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[21] Appl. No. 792,032
[22] Filed Jan. 17, 1969
[45] Patented June 28, 1971
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[54] VITAL PULSE DISPLAY AND DISPLAY PROCESS
EMPLOYING A REPETITIVE SCANNING TAPE
SYSTEM TO MINIMIZE DISPLAY FLICKER
28 Claims, 2 Drawing Figs.

[52] U.S. Cl. 128/2.06R,
340/174.1
[51] Int. Cl. A61b 5/04
[50] Field of Search 128/2.05
(M), 2.05 (P), 2.05 (R), 2.06 (B), 2.06 (G);
346/69, 135, 136; 274/4; 340/174.1

ABSTRACT: A physiological pulse display means and process features a tape loop recording system with a stationary record head and a repetitively scanning read head moving at a higher speed than the tape whereby the usual flicker on the oscilloscope screen is reduced.

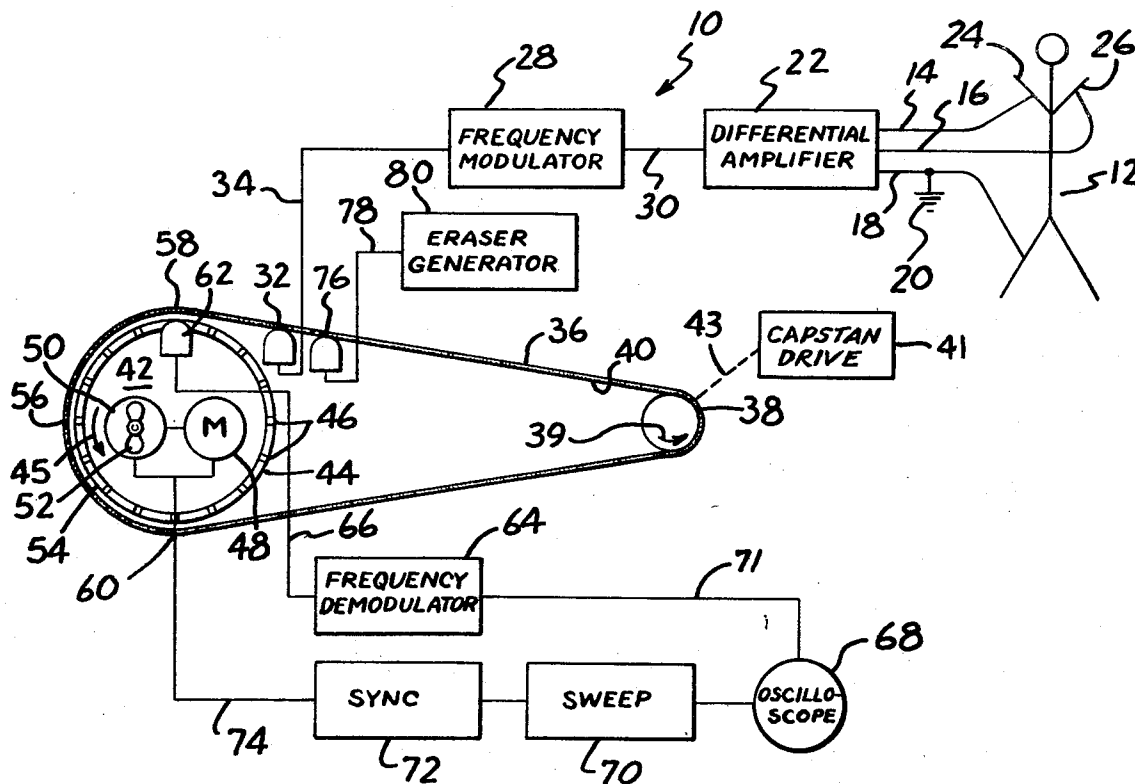


FIG. 1

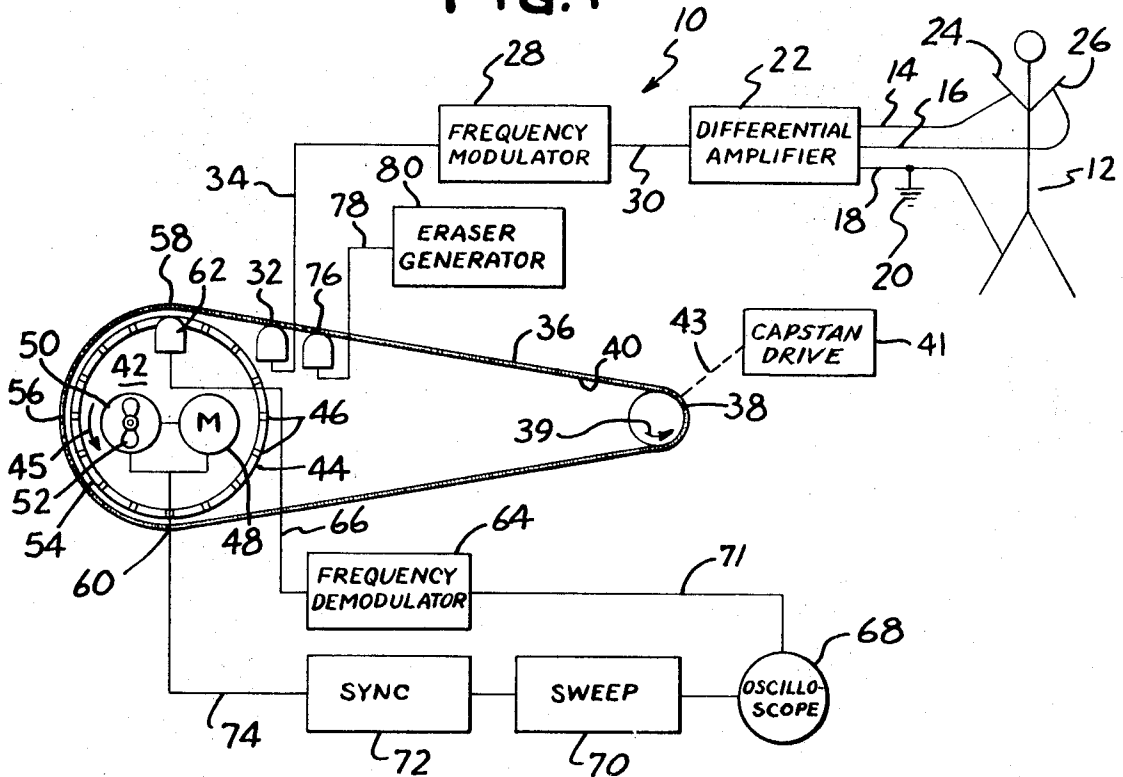
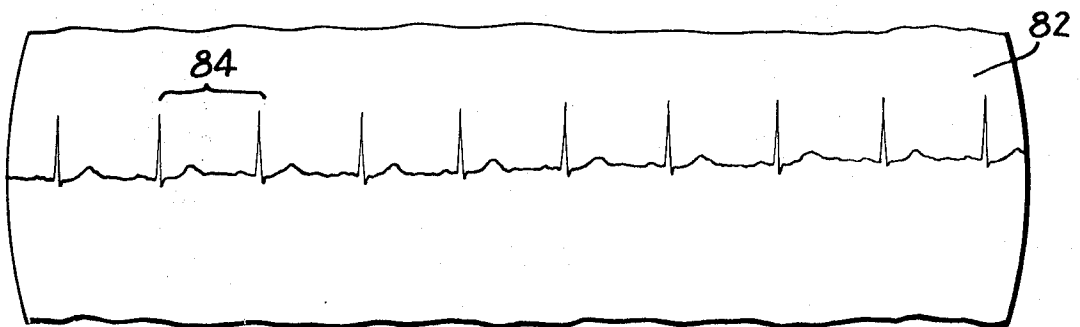


FIG. 2



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VITAL PULSE DISPLAY AND DISPLAY PROCESS EMPLOYING A REPETITIVE SCANNING TAPE SYSTEM TO MINIMIZE DISPLAY FLICKER

The present invention relates to displays. Particularly the invention relates to displaying physiological pulses. Specifically the invention relates to graphlike displays of vital heart function.

