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(54) **MOVEMENT AND EVENT SYSTEMS AND ASSOCIATED METHODS**

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Related U.S. Application Data

(63) Continuation of application No. 10/297,270, filed on Dec. 4, 2002, filed as 371 of international application No. PCT/US01/51620, filed on Dec. 17, 2001.

(60) Provisional application No. 60/256,069, filed on Dec. 15, 2000. Provisional application No. 60/257,386, filed on Dec. 22, 2000. Provisional application No. 60/259,271, filed on Dec. 29, 2000. Provisional application No. 60/261,359, filed on Jan. 13, 2001. Provisional application No. 60/285,032, filed on Apr. 19, 2001. Provisional application No. 60/323,601, filed on Sep. 20, 2001.

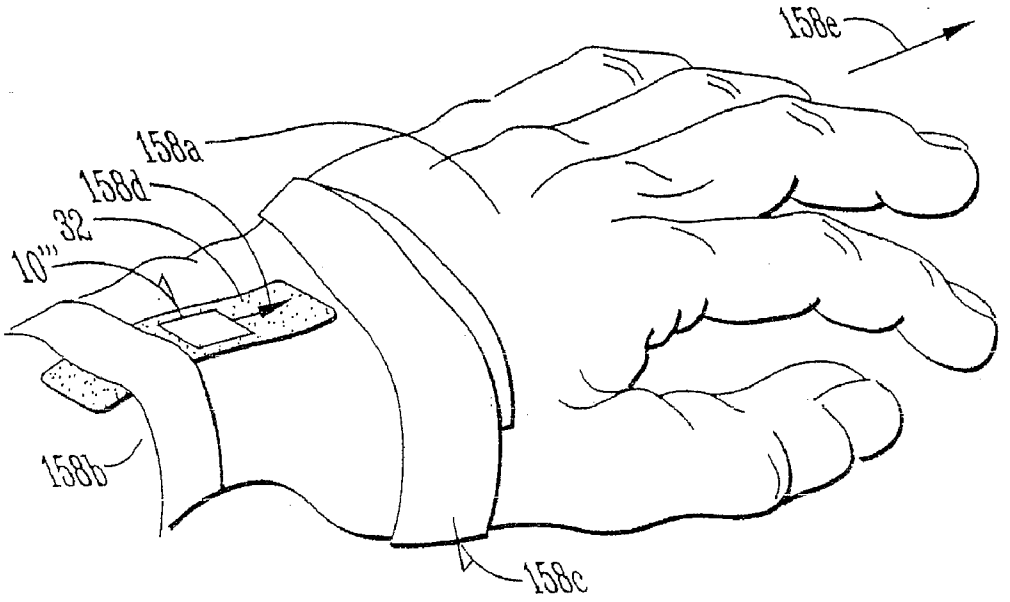
Publication Classification

(51) **Int. Cl.**
G06F 17/40 (2006.01)

(52) **U.S. Cl.** **702/187**

(57) **ABSTRACT**

The invention provides a smart sensor (**10**) in the form of an adhesive bandage (**32**). The sensor (**12**) sticks to people and objects and wirelessly communicates with remote receivers (**24**). Internal detectors (**12**) sense conditions associated with movement or the environment of the sensor. Typically, sensors of the invention communicate by an RF transmitter or transceiver (**16**). Groups of sensors may be combined within a common canister that imparts date and time information and "power on" when dispensed.



