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APPARATUS AND METHOD FOR DETECTING, COMPARING AND RECORDING HEART VALVE MUSCULAR ACTIVITIES

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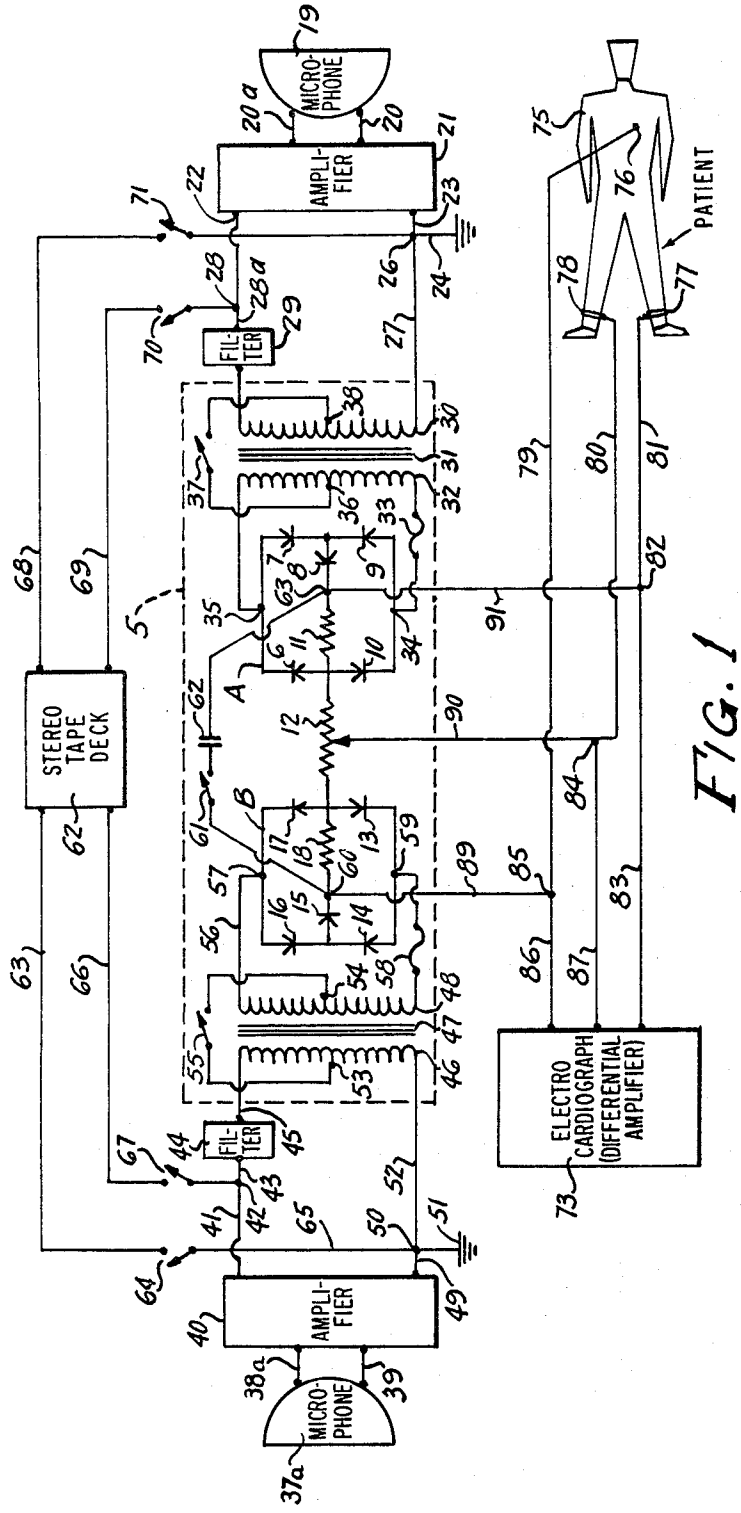


