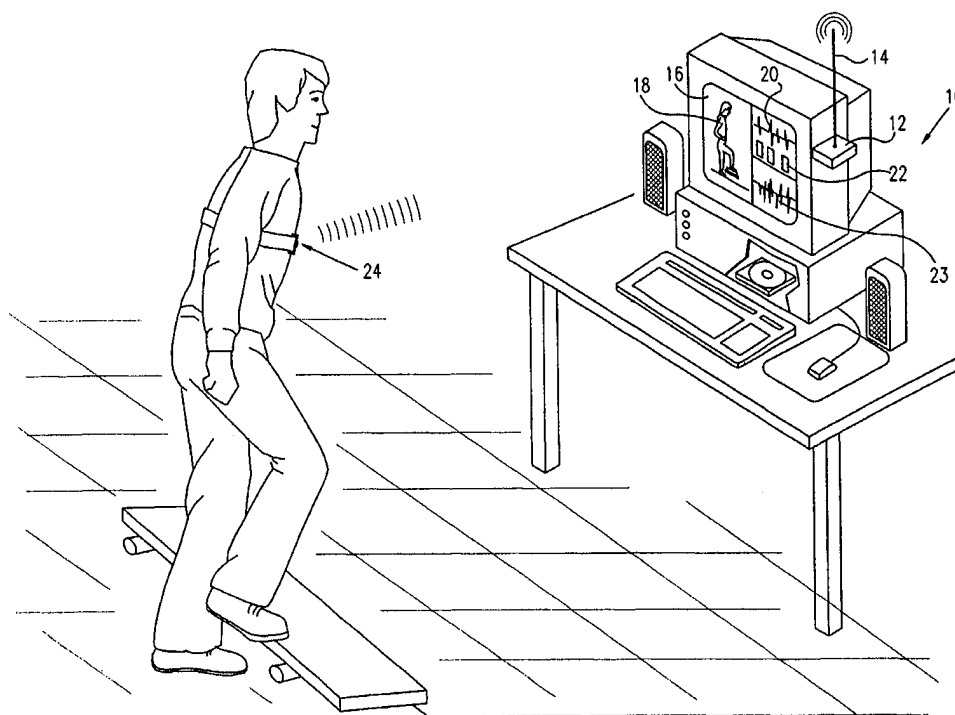


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<p>(21) International Application Number: PCT/IL98/00126</p> <p>(22) International Filing Date: 19 March 1998 (19.03.98)</p> <p>(30) Priority Data: 120507 24 March 1997 (24.03.97) IL</p> <p>(71) Applicant (for all designated States except US): KEYTRON ELECTRONICS & TECHNOLOGIES LTD. [IL/IL]; Science Park, Kiryat Weizmann 3, P.O. Box 2111, 76120 Rehovot (IL).</p> <p>(72) Inventors; and (75) Inventors/Applicants (for US only): KRUPKA, Yaakov [IL/IL]; Bustanai Street 10, 76289 Rehovot (IL). KRUPKA, Eyal [IL/IL]; Bustanai Street 10, 76289 Rehovot (IL). ZILKA, Eli [IL/IL]; Ben Ezer Street 13, 49209 Petach Tikva (IL).</p> <p>(74) Agents: COLB, Sanford, T. et al.; Sanford T. Colb & Co., P.O. Box 2273, 76122 Rehovot (IL).</p>		<p>(81) Designated States: AU, CA, IL, JP, NO, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).</p> <p>Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>

(54) Title: EXERCISE MONITORING SYSTEM



(57) Abstract

This invention is an interactive exercise monitoring system and method including a body mounted motion sensor (24), a user sensible output indicator (16) indicating to a user an exercise motion parameter derived from an output of the body mounted motion sensor (24), as well as a desired exercise motion parameter for comparison therewith.

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EXERCISE MONITORING SYSTEM

FIELD OF THE INVENTION

The present invention relates to exercise monitoring systems generally.

BACKGROUND OF THE INVENTION

Various types of exercise monitoring systems are known in the prior art patent literature.

U.S. Patent 5,527,239 describes a pulse rate controlled exercise system which includes a pulse rate monitor and a user viewable display which indicates the user's pulse rate during exercise.

U.S. Patent 5,598,849 describes an interactive exercise monitoring system and method which also includes a pulse rate monitor and which is interconnected via a modem with a network for downloading exercise regime data to guide a user.

U.S. Patent 5,466,200 describes interactive exercise apparatus which displays a user's progress through a simulated environment.

U.S. Patent 5,547,439 describes an exercise system using a plurality of exercise cycles and a display indicating progress of multiple cycles along a simulated travel path.

U.S. Patent 4,907,795 describes a computerized exercise monitoring system and method for monitoring a user's exercise performance, wherein current performance is compared with a user's past performance.

U.S. Patent 5,591,104 describes a physical exercise video system including an interface between an exercise machine and a video monitor.

U.S. Patent 5,577,981 describes a virtual reality exercise machine and computer controlled video system.

U.S. Patent 5,383,826 describes a user interface console for exercise equipment including a display for displaying various exercise parameters.

U.S. Patent 5,403,256 describes aerobic apparatus for providing support and coordination of exercise motions to a user.

Various types of body mounted exercise devices employing accelerometers are described in the following U.S. Patents: 3,797,010; 4,7765,323; 5,330,510; 4,428,378; 4,926,863; 5,354,317; 5,425,750; 5,031,615; 5,382,473; 5,342,404; 5,179,947; 5,423,869; 4,140,132; 5,014,700; 5,370,667.

Various types of heart monitors are described in the following U.S. Patents: 5,497,779; 5,474,077; 5,467,771; 5,464,021; 5,316,008; 5,228,449; 5,197,489; 4,938,228; 4,807,639; 4,489,731; 4,425,921; 4,409,983; 4,331,154; 4,307,727; 4,295,472; 4,230,127; 4,202,350.

Additional U.S. Patents of interest include: 3,709,042; 4,434,801; 5,314,389; 5,394,879; 5,486,818.

Attention is also directed to Validity of the Computer Science and Applications, Inc. (CSA) activity monitor by Edward L. Melanson, Jr. and Patty S. Freedson, Medicine and Science in Sports and Exercise, 1995, pp 934 - 940.

SUMMARY OF THE INVENTION

The present invention seeks to provide an interactive exercise monitoring system which may be independent of an exercise machine.

There is thus provided in accordance with a preferred embodiment of the present invention an interactive exercise monitoring system including:

- a body mounted motion sensor; and

- a user sensible output indicator indicating to the user an exercise motion parameter derived from an output of the body mounted motion sensor as well as a desired exercise motion parameter for comparison therewith.

There is also provided in accordance with a preferred embodiment of the present invention an interactive exercise monitoring system including:

- a body mounted heart rate sensor; and

- a user sensible output indicator indicating to the user a desired exercise motion parameter derived from a comparison of a desired range of heart rate parameters with the direction of change and rate of change of the user's heart rate as determined by the sensor.

In accordance with a preferred embodiment of the present invention, the interactive exercise monitoring system is a combination of all of the foregoing elements.

There is additionally provided in accordance with a preferred embodiment of the present invention an interactive exercise monitoring method including:

using a body mounted motion sensor to sense user motion during exercise; and

indicating to the user an exercise motion parameter derived from an output of the body mounted motion sensor as well as a desired exercise motion parameter for comparison therewith.

There is further provided in accordance with a preferred embodiment of the present invention an interactive exercise monitoring method including:

sensing the user's heart rate; and

indicating to the user a desired exercise motion parameter derived from a comparison of a desired range of heart rate parameters with the direction of change and rate of change of the user's heart rate.

In accordance with a preferred embodiment of the present invention, the interactive exercise monitoring method is a combination of all of the foregoing steps.

In accordance with a preferred embodiment of the invention the user sensible output indicator and the indicating step employ both visual and audible indications. Alternatively either may be employed. Preferably, the visual indicator indicates the motion that the user is supposed to carry out and the audible indicator indicates the tempo at which the motion is to be carried out.

