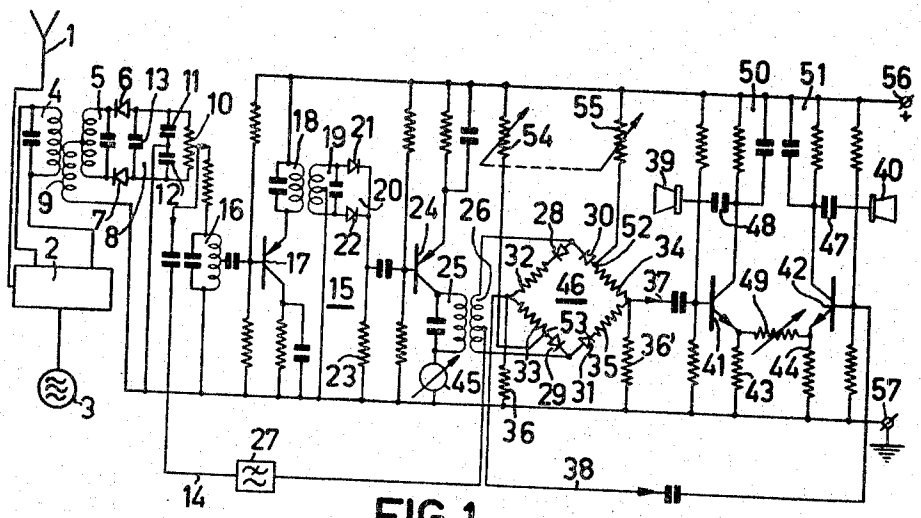

FIG.1

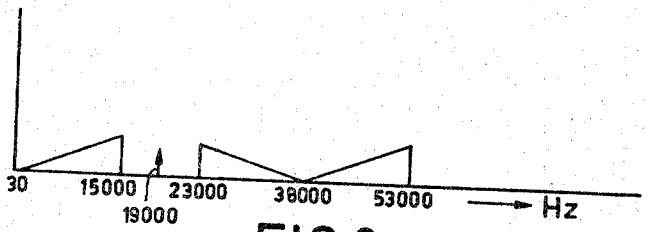

FIG.2

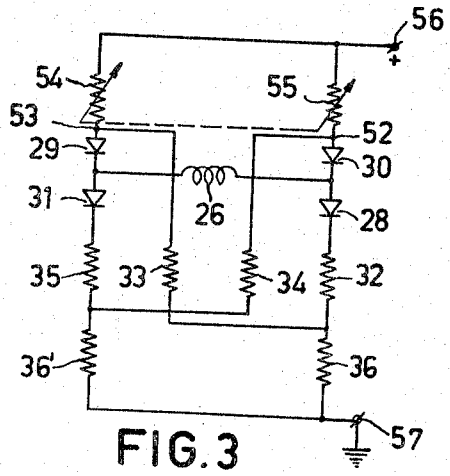

FIG.3

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DEVICE FOR THE STEREOPHONIC REPRODUCTION OF SIGNALS

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4 Claims. (Cl. 179—15)

The invention relates to a device for the stereophonic reproduction of signals, supplied in the form of the sum signal $A+B$ of the coherent stereophonic signals A and B and of the difference signal $A-B$ of said coherent stereophonic signals, transmitted by amplitude-modulation of a subcarrier frequency with suppression of the carrier, in common with a pilot signal of half the carrier frequency, which device comprises at the input end, the parallel combination of an information channel passing the stereophonic signals and a pilot channel passing solely the pilot signal and comprising a frequency doubler, for the local production of the subcarrier frequency, whilst the information channel and the pilot signal channel are connected, for restoring the coherent stereophonic signals A and B, the diagonal points of a ring which comprises, in each branch, the series combination of a resistor and a rectifier, the rectifiers having, around the ring, the same pass directions, whereas the coherent signals A and B are derived from output resistors connected to the further diagonal points of the ring.

In the copending United States patent applications Ser. No. 271,292, filed Apr. 8, 1963 and Ser. No. 401,377, filed Oct. 5, 1964 such stereophonic reproducing devices are described, in which in accordance with the fact whether a stereophonic signal or a monaural signal is received, automatic changeover to stereophonic or monaural reproduction respectively is carried out. From elaborate tests the applicant has now found that the monaural reproduction quality, particularly of monaural signals of low amplitudes, did not come up completely to expectations.