FIG. 1

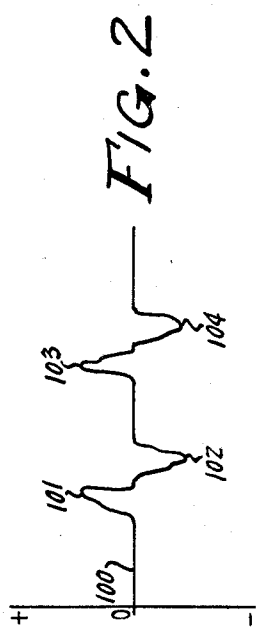


FIG. 2

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APPARATUS AND METHOD FOR DETECTING, COMPARING AND RECORDING HEART VALVE MUSCULAR ACTIVITIES

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ABSTRACT OF THE DISCLOSURE

A dual input phonocardiographic circuit including a pair of microphone pick ups, a pair of Wheatstone bridge circuits for receiving the outputs of the microphone pick ups, each of said Wheatstone bridges including a R-C filter and divider circuit, interconnecting filter means between the Wheatstone bridge circuits, a recorder for preserving the microphone output signals and for applying said microphone output signals to the Wheatstone bridge circuits, and the circuitry for simultaneously applying the output signals from the Wheatstone bridge circuits to a differential amplifier and visual recorder for analysis and inputs and a diagnostic method using said circuitry are disclosed.

This invention pertains to a unique, dual, full wave bridge circuit arrangement and combination of apparatus to mix a plurality of low voltage audio signals from different sources and change their forms into low frequency polarized analogs.

More particularly, this invention relates to a method and multiple bridge circuit and combination of apparatus to record stereo (sounds from two valve areas) heart sounds in an analog form for presentation on an electrocardiograph recording machine with minimal amplifications from the heart sound transducers to demonstrate instantaneously and graphically the relative sound intensities at two heart areas by graphical deviations from a recorded null signal baseline.

The standard clinical phonocardiograph reproduces graphically the actual chest wall vibrations rather than the low frequency, polarized electrical analog method of the present invention. This invention permits a graphical study of heart sounds or murmurs which predominate in one area or another of the heart which bear a direct relationship to specific valve closure and the point at which murmurs and other sounds are produced by the heart. By this technique, considerably more diagnostically useful information is produced than with a standard clinical phonocardiograph which reproduces graphically the actual chest wall vibrations, rather than the low frequency, polarized electrical analog method of this invention.

The primary object of this invention is to provide a method and means for mixing, amplifying, recording and changing simultaneously a pair of audio signals of heart muscle and valve activity within living bodies into analog form such that the resulting instantaneous differential signal polarity will be a function of the relative intensities of the signals at any instant.

Another object of this invention is to provide an apparatus for detecting stereo heart sounds from two different heart valve areas, simultaneously amplifying the signals, and passing the amplified signals to a differential recorder, such as an electrocardiograph.

A further object of the present invention is to provide an electronic apparatus which will mix low level audio signals from two different sources, change their forms into low frequency analogs, and feed same into a differential amplifier-recorder such as a conventional electrocardiograph where the instantaneous signal polarity will be a function of the relative intensities of the two signals at that particular instant.

An additional object of the present invention is to provide a multiple heart sound electronic apparatus for use with a standard single channel electrocardiograph, which will detect heart beats in recorded stereo form from two different areas of the heart, mix the signals, and feed the mixed signals in analog form through the single channel for recording on the electrocardiograph.

A still further object of the invention is to provide a polarized electrical analog method of diagnosing heart sounds or murmurs that predominate in one area over another heart area which bear a direct relationship to specific heart valve hemo-dynamics, specific location of sounds and specific timing action between the two sounds or murmurs.

Another object of the invention is to provide means to reproduce the alternating current signals from either input at the differential inputs, or balance the two instantaneous alternating current signals, having the circuitry so arranged that integration may be employed, if desired, without imbalancing the two bridges, such as a capacitor means that does not affect bridge balance.

A further object of the present invention is to produce graphic records of relative sound intensities from two channel tape recorders when heart sounds from two valve areas have been simultaneously recorded on the two sound tracks which may then be played back through the bridge arrangement in analog form for analysis by the physician.

A still further object of the present invention is to provide means for a physician to employ, at a minimal cost, readily available conventional high-fidelity stereo tape recorders containing conventional preamplifiers to record his patient's heart sounds on tape and obtain further clinical records from multiple bridge circuitry arrangement attached to a clinical electrocardiograph.