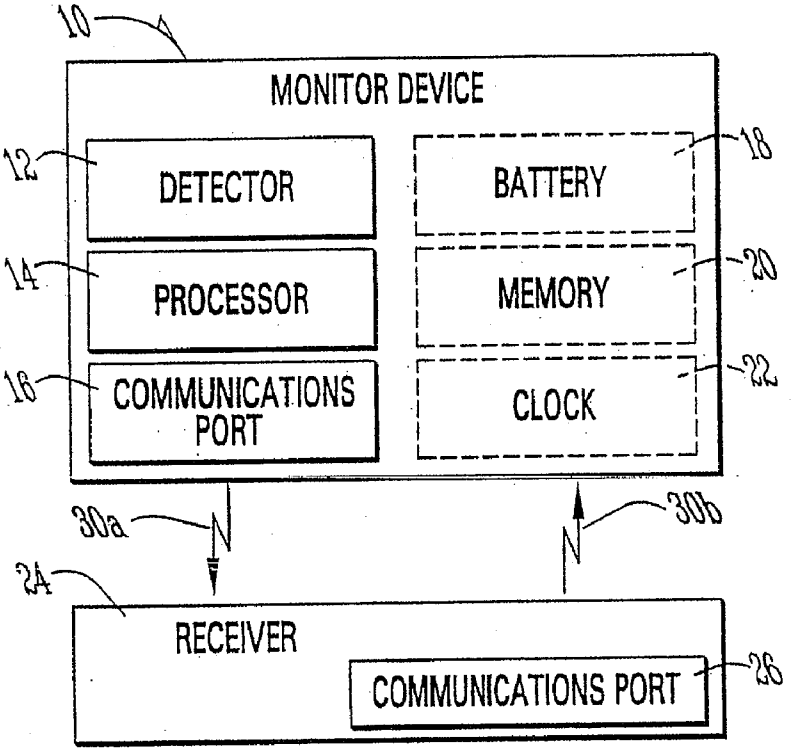

10
MONITOR DEVICE
12
DETECTOR
14
PROCESSOR
16
COMMUNICATIONS PORT
18
BATTERY
20
MEMORY
22
CLOCK
30a
30b
24
RECEIVER
26
COMMUNICATIONS PORT

FIG.1

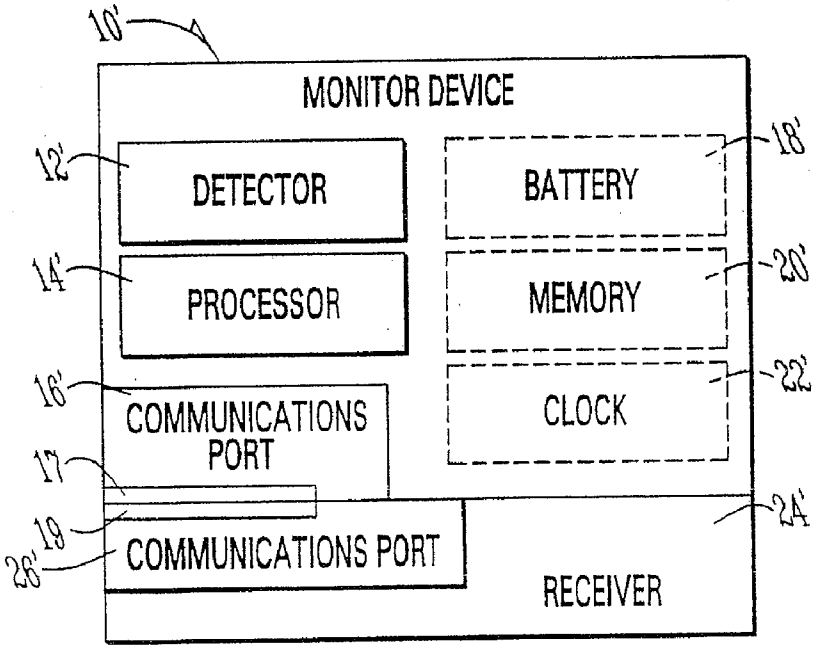

10'
MONITOR DEVICE
12'
DETECTOR
14'
PROCESSOR
16'
COMMUNICATIONS PORT
17
19
26'
COMMUNICATIONS PORT
18'
BATTERY
20'
MEMORY
22'
CLOCK
24'
RECEIVER