In accordance with a preferred embodiment of the present invention, the method and system sense whether the user is about to exceed desired upper or lower limits of heart rate and prophylactically changes the tempo, prior to exceedance of such limits, so as to urge the user to stay within the limits.

Further in accordance with a preferred embodiment of the present invention, a visual indicator indicates on a time scale both a desired pattern of movements and the user's actual pattern of movements, so as to enable and encourage the user to bring his movements into phase and tempo with the desired pattern.

In accordance with a preferred embodiment of the present invention, the body mounted heart rate sensor and motion sensor are both incorporated in a single belt worn by the user during exercise. Preferably, the belt communicates via a wireless link with the indicator apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

Fig. 1 is a simplified pictorial illustration of an exercise monitor system constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 2 is a simplified pictorial illustration of a body mountable sensor belt useful in the system of Fig. 1;

Fig. 3 is a simplified block diagram illustration of the system of Fig. 1;

Fig. 4 is a simplified block diagram illustration of the electronic circuitry employed in the belt of Fig. 2;

Figs. 5A, 5B, 5C and 5D are together a schematic illustration of the electronic circuitry of Fig. 4;

Fig. 6 is a schematic illustration of a wireless receiver employed in the circuitry of Fig. 3;

Fig. 7 is a simplified flow chart illustration of the operation of the system of Fig. 3; and

Fig. 8 is a simplified timing diagram illustrating operation of the system of Figs. 3 and 7.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Reference is now made to Fig. 1, which illustrates an exercise monitor system constructed and operative in accordance with a preferred embodiment of the present invention. The system preferably comprises a conventional personal computer 10, such as an IBM or IBM compatible 486 with a disk or CD ROM drive and an audio

card and enhanced audio apparatus. Associated with the computer 10 is preferably an RF receiver assembly 12 including an antenna 14.

In accordance with a preferred embodiment of the present invention, a display screen 16 of the computer 10 displays a number of exercise parameters, preferably including an animated image 18 illustrating an exercise to be carried out, a time graph 20 indicating a pattern and timing of desired motion corresponding to the exercise illustrated by animated image 18, one or more additional exercise parameter indicators 22, including, for example, user heart rate, desired heart rate, calories expended, time elapsed, etc.

It is a particular feature of the present invention, that the display screen 16 also preferably indicates in real time the pattern and timing 23 of the actual motion of the user in real time. This display enables a user to match his activity, in terms of motion and the timing thereof to the desired motion pattern and its timing.

The user parameters, such as heart rate and motion are communicated to the computer 10 via receiver assembly 12 by a body mounted transducer assembly 24, typically in the form of a chest belt worn by the user either under or over his clothing. If the electrodes do not directly contact the body of the user, the intervening clothing at the electrode locations should be dampened so as to be electrically conductive.

Reference is now made to Fig. 2, which is a simplified pictorial illustration of a body mountable sensor belt useful in the system of Fig. 1. The belt, indicated generally by reference numeral 30, comprises a strap 32, typically of an elastic substrate, with associated buckles 34 for adjustment. Mounted on strap 30 and facing inwardly are at least two heart rate sensor (ECG) electrodes 36 which are coupled by suitable conductors 38 to signal processing circuitry 40. Signal processing circuitry 40 also receives an input from an accelerometer 42, such as an MTC-1 accelerometer commercially available from Hephzibah Industries Co. of Inchon, Korea, and power from batteries 44 and provides a wireless output via an antenna which is preferably embodied in conductor 38. An ON-OFF/ADVANCE switch 48 enables the user to selectably activate the circuitry of belt 30 and control operation of additional features of the system.

Reference is now made to Fig. 3, which is a simplified block diagram illustration of the system of Fig. 1. It is seen that in the body mounted transducer

assembly 24, ECG electrodes 36 output to an ECG amplifier 50, which in turn, outputs via a filter 52 to a microprocessor 54. Accelerometer 42 preferably outputs via an amplifier/filter assembly 56 to microprocessor 54.

Microprocessor 54 preferably outputs serial data via an RF transmitter 58 and antenna 46 to wireless receiver assembly 12 via antenna 14. Receiver assembly 12 preferably outputs via a serial interface 60 to the computer 10, which receives inputs from a control program 62 and an application program 64, which is typically embodied in a CD-ROM and includes at least animation, rhythm, and music inputs.

Display screen 16 receives inputs representing both desired exercise parameters and real time user exercise parameters, also referred to as feedback data, from the computer 10 and displays them for the user. A speaker 66 preferably provides a pacer rhythm and music which is time coordinated with the images displayed to the user.

Reference is now made to Fig. 4, which is a simplified block diagram illustration of the electronic circuitry employed in the body mounted transducer assembly of Fig. 2. Figs. 5A, 5B, 5C and 5D together provide a schematic illustration of the electronic circuitry of Fig. 4. Fig. 6 is a schematic illustration of a wireless receiver employed in the circuitry of Fig. 3. These figures are believed to be self-explanatory in view of the preceding description. Therefore, in the interest of conciseness, additional textual descriptions are not provided.

Reference is now made to Figs. 7 and 8, which are respectively a simplified flow chart and timing diagram illustrations of the operation of the system of Fig. 3.

Fig. 8 illustrates the user's heart rate in beats per minute (BPM) in real time as a function of time from the onset of exercise. Indicated on Fig. 8 are respective minimum and maximum limits for user heart rate under aerobic exercise, R1 and R4 as well as preferred lower and upper limits for user heart rate during aerobic exercise, R2 and R3. The continuous line represents an ideal curve for the change in the heart rate as a function of time. The continuous-black-dotted curve represents a typical controlled fluctuation in the heart rate in accordance with a preferred embodiment of the present invention, as described hereinbelow.

A desired exercise motion parameter, such as the tempo of an audio output, is maintained constant during a warm-up period, which is defined as the concurrent occurrence of the following two conditions:

- a. Within 3 minutes of the start of exercise; and
- b: User's heart rate is below R1, for example 140 BPM.

If the user's real time heart rate HRT is less than or equal to R2, the rate of the desired exercise motion parameter is increased, typically by increasing the tempo of the audio output. Once the tempo is increased, the tempo is maintained constant for a fixed period of time, preferably 3 minutes.

If the user's real time heart rate HRT is greater than or equal to R3, the rate of the desired exercise motion parameter is decreased, typically by decreasing the tempo of the audio output. Once the tempo is decreased, the tempo is maintained constant for a fixed period of time, preferably 3 minutes.

If the user's real time heart rate HRT is between R2 and R3 and if the time derivative of the user's real time heart rate HRT is greater than a predetermined maximum rate of change threshold dL1, the rate of the desired exercise motion parameter is decreased, typically by decreasing the tempo of the audio output. Once the tempo is decreased, the tempo is maintained constant for a fixed period of time, preferably 3 minutes.

If the user's real time heart rate HRT is between R2 and R3 and if the time derivative of the user's real time heart rate HRT is less than a predetermined minimum rate of change threshold dL2, the rate of the desired exercise motion parameter is increased, typically by increasing the tempo of the audio output. Once the tempo is increased, the tempo is maintained constant for a fixed period of time, preferably 3 minutes.

It may be appreciated that by using the present invention, a typical plot of a user's heart rate may appear to oscillate within the limits R2 and R3 as shown in Fig. 8.

It is appreciated that the circuitry of Fig. 3, as exemplified in Figs. 7 and 8, samples the rate of change and direction of change of the heart rate, as well as the absolute value of the heart rate. If the above three parameters indicate that the user's heart rate will, unless changed, either exceed the upper desired heart rate limit or fall

below the lower desired heart rate limit, the tempo of the exercise parameters supplied to the user, both visually and audibly are modified accordingly, so as to cause the rate of motion of the user to be modified such that the user's heart rate remains within the desired limits.

It is a particular feature of the present invention that in contrast to the prior art wherein corrective action is taken upon exceedance of the limits, the present invention avoids exceedance of the limits.