Another object of the invention is to provide a multiple bridge and circuitry means so that while an electrocardiogram is being recorded from a patient, the heart sounds or their electrical analog can be superimposed on the electrocardiographic tracing by attaching the output electrodes of the new bridge means to the electrodes attached to the patient.

A further object of the invention is to provide a multiple electronic bridge means and circuitry means adaptable to be suitably interconnected between a pair of microphones, patient, electrocardiograph machine and stereo tape deck.

A still further object of the present invention is to provide a polarized electrical analog method of diagnosing heart sounds or murmurs that predominate in one area over another heart area which bears a direct relationship to specific heart valves and the point at which murmurs and other sounds are produced by the heart.

Still other objects, advantages and improvements will become apparent from the following description, taken in connection with the accompanying drawing in which:

FIGURE 1 is a schematic diagram showing the new multiple bridge circuit arrangement and electrical hookup of various apparatus to a patient for heart performance diagnosis by a physician; and

FIGURE 2 is a graph of a resulting signal of FIGURE 1 taken by a microphone means having a positive polarity over the aortic areas and a negative polarity over the pulmonic areas of the heart after balancing of sound amplification over both valve areas of the heart.

Referring to the drawings:

FIGURE 1 discloses the new dual full wave bridge as generally indicated by the broken line rectangle 5. Bridge A is formed by rectifying diodes 6, 7, 8, 9 and 10 together

with a suitable resistance 11 across the output of the bridge in conjunction with potentiometer 12. Bridge B is formed by rectifier diodes 13, 14, 15, 16 and 17 together with a suitable resistance 18 across the output of the bridge in conjunction with potentiometer 12. Resistances 11 and 18 of bridges A and B, respectively, are interconnected to potentiometer 12 to form a resistance path across the output of each bridge to produce the desired signal voltage.

The two full wave rectifying bridges A and B are conventional except, for the two added rectifying diodes 8 and 15 that limit the backward flow of current below the level obtained with a conventional bridge composed of solid state low current diodes. Without additional diodes 8 and 15 in the circuit of the dual rectifier 5 there would be an unacceptable reverse current flow which would distort the balance of the dual bridge.

Microphone 19 is connected by leads 20 and 20*a* to amplifier 21 the output of which is connected by leads 22 and 28*a* to filter 29 which is connected to primary winding 30, and by leads 23 and 27 to the primary winding 30 of isolation transformer 31. Ground 24 is connected to lead 23 at point 26. The secondary winding 32 of isolation transformer 31 is connected to point 35 of bridge A and by patient protective fuse 33 to point 34 of bridge A. Primary winding 30 is connected at point 38 through switch 37 to centertap 36 of secondary winding 32 of isolation transformer 31 for reasons which will be later explained.

Microphone 37*a* is connected by leads 38*a* and 39 to amplifier 40, the output of which is connected by leads 41 and 43 to filter 44 and by leads 49 and 52 to the primary winding 46 of isolation transformer 47. Winding 46 is further connected by lead 45 to filter 44. Ground 51 is connected to point 50 of lead 49. The secondary winding 48 of isolation transformer 47 is connected by patient protective fuse 58 to point 59 of bridge B, and by lead 56 to point 57 of the bridge B. Centertap means 53 of primary winding 46 is connected by switch 55 to centertap 54 of secondary winding 48 of isolation transformer 47 in a manner as illustrated in bridge A.

Stereo tape deck 62 has an input connected by leads 63 and 66 connected to switches 64 and 67 which are connected by lead 65 to point 50 of lead 49 and point 42 of lead 41, respectively, of amplifier 40. The other input of stereo tape deck 62 is connected by leads 68 and 69 by switches 70 and 71 to point 28 of lead 22 and to point 26 of lead 23 of amplifier 21.

FIGURE 1 further shows the application of the method and apparatus of the present invention in which a patient 75 is connected by a common chest wall electrode 76 by leads 79 and 86 in concert with other body or leg electrodes 77 and 78 also through leads 80, 87, 81 and 83 to an electrocardiograph recording machine 73 as shown. Transducers 19 and 37 are applied to the chest over separate heart valve areas of the heart and the resultant signal through dual bridge 5 is superimposed by circuitry in correct relationship on the electrocardiograph machine 73 by points 60 of bridge B being connected by lead 89 to point 85 of lead 86, and potentiometer 12 being connected by lead 90 to point 84 of lead 87, and point 63 of bridge A being connected by lead 91 to point 82 of lead 83, as shown.