FIG.1A

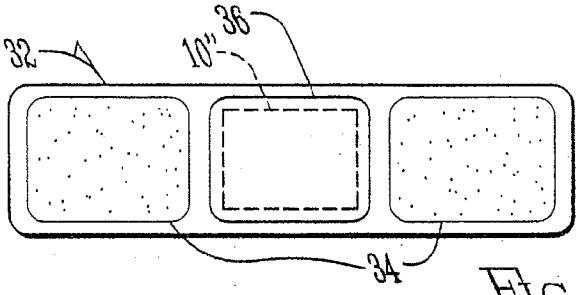


FIG. 2

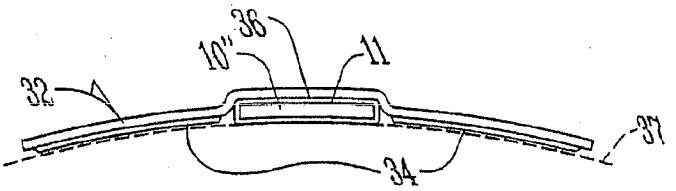


FIG. 2A

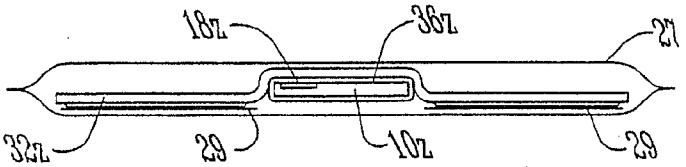


FIG. 2B

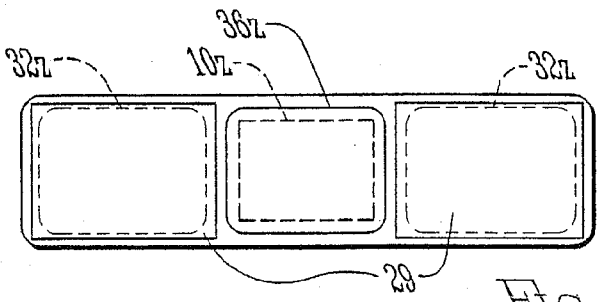


FIG. 2C

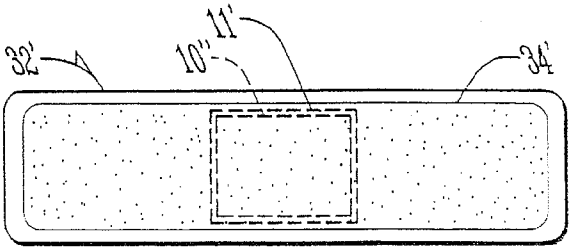


FIG. 2D

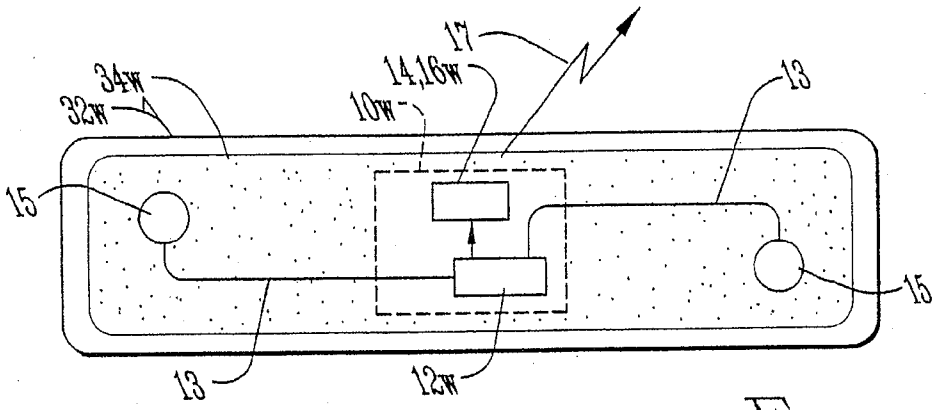


FIG.2E

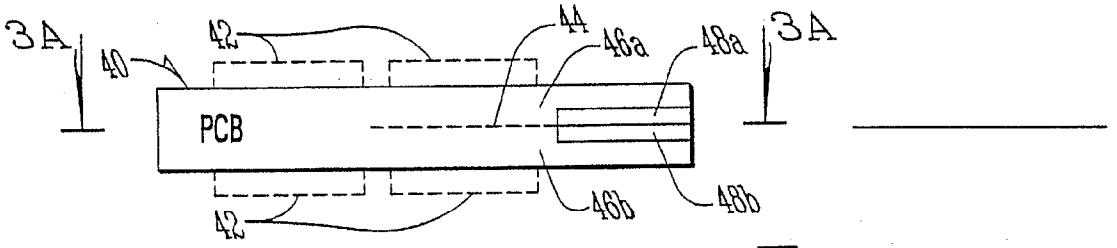


FIG.3