The invention has for its object to provide a device of the type described above, in which the monaural reproduction quality is considerably improved in a surprisingly simple manner.

The device according to the invention is characterised in that the junction of the series resistor and the rectifier in a ring branch and the corresponding junction in the opposite ring branch are connected each through a separate resistor to the terminal of a bias voltage source, the other terminal of which is connected through the two output resistors, as connections passing direct current, to the diagonal points of the ring connected to said resistors, said bias voltage source provides for all rectifiers of the ring a substantially identical bias adjustment in the forward direction.

The invention and its advantage will now be described more fully with reference to the figures.

FIG. 1 shows a stereophonic receiver comprising a device according to the invention;

FIG. 2 shows a frequency diagram and FIG. 3 shows a detailed diagram for explaining the operation of the device according to the invention.

The stereophonic receiver shown in FIG. 1 is intended for the reception of signals transmitted by frequency modulation of the same carrier frequency, said signals being formed by the sum signal $A+B$ of the coherent stereophonic signals A and B, for example in the band from 30 to 15,000 c./s. and the difference signal $A-B$ transmitted with carrier suppression on a subcarrier frequency of 38 kc./s. by amplitude-modulation and by a pilot signal of 19 kc./s., the modulation signal thus formed in the band from 30 to 53,000 c./s. modulating in frequency the carrier frequency with a sweep of 75 kc./s. at a maximum.

The stereophony receiver comprises an aerial **1**, an intermediate-frequency stage **2** with a mixing stage and an oscillator **3**, connected thereto, the intermediate frequency oscillations obtained by mixing in the band from 10,700 kc./s. being supplied, subsequent to amplification and inhibition, if necessary, in the intermediate frequency stage **2**, to an output filter which is formed by two coupled circuits **4**, **5**.

The bandpass filter **4**, **5** forms part of a type of frequency detector known for the detection of normal frequency modulation transmissions and comprises two rectifiers **6**, **7**, which are connected to the ends of the circuit **5** and which pass current in opposite directions, and which are connected to an output impedance **8**, whilst a centre tap of the circuit **5** is connected to the end of a coupling coil **9**, connected to the circuit coil **4**. The output impedance **8** of the frequency detector is formed by a resistor **10**, which is shunted by the series combination of two capacitors **11**, **12** with an earth connected junction and a smoothing capacitor **13**, whilst the output voltage of the frequency detector is derived from the centre tap of the resistor **10**.

At the output impedance of the frequency detector **6**, **7** there appears an output voltage of the waveform shown in FIG. 2 in the frequency diagram. It will be seen from the figure that it is composed of the sum signal $A+B$ in the band from 30 to 15,000 c./s., the difference signal $A-B$ in the band from 23,000 to 53,000 c./s. modulating the subcarrier of 38 kc./s. with carrier suppression and the pilot signal of 19,000 c./s.

In order to restore the coherent stereophonic signals A and B from the output voltage of the frequency detector **6**, **7** of FIG. 2 these signals are supplied to a device comprising, at the input end, the parallel combination of an information channel **14** passing the output voltage of the frequency detector and a pilot channel **15**, passing solely the pilot signal and comprising a frequency doubler **20** for producing the subcarrier frequency of 38 kc./s. In the embodiment shown the pilot channel comprises an input pilot filter **16** and a transistor **17**, connected as a pilot signal amplifier, the output circuit including a pilot signal filter formed by two coupled circuits **18**, **19**, the output voltage of which is fed to the frequency doubler **20**, which is formed by a push-pull rectifier comprising rectifiers **21**, **22** and an output resistor **23**.

To the output circuit of the frequency doubler **20** there is connected a transistor **24**, connected as an amplifier, the collector circuit of which includes a circuit **25**, tuned to the subcarrier frequency of 38 kc./s., and an indicator **45**, formed by a direct current meter. The local carrier oscillation obtained from the frequency doubler **20** is fed, subsequent to amplification in the transistor **24**, through the circuit **25** for further processing to a coupling coil **26**, whilst the indicator **45** deflects to indicate the presence of a local carrier oscillation.