FIGURE 2 shows a resultant tracing of the invention on the electrocardiograph machine 73 taken with a microphone over the aortic area of the heart and a microphone over the pulmonic area of the heart after balancing of the sound signals through dual bridge 5 for both heart valve areas.

Line 100 is the baseline, absent the electrocardiographic trace, produced by the differential amplifier recorder 73. Lines 101 and 103 are the resulting positive polarity signals during systole and diastole over the aortic area. Lines 102 and 104 are the resulting negative polarity signals during systole and diastole over the pulmonic area. Thus, timing and relative differential intensities of the sounds are graphically illustrated.

In order to balance the resistances between the two differential leads 89 and 91 of FIGURE 1 and the center ground 90, a potentiometer 12 is used to give maximum common mode rejection in the differential amplifier recorder 73.

It should be noted that switching in capacitor 62 by closing switch 61 does not affect the balance achieved.

In operation, a first microphone 19 is positioned adjacent a first position on the patient's body for receiving audible vibrations which result from a first heart valve muscular activity, a second microphone, 37*a*, is positioned adjacent a second position on the patient's body for receiving audible vibrations resulting from a second heart valve muscular activity, the output signals of the first and second microphones are individually rectified to produce variable DC voltage signals, and an algebraic amplitude differential signal derived from the combined rectified output signals of the first and second microphones is recorded in the form of a reference base signal with positive and negative variations from the base signal which are generally quantitative functions of the relative amplitudes of the audible vibrations which result from the first and second heart valve muscular activity. The rectified output signals may be partially integrated by capacitor 62 prior to recording the algebraic amplitude differential signal. While not shown in FIGURE 2, an electrocardiographic signal may be simultaneously recorded with the algebraic amplitude differential signal by superimposing the two signals on the recording medium.

It is to be noted that if only one signal is fed into the present bridge arrangement 5, with switches 37 and 55 open, a fully rectified output will be produced between leads 89 and 90 if the signal is applied through bridge B. If only one signal is fed into the present bridge arrangement 5, with switches 37 and 55 open, a fully rectified output will be produced between leads 91 and 90, but with opposite polarity when rectified through bridge A.

If two identical electrical currents, identical in frequency and electron flow, are fed into both bridges A and B simultaneously, and if the diodes and bridge resistors are balanced through potentiometer 12, the two signals will cancel each other insofar as the differential amplifier recorder 73 is concerned. If sufficient integration is permitted by closure of switch 61, which places capacitor 62 across the differential output leads 89 and 91, the system can be made essentially phase independent providing the proper RC constant for the combination of capacitor 62 and resistors 11 and 18 and potentiometer 12 is provided for the lowest frequency presented to bridge network 5.

If, on the other hand, one does not desire to rectify the signal, but rather to present an alternating current signal at the differential output means 89 and 91, then switches 37 and 55 are closed. This permits, at the low voltage and current level at which the bridge is operated, the signal presented at the transformers 31 and 47 inputs to be presented at a reduced level at differential output leads 89 and 91 to the differential amplifier recorder 73.

By the switching arrangement explained above, a physician can either reproduce the signals presented in their actual wave form and balance the alternating current signals, depending on phase and amplitude, or the fully rectified integrated or nonintegrated signals. If rectification is chosen the signals can be balanced if identical, or if not identical the stronger signal will cause positive or negative deviation of the differential amplifier recorder 73 readout depending on the relative signal intensities presented at any given instant.

Another important feature of the present invention in actual use is in obtaining graphic records of relative sound intensities from two channel tape recorders when heart sounds from two valve areas have been simultaneously recorded on the two tracks and then are played back into the present bridge arrangement presented.

Also, it is to be noted in the present invention, that while an electrocardiogram is being taken from a patient, the heart sounds or their electrical analog can be superimposed on the electrocardiographic tracing by attaching bridge 5 output to the electrodes attached to the patient. This is the reason for showing the two patient protective fuses 33 and 58 in FIGURE 1 which limit the maximum current which can reach the patient in the event of a short circuit or other malfunction. This is an important factor, in that, the electrical voltages generated during cardiac activity are used quite commonly to identify the part of the cardiac cycle during which a given sound is produced. The electrocardiographic trace is omitted from FIGURE 2 for purposes of clarity.