If no control is exercised over the heart rate, it is possible that the heart rate may rise above R4 or drop below R1.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined only by the claims which follow:

C L A I M S

1. An interactive exercise monitoring system comprising:
a body mounted motion sensor; and
a user sensible output indicator indicating to a user an exercise motion parameter derived from an output of the body mounted motion sensor as well as a desired exercise motion parameter for comparison therewith.
2. An interactive exercise monitoring system comprising:
a body mounted heart rate sensor; and
a user sensible output indicator indicating to a user a desired exercise motion parameter derived from consideration of a desired range of heart rate parameters with the direction of change and rate of change of the user's heart rate as determined by the sensor.
3. An interactive exercise monitoring system according to claim 1 and also comprising:
a body mounted heart rate sensor; and
a user sensible output indicator indicating to a user a desired exercise motion parameter derived from consideration of a desired range of heart rate parameters with the direction of change and rate of change of the user's heart rate as determined by the sensor.
4. A system according to any of the preceding claims and wherein said user sensible output indicator employs audible indications.
5. A system according to any of the preceding claims and wherein said user sensible output indicator employs visual indications.
6. A system according to claim 5 and wherein said user sensible output indicator indicates the motion that the user is supposed to carry out.

7. A system according to claim 4 and wherein said user sensible output indicator indicates the tempo at which user motion is to be carried out.
8. A system according to any of the preceding claims 1 - 3 and wherein said user sensible output indicator employs visual indications which indicate the motion that the user is supposed to carry out and audible indications which indicate the tempo at which user motion is to be carried out.
9. A system according to any of the preceding claims and also comprising an exercise pacer which senses whether the user is about to exceed desired upper or lower limits of heart rate and prophylactically changes the tempo, prior to exceedance of such limits, so as to urge the user to stay within the limits.
10. A system according to any of the preceding claims and also comprising a visual indicator which indicates on a time scale both a desired pattern of movements and a user's actual pattern of movements, so as to enable and encourage the user to bring his movements into phase and tempo with the desired pattern.
11. A system according to any of claims 2 - 10 and wherein the body mounted heart rate sensor and motion sensor are both incorporated in a single belt worn by the user during exercise.
12. A system according to claim 11 and wherein said belt communicates via a wireless link with the indicator apparatus.
13. An interactive exercise monitoring method including:
using a body mounted motion sensor to sense user motion during exercise; and

indicating to a user an exercise motion parameter derived from an output of the body mounted motion sensor as well as a desired exercise motion parameter for comparison therewith.

14. An interactive exercise monitoring method including:
sensing a user's heart rate; and
indicating to the user a desired exercise motion parameter derived from a comparison of a desired range of heart rate parameters with the direction of change and rate of change of the user's heart rate.
15. An interactive exercise monitoring method according to claim 13 and also including:
sensing a user's heart rate; and
indicating to the user a desired exercise motion parameter derived from a comparison of a desired range of heart rate parameters with the direction of change and rate of change of the user's heart rate.
16. A method according to any of the preceding claims 13 - 15 and wherein said indicating step employs audible indications.
17. A method according to any of the preceding claims 13 - 16 and wherein said indicating step employs visual indications.
18. A method according to claim 17 and wherein said indicating step indicates the motion that the user is supposed to carry out.
19. A method according to claim 16 and wherein said indicating step indicates the tempo at which user motion is to be carried out.
20. A method according to any of the preceding claims 13 - 15 and wherein said indicating step employs visual indications which indicate the motion that the user is

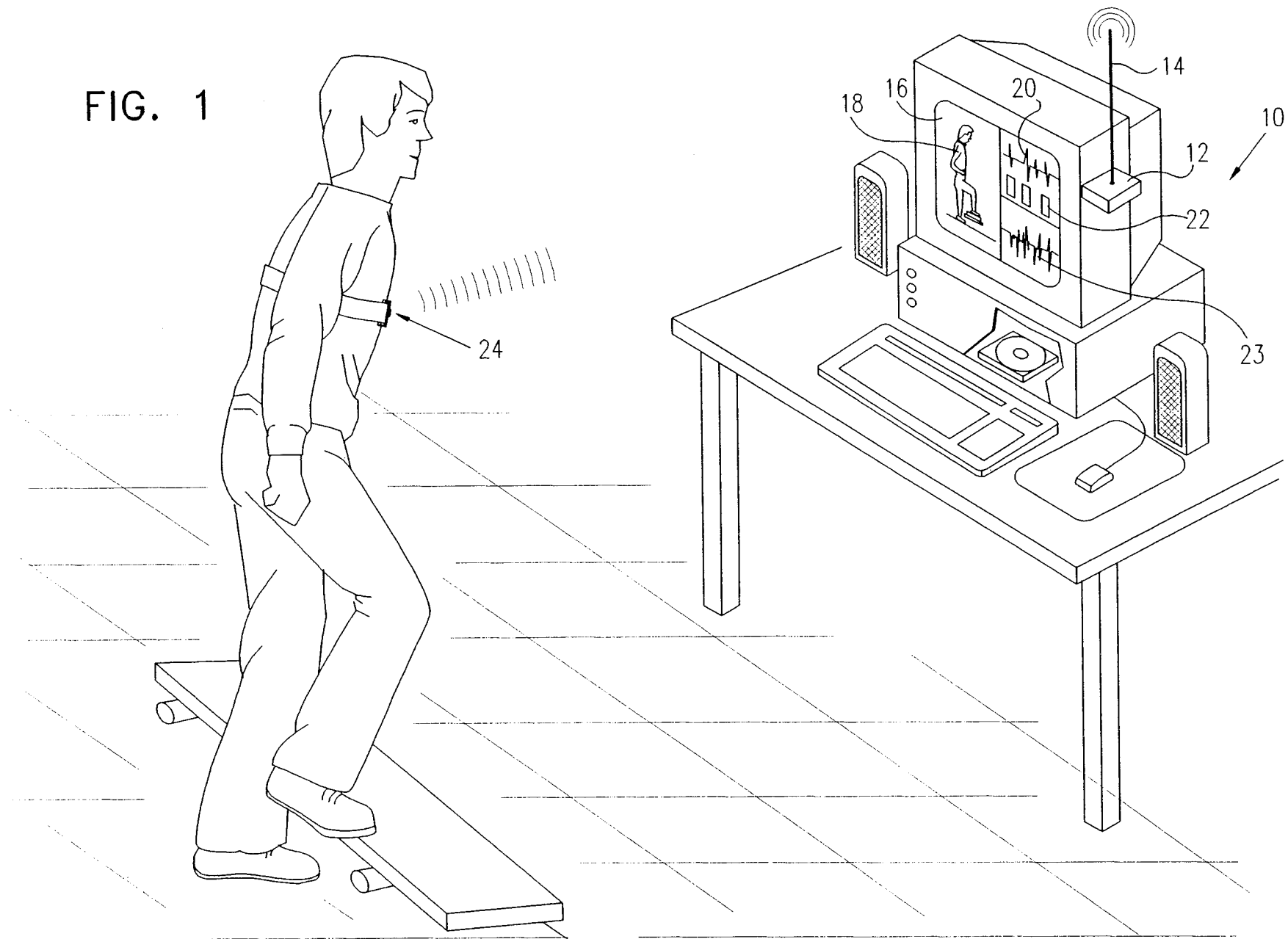
supposed to carry out and audible indications which indicate the tempo at which user motion is to be carried out.

21. A method according to any of the preceding claims 13 - 20 and also comprising exercise pacing which senses whether the user is about to exceed desired upper or lower limits of heart rate and prophylactically changes the tempo, prior to exceedance of such limits, so as to urge the user to stay within the limits.

22. A method according to any of the preceding claims 13 - 21 and also comprising providing a visual indicator which indicates on a time scale both a desired pattern of movements and a user's actual pattern of movements, so as to enable and encourage the user to bring his movements into phase and tempo with the desired pattern.