The information channel **14** is connected to the centre tap of the coupling coil **26** through a low bandpass filter **27**, allowing only the information signals to pass and in order to restore the coherent stereophonic signals A and B the ends of the coupling coil **26** are connected to the diagonal points of a ring **46**, each of the ring branches including the series combination of a series resistor **32**, **33**, **34**, **35** and a rectifier **28**, **29**, **30**, **31**, the latter having the same pass directions in the course of the circuit **46**. The two rectifiers **28**, **29** and the two rectifiers **30**, **31** constitute each an electronic switch, the output voltage of the two electronic switches thus formed **28**, **29** and **30**, **31** being derived from output resistors **36**, **36'**, located at diagonal points of the ring **46**.

The coherent stereophonic signals A and B are derived from the output resistors **36**, **36'** of the two electronic switches **28**, **29** and **30**, **31** and are fed to reproducing devices **39**, **40** through low frequency amplifiers located in separate reproducing channels. The low frequency amplifiers are constructed in an identical manner and are provided with transistors **41**, **42** the emitter circuits including non-shunted resistors **43**, **44**, whilst the amplified coherent signals A and B are derived from output impedances **50**, **51**, included in the collector circuits of the transistors **41**, **42**, said impedances being connected, as is shown diagrammatically in the figure, through separating capacitors **47**, **48** to the reproducing devices **39**, **40**. Cross talk between the reproducing channels **37**, **38** is compensated for in the device shown in a simple manner by means of a transverse resistor **49**, connected between the emitter circuits **43**, **44** of the transistors **41**, **42**, said resistor being adjustable for the cross talk compensation. A cross talk of better than −40 db was realized in this case, which may be considered to be excellent for stereophonic reproduction.

The operation of the device described above will now be explained more fully.

When the stereophonic signal illustrated in FIG. 2 appears at the output circuit of the frequency detector **6**, **7** it is fed through the information channel **14** to the centre tap of the coupling coil **26**, whilst in the pilot channel **15** the pilot signal selected in the circuit **16** and amplified in the pilot amplifier **17** is fed, subsequent to frequency doubling in the frequency doubler **20**, as a local subcarrier frequency to the electronic switches **28**, **29** and **30**, **31**, said frequency serving as a switching signal for the electronic switches **28**, **29**, **30** and **31**.

If the phase of the local subcarrier frequency at the coupling coil **26** corresponds accurately with the phase of the carrier frequency associated with the incoming signal, which phase adjustment may be carried out in a simple manner by detuning one of the circuits **18**, **19** of the pilot filter in the output circuit of the pilot amplifier **17**, the coherent stereophonic signals A and B appear across the output resistors of the electronic switches **28**, **29**, **30**, **31**, which are rendered conducting in successive half periods by the local subcarrier frequency operating as a switching signal, so that a sampling value of the incoming information signal is obtained, during the consecutive half periods, at the output resistors **36**, **36'** of the electronic switches **28**, **29**, **30**, **31**, which value is formed at one output resistor by the sum of the sampling value of the $A+B$ signal and the value of the $A-B$ signal during the positive half period of the subcarrier frequency and at the outer resistor by the sum of the sampling value of the $A+B$ signal and the value of the $A-B$ signal during the negative half period of the subcarrier frequency. Smoothing of these sampling values by means of output impedances **50**, **51** in the output circuits of the low-frequency amplifiers **41**, **42**, forming smoothing filters, supplies the coherent stereophonic signals A and B and these smoothing filters **50**, **51**, which may, if desired, operate simultaneously as de-emphasis networks, suppress the pilot signal of 19 kc./s. coming in through the information channel **14**, as well as further detection residues.

At the appearance of a stereophonic input signal of the waveform shown in FIG. 2 the device so far described supplies a stereophonic reproduction of excellent quality, and at a monaural input signal for example in the frequency band from 30 to 15,000 c./s a monaural reproduction is obtained. In this case the pilot channel **15** does not provide a local carrier frequency and the monaural input signal is directly transmitted through the electronic switches **28**, **29**, **30** and **31** to the separate reproducing channels **37**, **38**. In accordance with the polarity of the input signal of each of the two electronic switches **28**, **29**, **30** and **31**, one of the rectifiers is conducting. With an input signal of positive polarity, for example the rectifiers **29**, **30** of the ring **46** are conducting, whereas the rectifiers **28**, **31** are cut off and conversely with an input signal of negative polarity the rectifiers **29**, **30** are cut off and the rectifiers **28**, **31** are conducting. Through the alternately conducting rectifiers **28**, **29**, **30**, **31** the monaural input signal is transmitted to the output impedances formed by the resistors **36**, **36'** of the electronic switches **28**, **29**, **30**, **31**.