A heretofore known type of display of vital heart function is exemplified by a conventional electrocardiogram. It is produced by an electrocardiograph, a transducer for converting pulsating voltage generated during vital heart performance into a mechanical force for actuating a stylus for producing a more or less permanent tracing within the limits of the opposite ends of a narrow band of paper and the like. Inherent in this type of graphic display as a broadly effective tool for diagnostic and other purposes is the requirement for accumulations of tracing paper. These may be objectionable, though of necessity tolerated, especially in detection of only occasionally occurring abnormal pulses. Moreover, the physical character of this type of display as well as the manner of its analysis abnegates its facility as a monitor either at a central station remote from a patient where a plurality of displays are considered or during the course of surgery when the heart performance of only a single patient is considered.

To enable expanded use of graphic displays of vital heart function and also to provide an alternate tool for overcoming objectionable features associated with paper tracings, heretofore, there has been developed apparatus which translates the voltage of vital heart performance into an oscilloscope display. This type of display is effective because of its attention engaging character, which facilitates its use in monitoring, especially during surgery. However, its effectiveness is limited because of the transient nature of the display of successive increments of heart function, due to short-lived glow of phosphors which produce the display according to voltage variation generated by a heart. Therefore, at any one time there is only visible intelligence of heart function during an exceedingly short period of time; and simultaneous display of a plurality of successive heart pulses is unobtainable at or about the time they occur.

Further improvement in the prior art comprises apparatus having means for producing a graphic readout or tracing, such as cardiogram, coupled with an oscilloscope. The producing means is arranged for actuation by an electrical phenomenon in the scope which is of an unusual or abnormal character. While this latter apparatus is highly sophisticated, and minimizes paper accumulation, procedures for study of abnormalities are the same as those used for cardiograms, conventional of which do not provide for expansion or amplification of the display to enable detailed analysis of heart functions.

A feature of the present invention is the capability for providing a persistent and simultaneous graphlike display of any selected number of sequential heart beat complexes on a display device such as an oscilloscope. It is another feature of the invention that the display optionally may be produced at, about, or after the time of the occurrences depicted therein. If the former, the display travels across an oscilloscope screen, the oldest demonstrated phenomenon passing out of view while the newest comes into view. Furthermore, another feature of the invention is its capability of magnifying any desired increments of a display of normal size.

The features result from an improved process for a graphlike display of vital heart performance and comprising the steps of first recording intelligence corresponding to consecutive heart pulse complexes. The record of the intelligence is then converted into an electrical effect corresponding to the consecutive heart pulse complexes. This effect is thereafter transmitted to an electronic display device to produce a pulsating visual display. Thereafter, repeated are the steps of: (a) converting the recorded intelligence into an electrical effect and (b) transmitting said repeatedly produced electrical effects to the oscilloscope circuitry, the steps of converting and transmitting being repeated at a rate such that flicker is minimized in the display.

Preferred apparatus embodying said features comprises a storage for intelligence. Means, when operating, condition phenomena associated with vital heart performance as intelligence for storage. Means are provided for connecting the conditioning means to a physiological pulse generator; and means are provided for applying the intelligence therefrom to said storage. A scanner is arranged to produce an electrical effect in response to stored intelligence, and means are provided for utilizing each electrical effect to produce a short-lived display. To minimize the flicker effect of the short-lived display, means are provided for repeatedly driving the scanner across the storage at a sufficiently rapid speed for that purpose. Also provided are means for removing stored intelligence as unstored intelligence is applied.

How further to achieve the foregoing, and other objects, features and advantages of the invention will become apparent from the following description and appended claims having a reference to the accompanying drawings in which:

FIG. 1 is a scheme of apparatus embodying one aspect of the invention.

FIG. 2 is a view of a display produced according to the said invention.

Referring now more particularly to FIG. 1, display apparatus, generally designated 10, is adapted to be coupled to the body of a person 12 who is shown schematically and whose heart is a low voltage electric pulse generator. The coupling agency is a plurality of electrical conductors 14, 16 and 18, of which conductor 14 is connected to one arm 24 of said person, conductor 16 is connected to his other arm 26, and conductor 18 is connected to his leg and to a source of reference potential shown as ground 20. The connections to body 12 are in a manner conventional for producing an electrocardiogram.