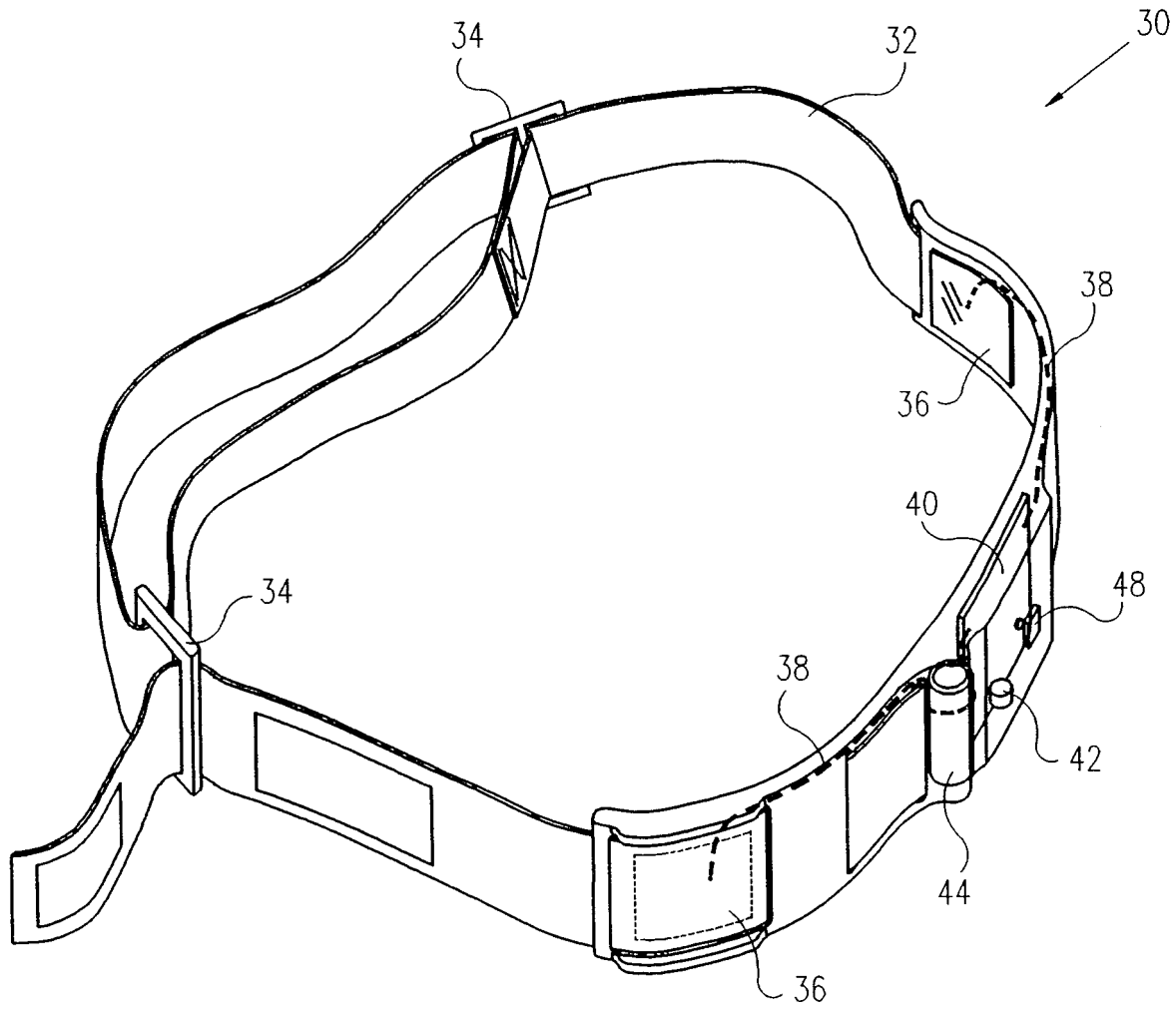
23. A method according to any of claims 13 - 22 and wherein the body mounted heart rate sensor and motion sensor are both incorporated in a single belt worn by the user during exercise and wherein said belt communicates via a wireless link.