Apart from the simplicity of construction of the device described so far offers the possibility of obtaining a stereophonic or monaural reproduction without mechanical change-over according as a sterophonic or a monaural input respectively is received, whilst the indicator **45** provides an indication whether a stereophonic or a monaural input signal is received. The applicant has found, however, that the reproduction quality of a monaural input signal, particularly in the case of low amplitude, does not come up to expectation, which was found to be due to the non-linear effects at the instants of change-over, i.e. the instants when the transmission of the monaural signal from one pair of rectifiers **29**, **30** or **28**, **31** is taken over by the other pair of rectifiers **28**, **31** or **29**, **30** respectively. The distortions of the monaural signal produced by said non-linear effects are for example of the order of a few percent.

Whilst maintaining the excellent reproduction quality of the stereophonic input signal, the reproduction quality of the monaural signal is improved, inaccordance with the invention, in a surprisingly simple manner to a considerable extent by connecting the junction **52** of the series resistor **34** and the rectifier **30** in one ring branch and the corresponding junction **53** in the opposite ring branch **29**, **33** each through a separate resistor **54** and **55** respectively to the terminal **56** of the supply voltage source, the earth-connected other terminal **57** of which is connected through the two output resistors **36**, **36'**, forming connections passing direct current, to the diagonal points of the ring **46**, connected to said output resistors **36**, **36'**. The direct voltage source supplies for all rectifiers **28**, **29**, **30**, **31** of the ring **46** a substantially identical bias adjustment in the pass direction.

For illustrating the variations of the direct currents FIG. 3 shows the ring **46** in the inverse position; identical elements are designated by the same reference numerals. The direct curent from the voltage source terminal **56** passing through the resistors **54**, **55** will thus be distributed among the resistors **33** and **34** and the circuits including the rectifiers **29**, **31** and **30**, **28** respectively, it passing subsequently through the output resistors **36** and **36'** to the terminal **57** of the voltage source, whilst the direct current in the two circuits including the rectifiers **29**, **31** and **30**, **28** provides a pre-adjustment of the rectifiers **29**, **31** and **30**, **28** in the pass direction. Owing to the symmetry a substantially identical pre-adjustment in the pass direction of all rectifiers **29**, **31**, **30**, **28** is obtained, which can be set in a simple manner to the desired value by rendering the two resistors **54**, **55** adjustable in common.

When a stereophonic signal is applied to the device according to the invention, the rectifiers **28**, **29**, **30** and **31** operating as electronic switches will be alternately by the local carrier fed to the coupling coil **26**, during each half period and cut off in the manner described above, so that the coherent stereophonic signals A and B can be derived through the alternately released electronic switches **28**, **29**, **30**, **31** from the output resistors **36** and **36'**. A direct current flows not only through the resistors **33**, **34** but also through the two rectifiers of the conducting electronic switches **28**, **29**, **30**, **31** and through the coupling coil **26**, said direct currents being identical for the two rectifiers of each of the electronic switches **28**, **29**, **30** and **31** owing to the symmetry of said switches. Owing to the identical pre-adjustment of the rectifiers **28**, **29**, **30**, **31** the stereophonic reproduction is not adversely affected in any respect and as stated above, this reproduction is of excellent quality.

When a monaural input signal is fed to the centre tap of the coupling coil **26**, the rectifiers **28, 31** are conducting in the manner described above with positive polarity of the monaural input signal and the rectifiers **29, 30** are conducting with negative polarity. Owing to the pre-adjustment of the rectifiers in the pass direction the distortions produced by the non-linear effects at the change-over are considerably reduced. At the instants when one pair of rectifiers **28, 31** or **29, 30** respectively is cut off, the other pair of rectifiers **29, 30** or **28, 31** respectively is already in the conducting state by the pre-adjustment in the pass direction. The improvement obtained is considerable. When by the common adjustment of the resistors **54, 55** the value of the pre-adjustment of the rectifiers **28, 29, 30** is set, it is found that with a given value of the setting current a fairly sharp minimum appears in the distortion level of the monaural signal reproduction; this distortion level has dropped by a factor of about 10. With the rectifiers employed of the AA119 type the minimum distortion level was found to lie at a setting current of $3/\mu a$.