This arrangement provides two circuits through a difference of differential amplifier 22 which may be of conventional construction. One of said circuits is comprised of conductors 14 and 18, and the other of said circuit is comprised of conductors 16 and 18, for producing a signal by amplifying the difference in the levels of potential in the circuits of conductors 14 and 16 and cancelling out interfering potentials. That is to say, the output of amplifier 22 is a pulsating voltage which is an amplification of the pulsating potential difference between arms 24 and 26, said difference being the potential variation across the heart in body 12 and representing heart activity. The character of the output of amplifier 22 is such that it cannot be used directly for forming a record in a conventional magnetic medium 40.

The signal output of amplifier 22 is transmitted therefore through a conductor 30 to a frequency modulator 28, which may be of conventional construction, for producing of a frequency modulated output capable of forming a record in the magnetic medium. Through a circuit wire 34, said last output is transmitted to a recording transducer 32. Transducer 32 may be of conventional construction and together with modulator 28 and amplifier 22 comprise means for conditioning pulses generated by the heart for recordal as intelligence. To that end the transducer generates a magnetic field which varies according to the variation in characteristics of the frequency modulated signal inducing said field. The magnetic field thus generated is disposed at a recording station relative which a storage, such as endless carrier or record tape 36, which may be of known construction, is arranged to be moved in a circuit by drive means, such as, a capstan 38. The latter herein is arranged for rotation in the direction of arrow 39 and is disposed at one end of the carrier loop.

Magnetic medium 40 may be conventional and comprises means for forming a record of intelligence according to the continuous energy output of the heart. To that end said medium is carried in a band or a strip longitudinally of carrier 36 on one surface, herein shown as its inner surface, adjacent which transducer 32 is disposed for applying intelligence to said storage.

A rotor 44, which is shown arranged for rotation in the direction of arrow 45, is disposed within the loop formed by

carrier 36, and the end thereof which is opposite capstan 38. The rotor herein may comprise a wall with a plurality of ducts or perforations 46 (only some of which are numbered), the wall being circular in cross section and defining an inner chamber 42. A motor 48, which may be disposed in chamber 42, is adapted to be driven by an alternating current. It is driveably and mechanically coupled to rotor 44. The motor may be in a common circuit with the motive means for impeller 52 of a blower 50 which is arranged in chamber 42 to provide a bearing cushion 54 about rotor 44 from air blown through ducts 46. Air cushion 54 supports only the end of the carrier loop opposite said capstan and enables movement of said carrier its rotor 44 in a manner such that its changing scan segment 56 is held by uniformly spaced a slight distance from the rotor. The scan segment is that length of carrier 36 which extends about 180° about rotor 44 between upstream and downstream positions 58 and 60 of closest proximation of the carrier with said rotor. Thus the points 58 and 60 represent the limits of a reading station extending along the path of movement of the carrier 36.

A scanner 62 comprised of a transducer for converting intelligence carried in magnetic medium 40 into an electrical effect (in a conventional manner for playing a record tape) is corotationally secured to the rotor, said scanner being disposed in operative association with scan segment 56. Herein, the scanner is shown as comprising a single transducer head mounted in the rotor wall and spaced radially from the center of rotor rotation. In consequence, the scan segment will be "read" during only part of the scanner cycle. If desired the scanner may comprise a pair of transducer heads carried in diametrically opposed positions in the rotor wall for substantially continuous carrier scanning.

The electrical effect generated during each scan cycle is transmitted from scanner 62 to a frequency demodulator 64 through a conductor 66. The demodulator is adapted to restore its electrical input to an output which is free of the effect impressed on the signal by modulator 28. A conductor 71 is arranged for transmitting the output of the demodulator to the vertical plates of an electronic display or cathode ray device herein shown as oscilloscope 68. The scope may be of any conventional type, such as an electrostatic deflection construction, as illustrated herein, or a magnetic deflection construction with a raster scan system.