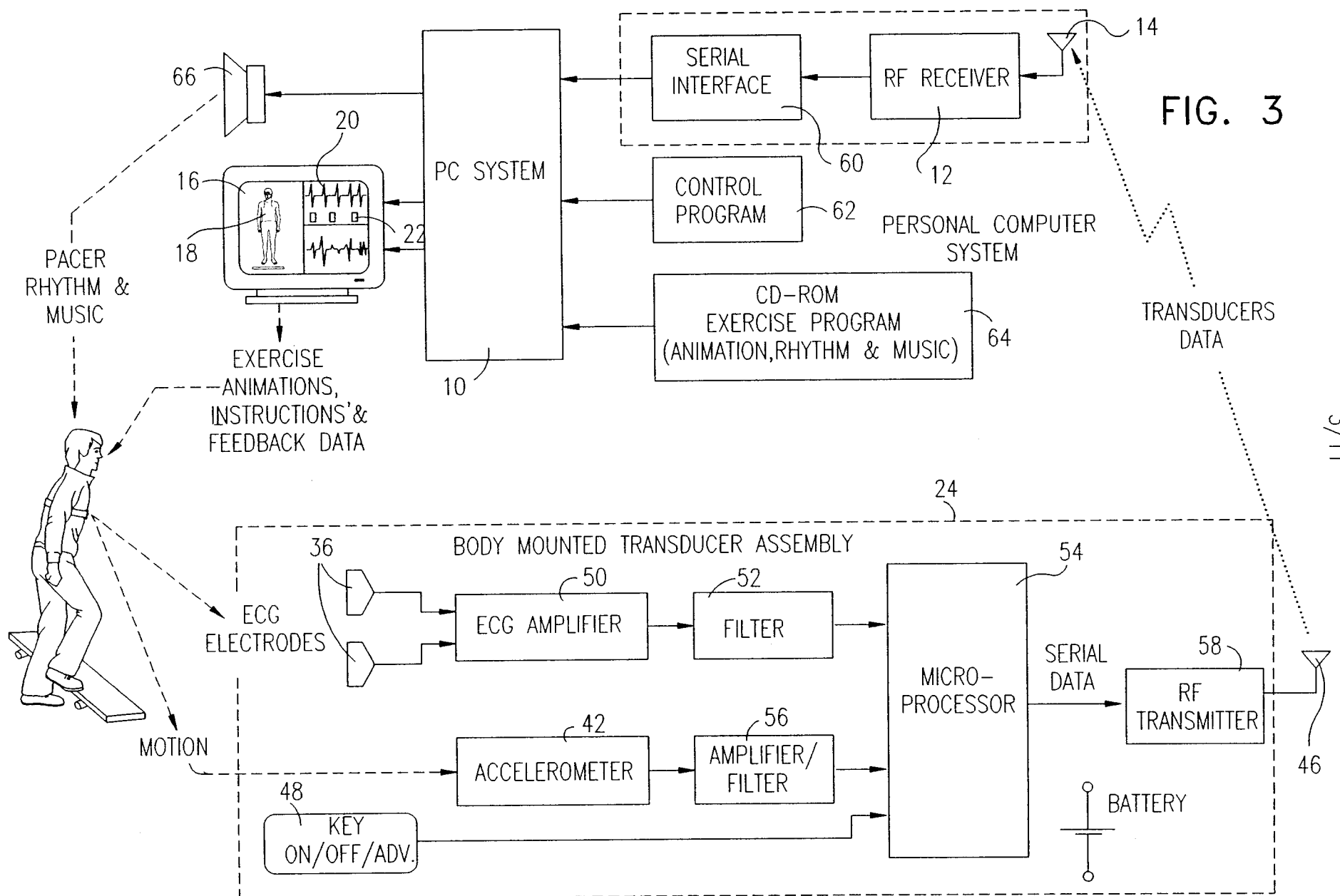
FIG. 1



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FIG. 2





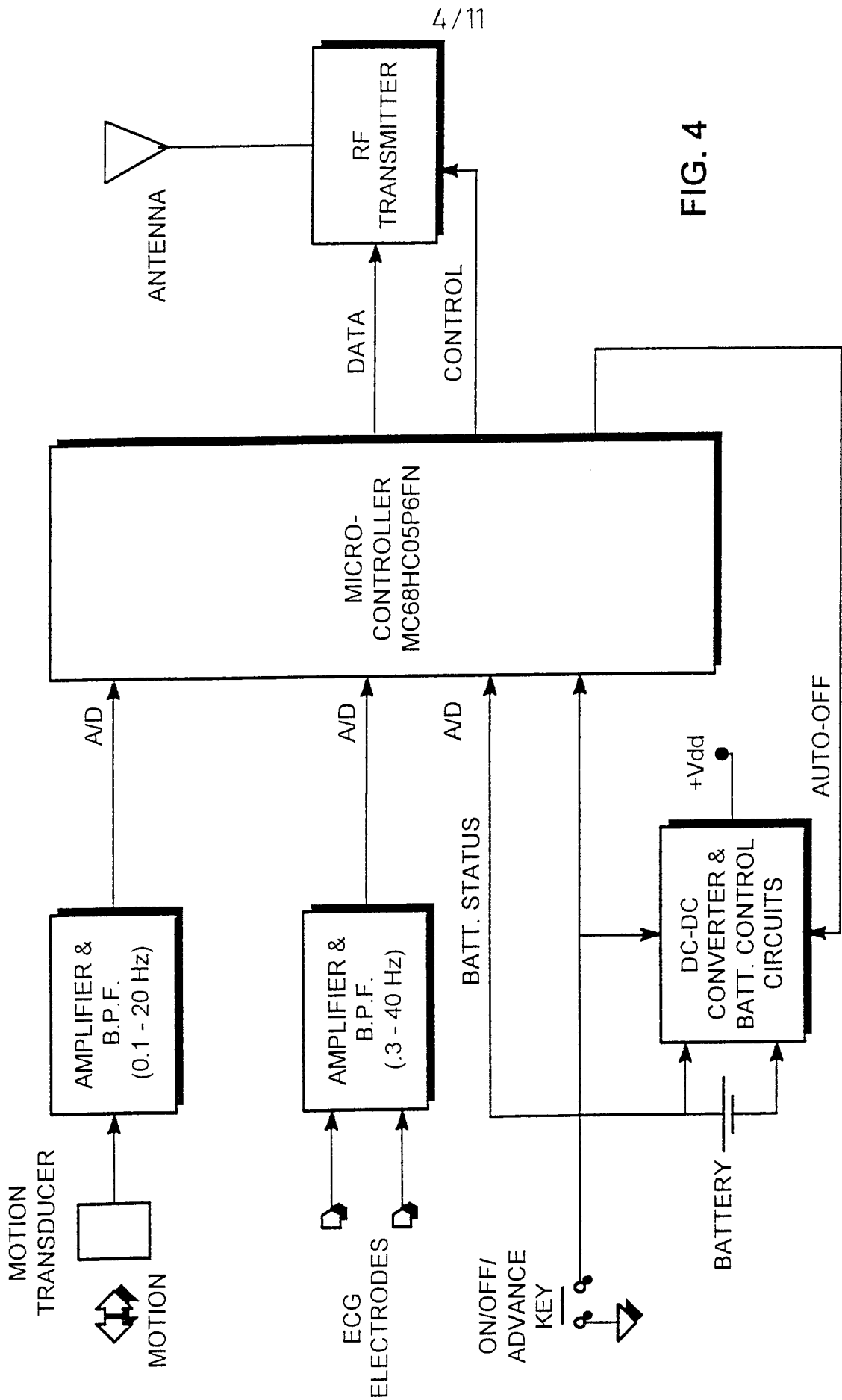
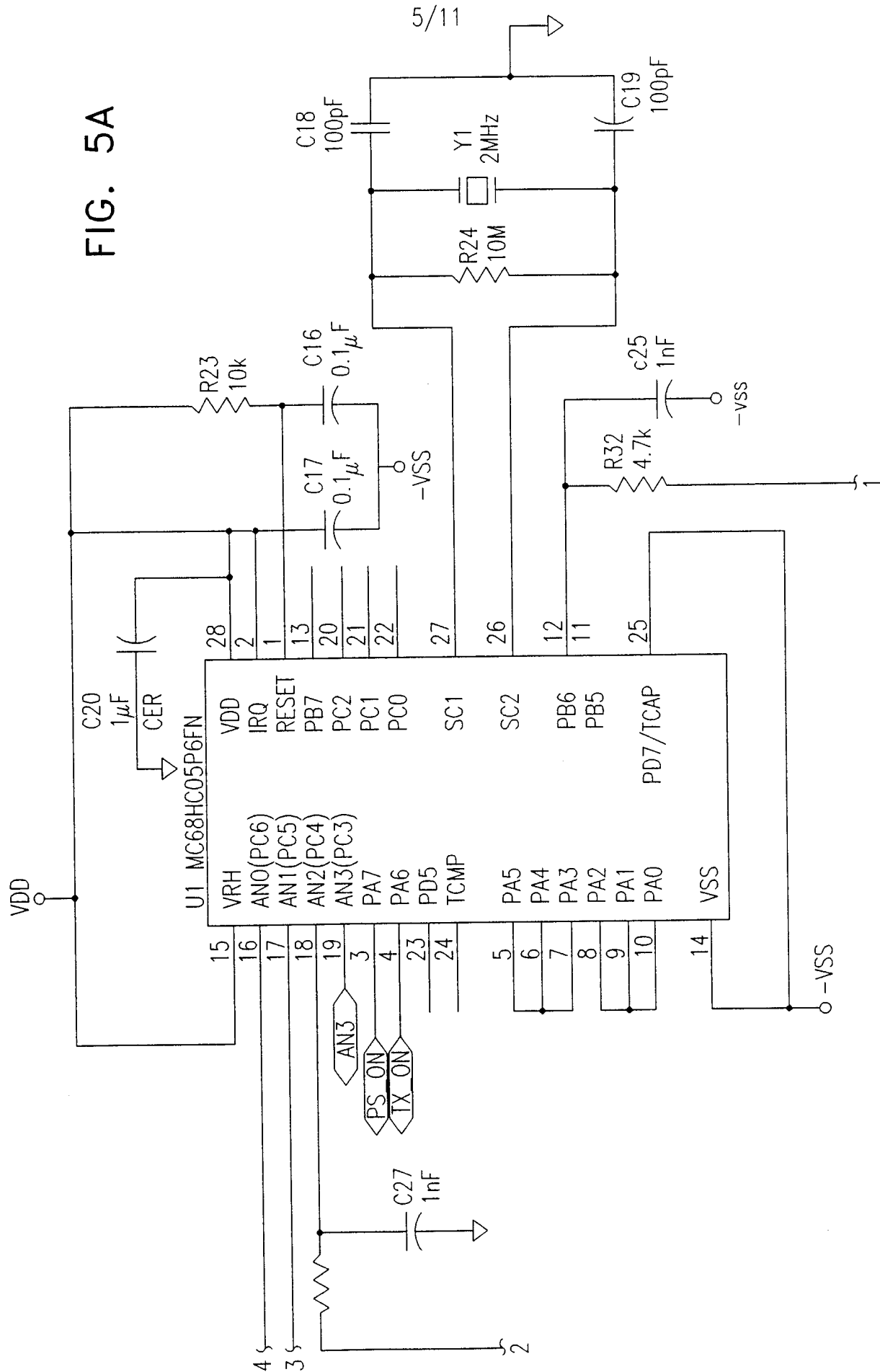