In essentially all of the present commercial phonocardiographs two recording channels are used. One channel records the heart sounds. The other channel reproduces a simultaneous electrocardiogram. The ability of the present system to mix the heart sounds from two different areas and to superimpose an electrocardiogram tracing on the resulting analog form for correct timing and selectively of the heart sounds obviates the need for multiple channel recording instrumentation, making it possible to use the standard single channel electrocardiograph now employed by most physicians in their practice.

The method and apparatus of the present invention can be used to compare the magnitude and time interval relationships of two audio voltages of muscular activities within a living body at any given instant. The identification of the predominant voltage being defined by a positive deflection from one source, or a negative deflection from another source when used with a differential amplifier recorder means, such as, the standard electrocardiograph.

The apparatus of the present invention can be made to function as above in a phase independent mode of operation.

Further, the above apparatus of this invention uniquely permits an electrical analog representing sounds from two areas of the heart to be superimposed on the simultaneously recorded electrocardiogram, thereby eliminating dual channel recording.

This new dual bridge apparatus permits the audio current to flow in two separate circuits and be presented in conventional form to a differential amplifier recorder or as an electrical analog and configured in such a way as to permit reproduction in both forms from either input singly or jointly. In the latter case, the polarity of the differential amplifier recorder determines whether or not a deviation above or below the baseline of a graph indicates predominance of one signal intensity relative to the other.

The above new apparatus when properly employed in reproducing heart sound intensities clearly indicates in which of two areas a given sound predominates at any point in time and is, therefore, diagnostically useful in identifying the origin of murmurs, the identification of valve sounds relative to the valve producing the sounds, and which if used quantitatively substantially helps the physician to follow any changes in heart sounds associated with changed cardiac functional status.

The present invention provides a unique dual full wave bridge circuit arrangement for the simultaneous presentation of the relative intensities of two electrical signals in the audio frequency range to a differential input amplifier recorder.

The present invention provides a substantially greater full wave rectification function of both bridges (less reverse current flow) by the addition of a fifth diode such as diode means 8 or 15 of bridge circuits A and B of FIGURE 1, when conventional solid state, low current diodes are used for rectification. In addition, the use of the fifth diode in each bridge circuit materially reduces the need to carefully match reverse current characteristics of the diodes comprising the conventional bridge; which materially reduces the time and cost required in the construction of such bridges commercially.

This invention provides a unique use of center tapped transformers at points 36, 38, 53 and 54 to prevent rectification by the associated full wave rectifiers when employed at low levels of voltage and current.

This invention, as explained above, employs the following method steps of receiving, mixing, amplifying, recording and changing simultaneously a pair of audio signals, of heart muscular activities within a living body, into analog form such that the resulting instantaneous signal polarity, as recorded on a differential amplifier recorder, will be dependent upon the intensity of the signals at any instant for diagnosis of heart disease.