The sweep cycle of scope 68 is controlled by a sweep circuit 70 which is uniformly triggered for starting each scope sweep horizontally by a conventional synchronizer circuit or "sync" 72. The "sync" itself is actuated or switched on for initiating each sweep cycle by conventional means. The latter may include a magnetic body carried with rotor 44 or the output shaft (not shown) of motor 48 for producing an electrical effect in an inductance coupled with or disposed in the "sync" circuit through a conductor 74. By such conventional means, the sweep cycle is synchronized with rotor 44.

An erasing transducer or eraser 76 is disposed adjacent the magnetic medium 40 downstream of scanner 62. In the illustrated embodiment, eraser 76 is disposed adjacent and upstream of transducer 32 for maximizing the length of a recording in medium 40. The eraser may be of any conventional construction and is connected through a conductor 78 to an eraser generator 80, or the like, the details of construction of which are well known and are not limiting on the present invention.

In practice, the relationship of rates of rotation of rotor 44 and carrier speed preferably is such that the intelligence in the magnetic medium 40 when disposed in scan segment 56 will be repeatedly "read" by scanner 62 as rotor 44 is driven. The record "reading" causes a continuous signal to be generated which, following demodulation in demodulator 64, will be impressed as a voltage on normally vertically spaced oscilloscope plates. Because of the short-lived nature of the phosphor of the oscilloscope, the display which is generated on its screen 82 tends to flicker. However, by cycling rotor 44 for "reading" segment 56 at least about 30 times per second,

while the carrier is relatively fixed, the flicker effect is minimized. If the scanner speed, while the carrier is relatively fixed and when there is only one scanner head above 30 cycles per second, flicker will seemingly disappear and an ostensible continuous display will show on screen 82.

When carrier 36 is stationary, scan segment 56 will correspondingly be static and the display on screen 82 will be static because scanner 62 repeatedly reads the same intelligence and the sweep cycle is synchronized with rotor 44, as aforescribed. However, when the carrier is driven, the display will appear to move in a manner such that the oldest intelligence shown will pass from view as new intelligence comes into view.

The normal rate of the angular movement of capstan 38 is such the carrier 36 moves slowly, preferably at a rate such that about 10 pulse complexes 84 (only one of which is numbered in FIG. 2) can be simultaneously viewed on screen 82. While the number of complexes 84 which are simultaneously viewable is not critical to the invention, the normal speed of carrier 36 should be such that not less than 1 pulse complex is normally viewable. On the other hand, if more than 20 pulse complexes simultaneously are displayed, a conventional screen 82 will appear crowded.

Considering that a normal heart beats approximately once per second and therefore develops about 1 pulse complex per second, the normal speed of carrier 36 should not exceed about one scan length 56 per second; nor should it be less than a twentieth of a scan length per second if screen crowding is to be avoided. By confining the carrier speed within such range, at least one heart complex and not more than about 20, depending upon the rate within the range selected, will be visible on screen 82.

By increasing the speed of the carrier from a normal condition, the display may be magnified so that even less than a single heart complex will occupy the entire display screen. To that end the drive of capstan 38 may be variable in character. However, magnifying capability through that agency will require means for making compensatory adjustment in at least one of modulator 28 or demodulator 64. Magnification can also be effected by changing the ratio of the scan speed and sweep speed in various ways which will be apparent to those knowledgeable in the art. However, if the scan speed is to be altered from a normal condition to effect magnification, provision should be made for altering either frequency modulation or demodulation. Highly effective, most economical and preferred for magnifying the display is adjustable means for increasing sweep speed from a normal condition in accordance with the level of magnification desired. Variable sweeps for that purpose are well known, and desired results can be obtained with a manual member (not shown) associated with the sweep for selecting a desired level of magnification.

Through use of the invention vital heart condition can be continuously monitored. An unusual condition, can be brought to immediate attention by, for example, a circuit arranged in the apparatus for triggering an audible alarm (not shown). Upon that occurrence the carrier drive can be interrupted, permitting analysis of the intelligence than on carrier 36. Moreover, because a length of carrier with recorded intelligence is available downstream of the scan segment, the heart condition prior to the occurrence of the unusual condition can be examined by adjusting the position of the carrier relative the scanner to bring selected portions of the carrier into the scan segment and a static readout position.