Apart from the excellent stereophonic reproduction quality, the particular simple construction and the possibilities of adjustment, the device according to the invention is distinguished by a considerable improvement in the reproduction quality of monaural signals, whilst it has furthermore been found that owing to the preadjustment of the rectifiers **28, 29, 30, 31** a given amount of compensation of the stray of rectifier characteristics is obtained.

For a practically tested device of the type described above the following data are given;

Rectifiers **28, 29, 30, 31**	4XAA119
Resistors **54, 55**	mohms 1.5
Resistors **32, 33, 34, 35**	kohms 15
Output resistors **36, 36'**	kohms 47
Supply voltage	v 15

What is claimed is:

1. A device for the stereophonic reproduction of signals supplied in the form of the sum signal $A+B$ of coherent stereophonic signals A and B and of the difference signal $A-B$ of said coherent stereophonic signals, amplitude modulating a subcarrier frequency with carrier suppression in common with a pilot signal of half the carrier frequency to the device, which comprise at the input end the parallel combination of an information channel passing the incoming stereophonic signals and a pilot channel passing solely the pilot signal, comprising a frequency doubler for the local production of the carrier frequency, the information channel and the pilot channel being connected, in order to restore the stereophonic signals A and B, to diagonal points of a ring comprising in each branch the series combination of a resistor and a rectifier, the rectifiers having the same pass direction in the course of the ring, whilst the coherent signals A and B are derived from output resistors connected to the further diagonal points of the ring, characterized in that the junction of the series resistor and the rectifier in one ring branch and the corresponding junction in the opposite ring branch are connected each through a separate resistor to the terminal of a bias voltage source and in that the other terminal of the bias voltage source is connected through the two output resistors forming connections passing direct currents to the diagonal points of the ring connected to said output resistors, said bias voltage source providing a substantially identical preadjustment of all rectifiers of the ring in the pass direction.

2. A device as claimed in claim **1**, characterized in that the two resistors lying between the terminal of the bias voltage source and the junction of the rectifier and the series resistor in the opposite ring branches are adjustable in common.

3. A demodulator circuit for stereophonic signals of the type comprising a sum signal of first and second coherent stereophonic signals and a difference signal of said first and second signals amplitude modulated on a suppressed subcarrier wave, said demodulator circuit comprising a source of said stereophonic signals, a source of oscillations of the frequency of said subcarrier wave, a bridge circuit, each arm of said bridge circuit comprising a series-connected resistor and rectifier, said rectifiers being poled to pass current in the same direction around said bridge circuit, means applying said oscillations with opposite phase to a first pair of diagonal junctions of said bridge circuit, first output impedance means connected between one of the remaining junctions of said bridge circuit and a point of reference potential, second output impedance means connected between the other remaining junction of said bridge circuit and said point, means applying said stereophonic signals between said point and said first pair of junctions with the same phase, bias means having one terminal connected to said point, and separate resistor means connecting the other terminal of said bias means to separate junctions between resistors and rectifiers of a pair of opposite arms of said bridge circuit, said bias means providing substantially identical forward bias for all rectifiers of said bridge circuit.

4. A demodulator circuit for stereophonic signals of the type comprising a sum signal of first and second coherent stereophonic signals and a difference signal of said first and second signals amplitude modulated on a suppressed subcarrier wave, said demodulator circuit comprising a source of said stereophonic signals, a source of oscillations of the frequency of said subcarrier wave, a bridge circuit, each arm of said bridge circuit comprising a series-connected resistor and rectifier with an electrode of the rectifier of one arm being connected to a first junction of said bridge circuit and an electrode of the rectifier of the opposite arm being connected to a second diagonally opposite junction of said bridge circuit, said rectifiers being poled to pass current in the same direction around said bridge circuit, means applying said oscillations with opposite phase between a first pair of opposite junctions of said bridge circuit, means applying said stereophonic signals between a point of reference potential and said first pair of junctions with the same phase, first output resistor means connected between said point and a junction of the remaining pair of junctions of said bridge circuit, second output resistor means connected between said point and the other junction of the remaining pair of junctions of said bridge circuit, a source of bias voltage having one terminal connected to said point, third resistor means connected between the other terminal of said bias source and a junction of the resistor and rectifier in said one arm or said bridge circuit, and fourth resistor means connected between said other terminal and the junction of the resistor and rectifier in said opposite arm of said bridge circuit, whereby a substantially identical forward bias is applied to each rectifier of said bridge circuit.

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