In use, the two microphones 19 and 37 are attached to or otherwise positioned adjacent the patient's body so as to pick up the audible sounds produced by the heart. One microphone preferentially picks up the sounds associated with one heart muscular activity and the other microphone preferentially picks up the sounds associated with a different heart muscular activity, normally the opening and closing of the valves in the heart. To this extent, the present invention is related to the prior art photocardiographs in that in the prior art microphones for picking up a single heart sound have been known and used. In the present invention, however, two such microphones are used to preferentially pick up two different heart sounds. The sounds picked up are converted to analogous electrical signals by the microphone. These electrical signals, like the sounds from which they are derived, have a major low frequency component and superimposed thereon high frequency components resulting from other heart sounds, breathing, and muscular activity of the patient in general. The two electrical signals produced by the two microphones are fed, respectively, into individual amplifiers and through a filter. A balanced filter arrangement for eliminating high frequency signals which result from a common source in the patient, such as breathing, etc., is provided by means of switch 61 and capacitor 62 which interconnect the rectified output of the two amplifiers. The rectified signals are then applied to the differential recorder 73 which is of the type conventionally used in electrocardiography. Since the two sounds produced by the heart occur at different time intervals and since it is possible by this apparatus to substantially remove extraneous signals and in particular the high frequency components, a comparatively simple trace is produced in the recorder of the electrocardiograph, such as is shown in FIGURE 2. The spacing between the positive and the negative pulses which represent, respectively, heart sounds in one area and heart sounds in another area as picked up by the different microphones, and the relative amplitudes of the traces and the major components of these traces provides diagnostic information to the physician. It is not possible to point to a single time displacement or amplitude characteristic as definitively establishing a particular physiological or physical characteristic of the heart or the associated circulatory system. As in conventional photocardiography, however, the information on the trace which is analogous to the sounds produced by the heart taken in conjunction with the past history of the patient, other symptoms exhibited by the patient, and interpreted through the skill and experience of a trained physician provide an additional and important diagnostic aid in determining the condition of the heart, past damage to the heart, a possible future injury to the heart depending upon the patient and the history and circumstances. While the particular differential recording and comparison of heart sounds described herein is novel and there is comparatively little information thereon, the diagnostic techniques and the information derived from photocardiography in general are applicable and are described in "Pediatric Cardiology" by Dr. Alexander S. Nadas, W. B. Saunders Company, Philadelphia, 1957; "Clinical Auscultation of the Heart" by Dr. Samuel

A. Levine and Dr. W. Proctor Harvey, the latter being an Associate Professor of Medicine at the Georgetown University School of Medicine, W. B. Saunders Company, Philadelphia, 1959; and "Cardiovascular Sound in Health and Disease" by Dr. Victor A. McKusick of The Johns Hopkins University School of Medicine, Williams & Wilkins Company, Baltimore, 1958.

From the foregoing, it will now be seen that there is herein provided an improved method and means for receiving, mixing, amplifying, recording and changing simultaneously a pair of audio signals into analog form such that the resulting instantaneous signal polarity will be dependent upon the intensity of the signals at any instant which accomplishes all the objects of this invention, and others, including many advantages of great practical utility and commercial importance.

It should be understood, of course, that the foregoing disclosure relates to only a preferred embodiment of the invention and that it is intended to cover all changes and modifications of the example of the invention herein chosen for the purposes of the disclosure, which do not constitute departures from the spirit and scope of the invention set forth in the appended claims.

What is claimed is:

1. Phonocardiographic apparatus for recording and comparing audible vibrations resulting from heart valve muscular activities, comprising:

first and second mechanical to electrical transducers for deriving an electrical signal from mechanical vibrations resulting from heart valve muscular activities;

first and second rectifier circuits connected respectively to the first and second transducers for producing variable amplitude direct current signals from the electrical signals received from the transducers, said direct current signals proportionally corresponding to the muscular vibrations in frequency and amplitude; a differential indicator; and

output circuit means for connecting the respective direct current signals to the differential indicator for indicating a signal differentially derived from the direct current signals, whereby signals from two muscular areas of the heart are simultaneously differentially presented for comparison and interpretation by a physician.

2. The invention of claim 1 wherein each of the rectifier circuits comprises:

a bridge circuit of four rectifiers;

a load resistance;

a fifth rectifier; and

means connecting the load resistance and the fifth rectifier in series across the output of the bridge circuit for limiting backward flow of current in the respective rectifier circuits.

3. The invention of claim 2 further comprising:

an integrating capacitor;

a switch;

circuit means connecting the switch and the capacitor in series between output points of the respective rectifier circuits to form, in connection with the output circuit, a resistance-capacitance time constant integrating circuit when the switch is closed for selectively reducing the high frequency components of the differentially presented signals.

4. Phonocardiographic apparatus for comparing audio mechanical vibrations resulting from heart valve muscular activities by analysis and interpretation of a trace from a differential recorder, which comprises:

first and second rectifier circuits having a plurality of input and a plurality of output points;

circuit means for connecting like polarity output points together to an input to the differential recorder;

circuit means for connecting the other like polarity output points individually to individual inputs to the differential recorder;

first and second mechanical to electrical transducers for connection at spaced selected points to a patient for deriving an electrical signal analog to mechanical vibrations resulting from heart valve muscular activities; a differential indicator; and

means electrically connecting the transducers individually to the first and second rectifier circuit inputs respectively, whereby rectified signals analogous to the mechanical vibrations are fed from the rectifier circuits to the differential recorder.