Preferably, transducer 32 should be disposed at the upstream end of scan segment 56 to the end that there is no appreciable lag between voltage generation and vital function displayed on screen 82. Where this is prevented because of mechanical considerations (FIG. 1), the recording station should be as close as possible to said upstream end.

As many substitutions and changes could be made in the above described process and construction, and an many apparently widely different embodiments could be conceived without departing from the scope and spirit of the invention, it

is intended that all matter contained in the accompanying specification shall be interpreted as being illustrative and not in a limiting sense.

We claim:

1. A process for displaying vital heart performance comprising the steps of:
 recording intelligence corresponding to consecutive heart pulse complexes;
 converting the recorded intelligence into an electrical effect corresponding to said consecutive heart pulse complexes;
 transmitting said effect to an electronic display device to produce a display, and successively repeating the steps of:

(1) converting again at least a portion of the recorded intelligence converted during preceeding conversion steps into an electrical effect and (2) transmitting said repeated electrical effects to said display device whereby said display device repeatedly displays each of said heart pulse complexes at a rate such that flicker visible to the human eye is minimized in the displays from electrical effects repeatedly transmitted to said electronic display device.

2. A process according to claim 1 in which each step of converting recorded intelligence into an effect comprises moving a scanner over a storage on which the recorded intelligence is carried.

3. A process according to claim 2 characterized by the step of moving the storage in a circuit while forming a record by applying said intelligence to said storage at a recording station.

4. A process according to claim 3 and including the step of interrupting storage movement for intervals of time and during said intervals performing a plurality of said converting steps.

5. A process according to claim 3 characterized by the further step of removing a portion of the recorded intelligence from said storage subsequent to the last conversion of said portion.

6. A process according to claim 5 in which the speed of the scanner is such that the storage is scanned at a rate of at least about 30 cycles per second.

7. A process according to claim 3 wherein the storage is moved at a speed such that intelligence corresponding to no less than 1 pulse complex will be scanned in each cycle of the scanner.

8. A process according to claim 7 wherein the storage is moved at a speed such that intelligence corresponding to no more than 20 pulse complexes will be scanned in each cycle of the scanner.

9. A process according to claim 7 wherein the speed of the storage is such that in 1 second it moves not more than the distance scanned by said scanner during 1 scan cycle.

10. A process according to claim 3 in which the speed of the storage is in a range of between about 1 scan length and 1/20 scan length per second.

11. A process according to claim 3 further characterized by the step of applying successive sweep signals in the electronic display device at a uniform rate and changing the relationship of scanning speed, storage speed and sweep speed for magnifying the display on said device.

12. A process according to claim 11 including the step of increasing the sweep speed relative to scanning speed and storage speed.

13. A process according to claim 11 including the step of increasing storage speed relative to scanning speed and sweep speed.

14. Heart function display apparatus comprising:
 cathode ray device;
 a rotor having air ducts;
 motive means driveably coupled to said rotor;
 means coupled to said cathode ray device for synchronizing the start of each of its sweep cycles with the cycling of said rotor;
 an impeller arranged for blowing air through said ducts to form a bearing air cushion about said rotor;

a capstan spaced from said rotor;

an endless magnetic record tape arranged in driveable association with said capstan and extending about said rotor for support on said air cushion;

a first transducer defining a recording station disposed adjacent said record tape;

a second transducer orbitably carried with said rotor in scanning association with a segment of said record tape;

means including a frequency modulator coupled to said first transducer for developing intelligence from a potential variation across a heart and recordable on said record tape; and

means including a frequency demodulator coupled to said second transducer for developing a voltage effect corresponding to said potential variation and transmitting said effect to said cathode ray device for display.

15. A combination according to claim 14 wherein means are provided to adjust the speed of the sweep of the cathode ray device relative the speed of the rotor to change the size of the display.

16. A combination according to claim 14 wherein said means for developing intelligence includes a differential amplifier arranged for connection to a vital pulse generating body.