FIG. 4

FIG. 5A



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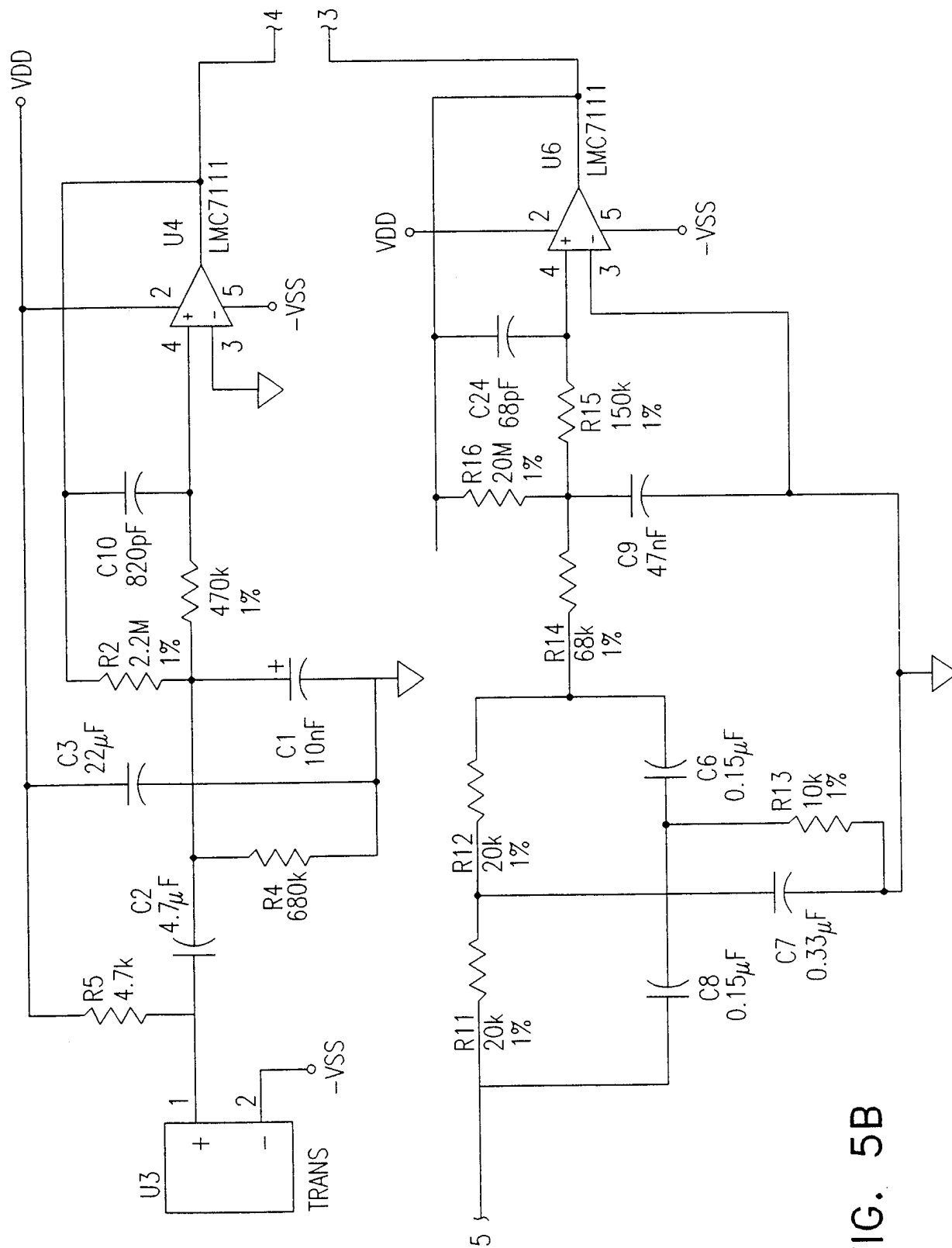
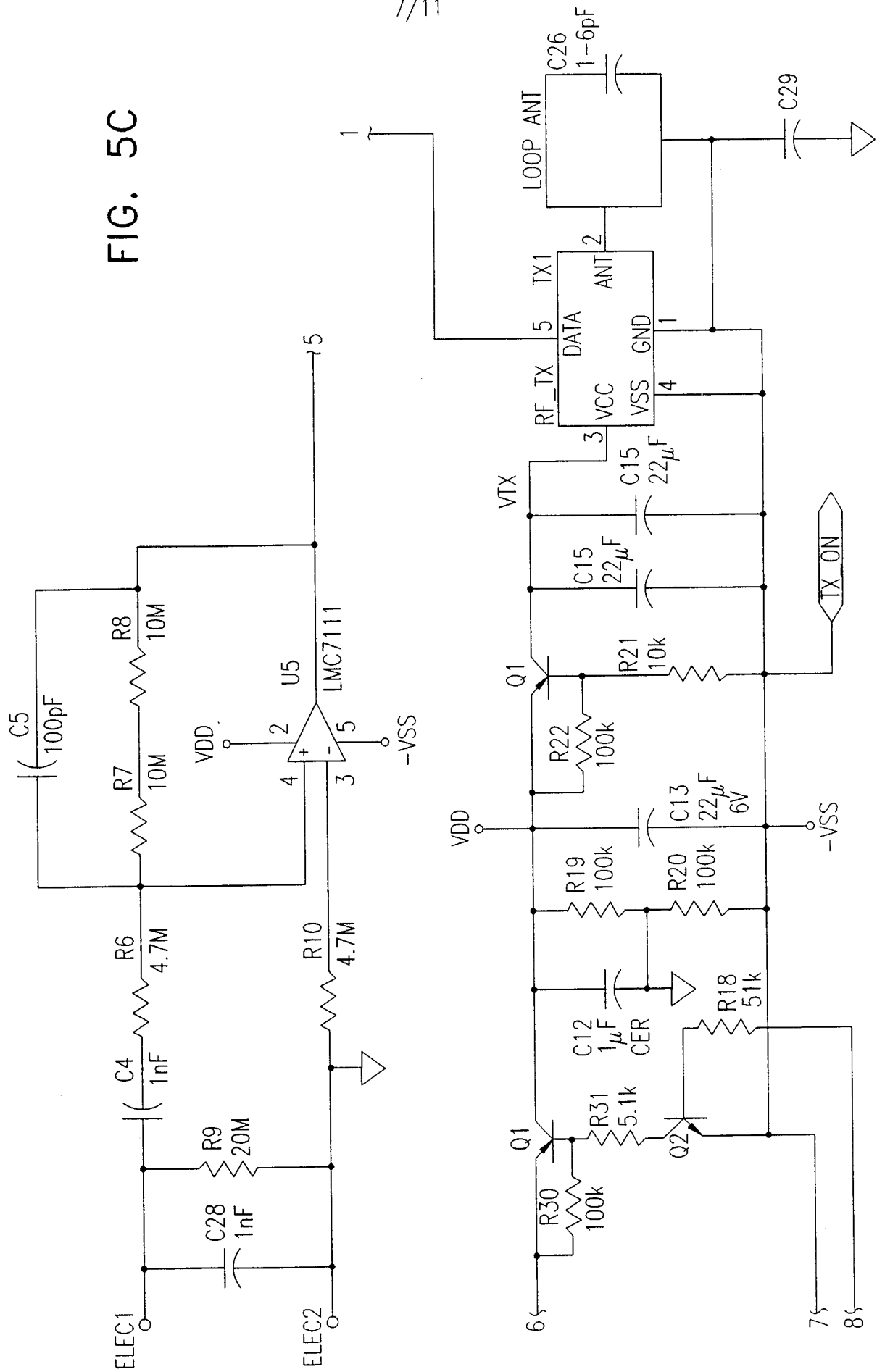
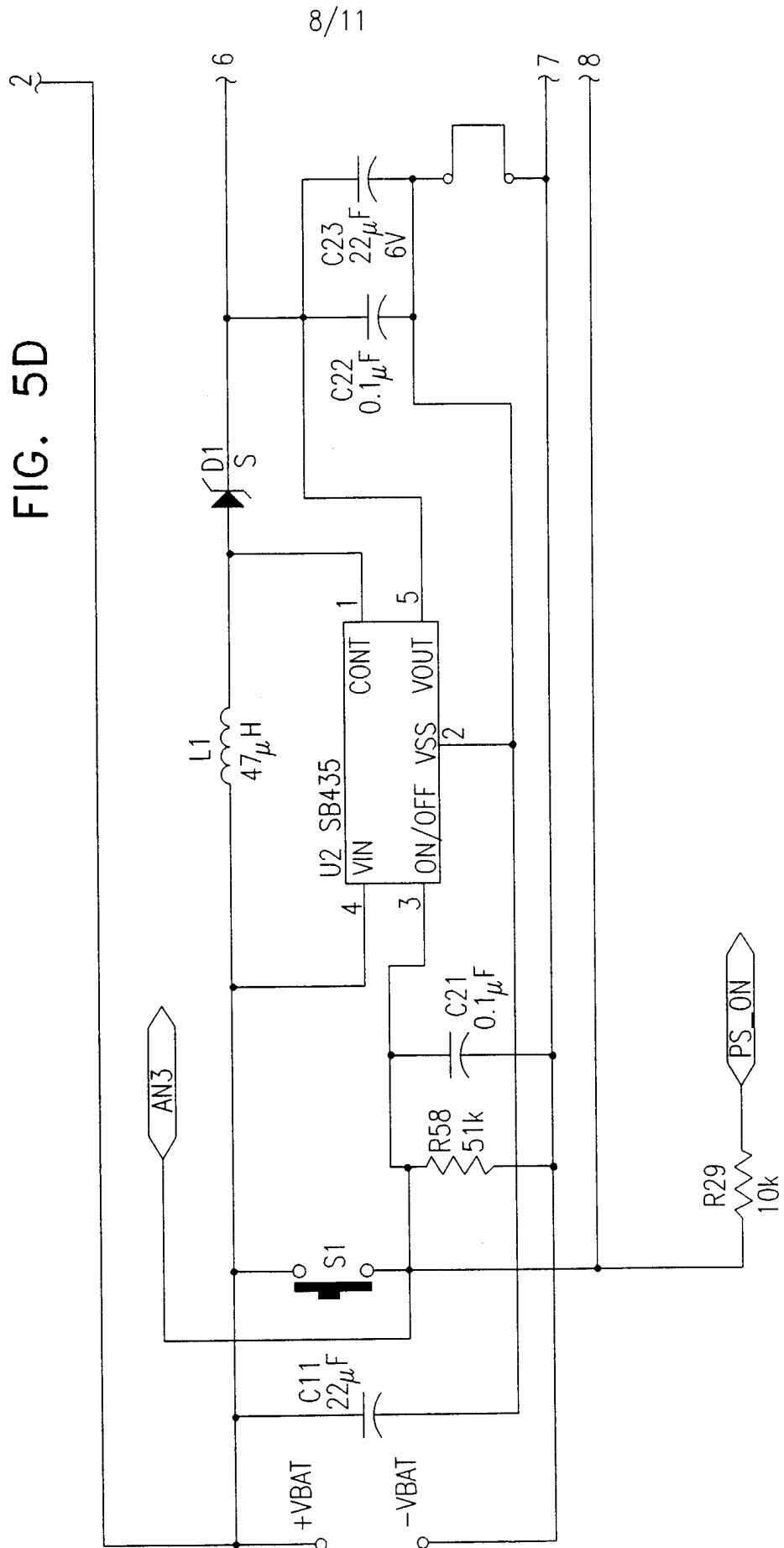