5. The invention of claim 4 wherein the means electrically connecting the transducers to each individual rectifier circuit input comprises:

an isolation transformer having a primary and a secondary winding, said windings having centertap connections; and

a switch connected between the centertap connections on the primary and secondary windings for selectively connecting said windings directly together.

6. Phonocardiographic apparatus for comparing two audio frequencies whereby signals from two muscular areas of the heart are simultaneously differentially presented for comparison and interpretation by a physician on the record produced by a differential recorder, comprising:

a first full wave bridge rectifier having a pair of input points and a pair of output points;

a second full wave bridge rectifier having a pair of input points and a pair of output points;

a voltage divider connected between one output point of the first rectifier and one output point of the second rectifier;

a circuit means connected to the voltage divider for selective connection to an input of the differential recorder for feeding a selected reference signal derived from the first and second rectifiers to the differential recorder;

circuit means connected to the other output point of the first rectifier for selective connection to an input of the differential recorder; and

circuit means connected to the other output point of the second rectifier for selective connection to an input of the differential recorder.

7. The apparatus of claim 6 further comprising:

a first additional rectifier;

a first bridge resistance;

circuit means connecting the first additional rectifier and the first bridge resistance in series between the output points of the first rectifier;

a second additional rectifier;

a second bridge resistance; and

circuit means connecting the second additional rectifier and the second bridge resistance in series between the output points of the second rectifier; and

wherein the circuit means for connecting the other output points of the first and second rectifiers is connected between the first additional rectifier and the first bridge resistance and between the second additional rectifier and the second bridge resistance, respectively.

8. The apparatus of claim 7 further comprising:

an integrating capacitor;

circuit means, including a switch, connecting one side of the integrating capacitor to a point between the first additional rectifier and the first bridge resistance and the other side of the integrating capacitor to a point between the second additional rectifier and the second bridge resistance for selectively reducing the high frequency components of the differentially presented signals.

9. The apparatus of claim 8 further comprising:

first and second isolation transformers having centertapped primary and secondary windings;

circuit means connecting the ends of the first isolation transformer secondary winding to the input points of the first rectifier;

circuit means connecting the ends of the second isolation transformer secondary winding to the input points of the first rectifier;

circuit means for connecting the primary and secondary centertaps of the first isolation transformer together; and

circuit means for connecting the primary and secondary centertaps of the second isolation transformer together.

10. A diagnostic method, comprising the steps of:

positioning a first microphone adjacent a first position on a patient's body for receiving audible vibrations resulting from a first heart valve activity;

positioning a second microphone adjacent a second position on a patient's body for receiving audible vibrations resulting from a second heart valve activity;

rectifying the output signal of the first microphone to produce a variable DC voltage;

rectifying the output signal of the second microphone to produce a variable DC voltage; and

recording an algebraic amplitude differential signal derived from the rectified output signals of the first and second microphones in the form of a reference base signal and positive and negative variations from the base signal, said positive and negative variations being generally quantitative functions of the relative amplitudes of the audible vibrations resulting from the first and second heart valve activity.

11. The method of claim **10** further comprising the step of:

partially integrating the rectified output signals prior to recording the algebraic amplitude differential signal.

12. The method of claim **10** further comprising the step of:

recording an electrocardiographic signal simultaneously with the recording of the algebraic amplitude differential signal by superimposing said signals on the recording medium.

References Cited

UNITED STATES PATENTS

3,236,230	2/1966	Follett	128—2.05
3,348,534	10/1967	Marx et al.	128—2.05
3,171,892	3/1965	Pantle	179—1
2,214,299	9/1940	Heller	128—2.06
2,409,749	10/1946	Foulger et al.	128—2.06
2,684,278	7/1954	Marchand	346—33
2,865,366	12/1958	Partridge	128—2.06
2,919,403	12/1959	Bunteabach	324—79
3,196,348	7/1965	Parker	324—120
3,199,508	8/1965	Roth	128—2.06
3,212,496	10/1965	Preston	128—2.06

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