17. A combination according to claim 14 wherein said capstan is selectively operable to selectively drive or stop said tape and said combination is characterized by a magnetic eraser disposed adjacent said tape and upstream and adjacent said recording station.

18. Apparatus for providing a graphical display corresponding to a series of physiological pulses, said apparatus comprising:

a recording medium;

first means for moving said recording medium along a path; second means responsive to said pulses for recording on said medium signals corresponding to said pulses;

said second means including a recording transducer disposed adjacent the path of said medium for recording signals on said medium;

a reading station adjacent the path of said medium and including a scanning transducer for scanning a segment of said medium at said reading station and producing electrical signals corresponding to the signals recorded on the scanned segment;

means for cyclically moving said scanning transducer in a direction paralleling the path of said medium over the extent of said reading station;

means producing synchronizing signals in timed relation to movement of said scanning transducer;

an oscilloscope including means producing a cathode ray beam;

sweep circuit means responsive to said synchronizing signals to control the sweep of said scanning beam; and,

means for applying said electrical signals to said oscilloscope;

said means moving said scanning transducer comprising means for cyclically moving said scanning transducer relative to said recording medium at a rate whereby said scanning transducer produces a plurality of electrical signals, one during each transducer cycle, for each signal recorded on the segment of said medium at said reading station;

whereby the cathode ray beam repetitively traces a display representing each signal recorded on the segment of said medium at said reading station.

19. Apparatus as claimed in claim 18 wherein said first means is selectively operable, whereby said cathode ray beam repetitively traces a display which appears to be stationary as long as said recording means is not moved.

20. Apparatus as claimed in claim 18 wherein said first means moves said record medium as it is scanned by said scanning transducer, whereby said cathode ray beam traces a moving display which moves at a rate related to the rate of movement of said record medium.

21. Apparatus for providing a graphical display corresponding to a series of physiological pulses, said apparatus comprising:

a record medium;
means responsive to said pulses and including a recording transducer disposed adjacent said record medium for recording signals on said record medium corresponding to said pulses;

means for moving said record medium, said recording transducer being stationary during recording whereby said signals are recorded in a longitudinal track on said record medium;

a reading station at which said record medium is repetitively scanned during one pass therethrough, said reading station being positioned downstream of said recording transducer and extending along the path of movement of said record medium for a distance greater than the length of record medium required to carry one signal;

scanning type reading transducer means for repetitively scanning said record medium along said longitudinal track and over the length of the record medium segment at said reading station;

means producing synchronizing signals related in time to scanning of said reading transducer means; and,

display means responsive to said synchronizing signals and said reading transducer means for visually displaying a waveform corresponding to said pulses.

22. Apparatus as claimed in claim 21 wherein said reading transducer means scans at a repetitive rate of at least about 30 repetitions per second.

23. Apparatus as claimed in claim 22 wherein said means moving said record medium moves said record medium a distance not greater than the length of said reading station during one second.

24. Apparatus as claimed in claim 21 wherein said display means comprises an oscilloscope having sweep circuit means for sweeping a cathode ray across a face of the oscilloscope; said synchronizing signals being applied to said sweep circuit means;

and the output of said reading transducer means being applied to said oscilloscope to control the vertical deflection of said cathode ray.

25. Apparatus as claimed in claim 21 wherein said means moving said record medium comprises variable drive means for driving said record medium at various selected speeds.

26. A method of presenting a visual display corresponding to physiological pulses, the representation of which is carried as signals on a record medium, said method comprising the steps off:

passing said record medium through a reading station; repetitively scanning each portion of the record medium with a transducer as it passes through said reading station to thereby produce plural electrical signals for each recorded signal during a single pass of the record medium through said reading station; and,

applying said electrical signals to a display device to repetitively produce a visual display of each physiological pulse as the portion of said medium carrying each pulse passes through the reading station.

27. The method as claimed in claim 26 and further comprising the steps of:

generating synchronizing signals in synchronism with the scanning of said transducer; and,

applying said synchronizing signals to said display device.

28. The method as claimed in claim 26 and comprising the further step of stopping said record medium whereby the same pulses are repetitively displayed with apparent movement.

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