FIG. 5B

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FIG. 5C





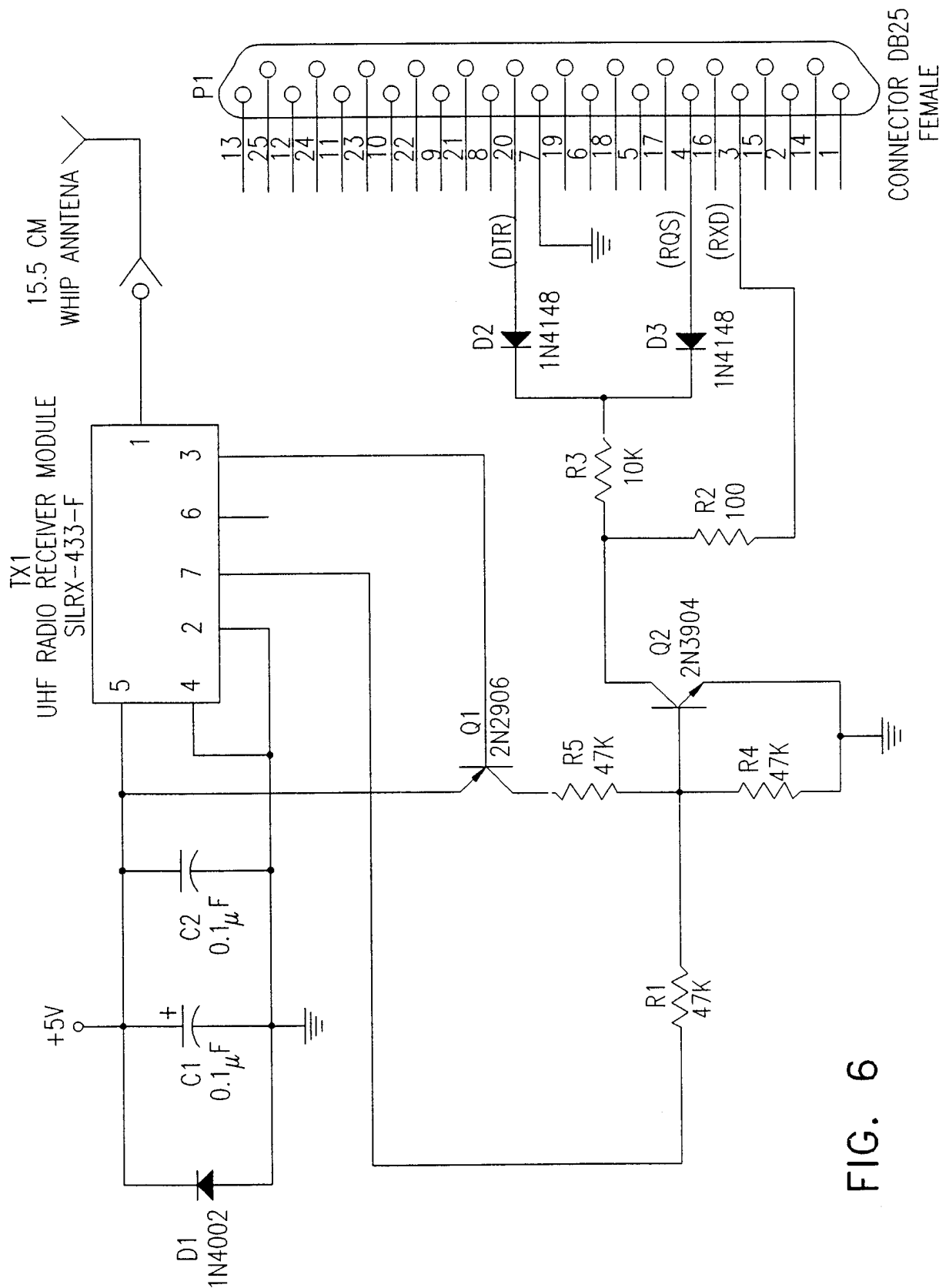


FIG. 6

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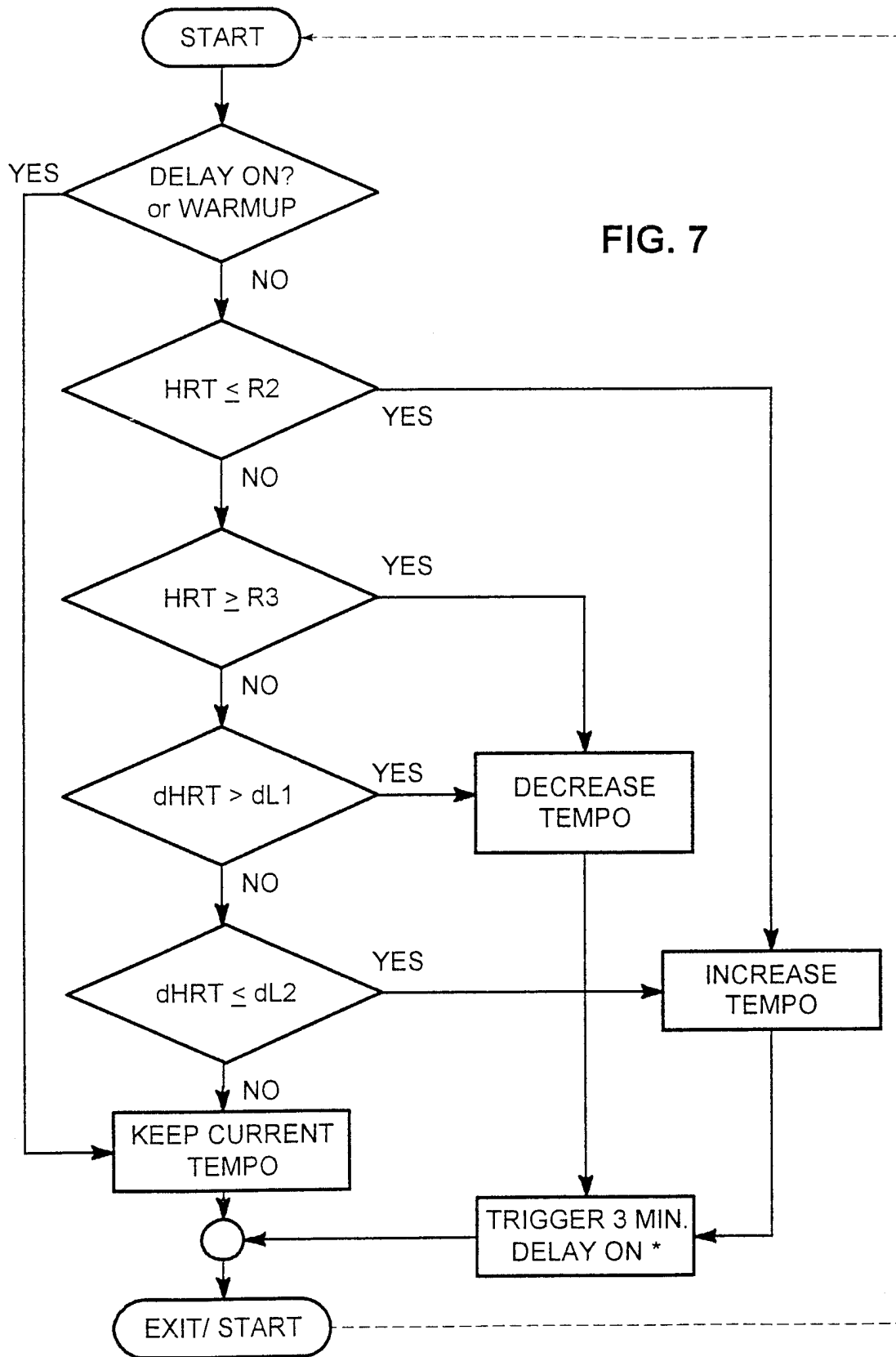
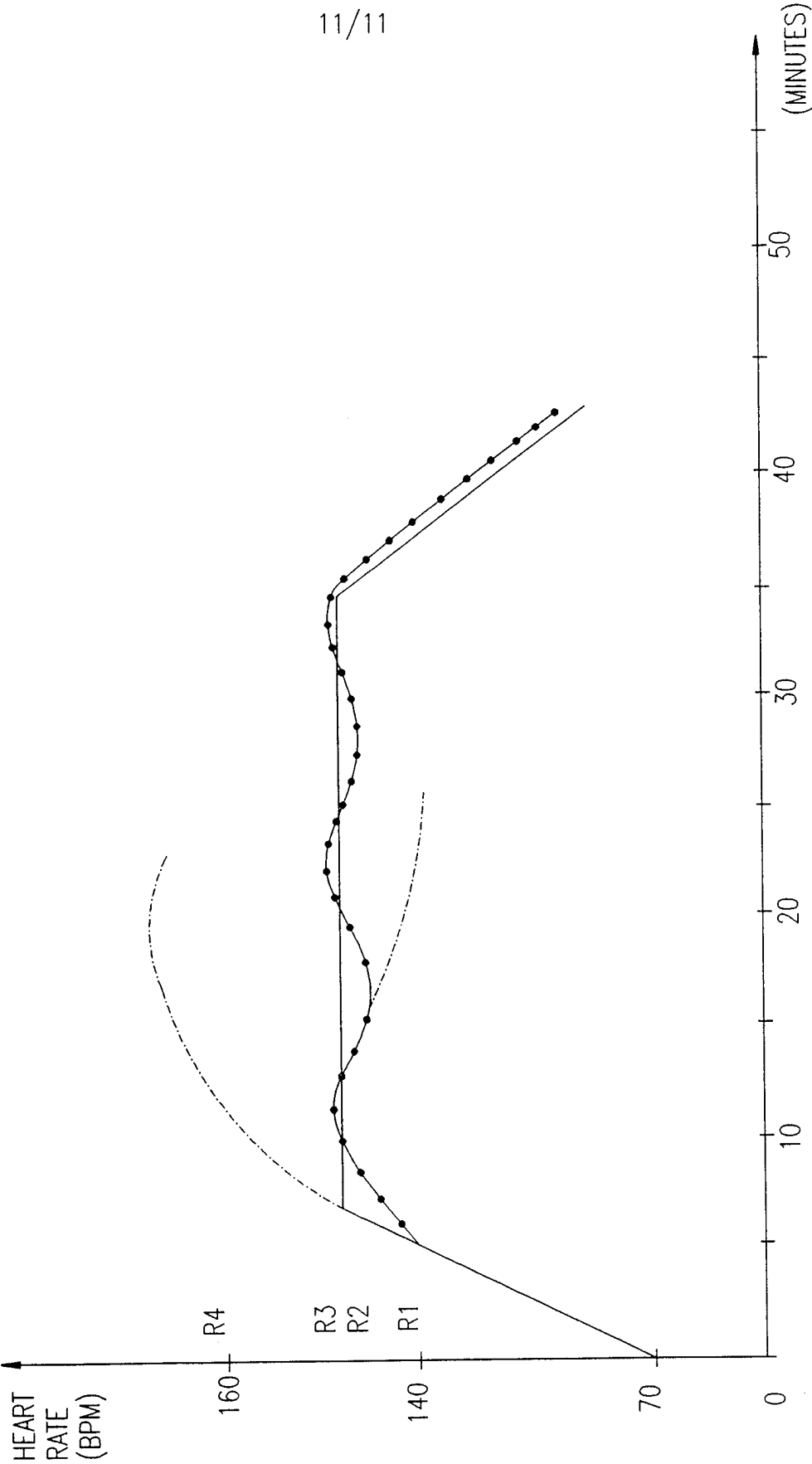


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL98/00126

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : A63B 24/00

US CL : 482/8

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 482/1-9, 900-902

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,462,504 A (TRULASKE ET AL) 31 OCTOBER 1995, ENTIRE DOCUMENT.	2-23
Y	US 5,527,239 A (ABBONDANZA) 18 JUNE 1996, ENTIRE DOCUMENT.	2-22
Y	US 5,067,710 A (WATTERSON ET AL) 26 NOVEMBER 1991, ENTIRE DOCUMENT.	2-22
Y, P	US 5,702,323 A (POULTON) 30 DECEMBER 1997, ENTIRE DOCUMENT.	1



Further documents are listed in the continuation of Box C.



See patent family annex.

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