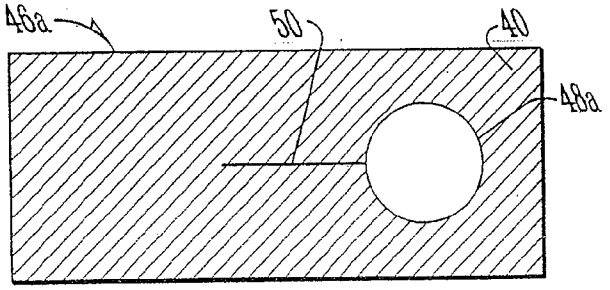


FIG.3A

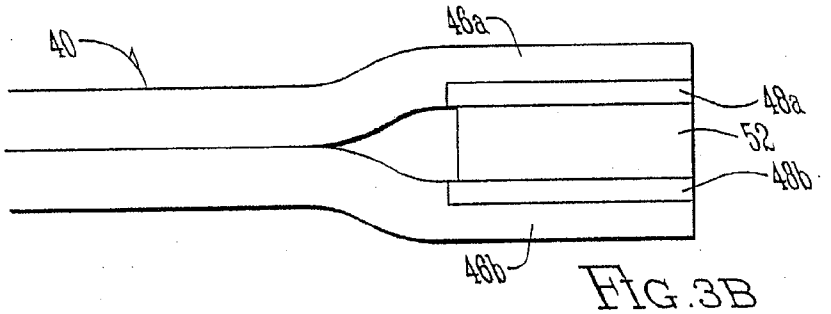


FIG.3B

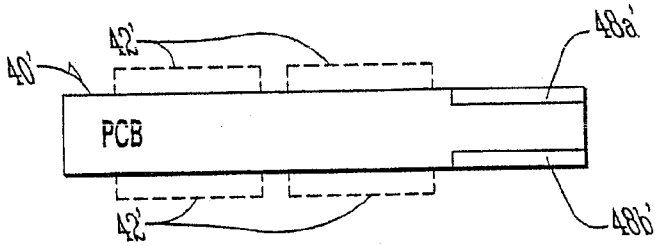


FIG.3C

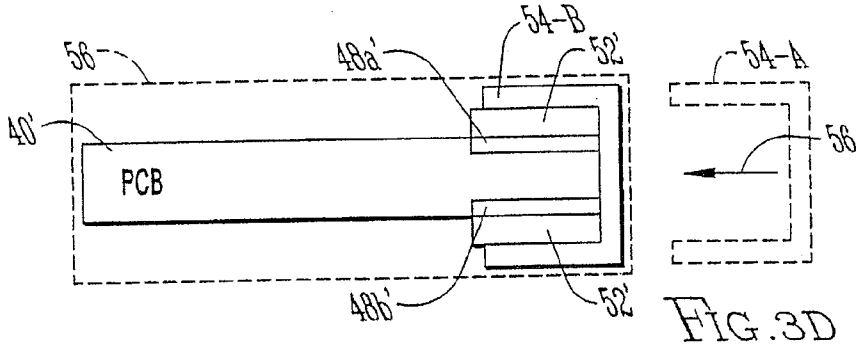


FIG.3D

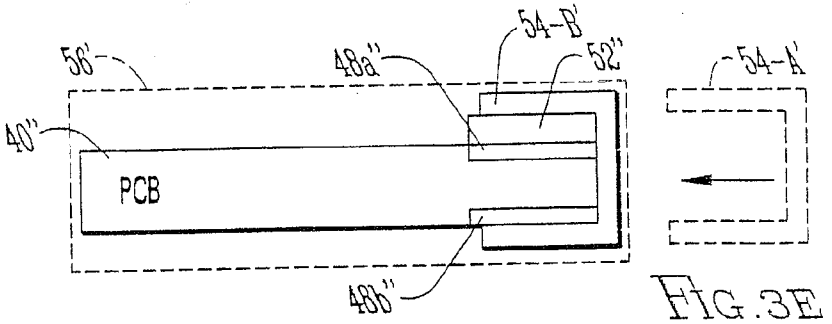


FIG.3E

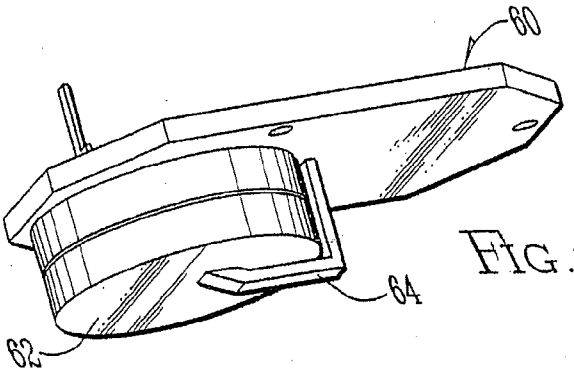


FIG.3F

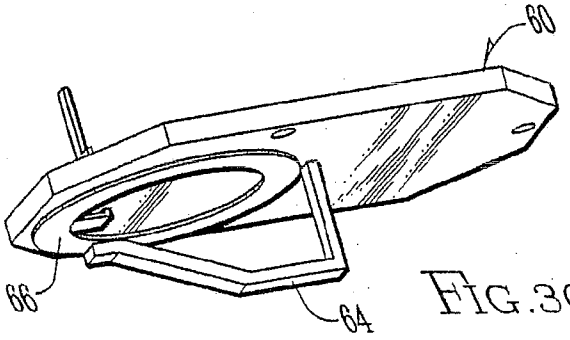


FIG.3G

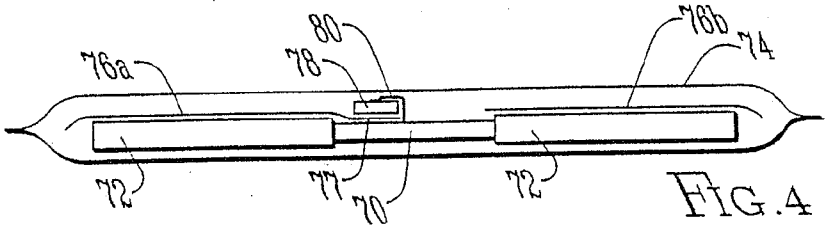


FIG.4

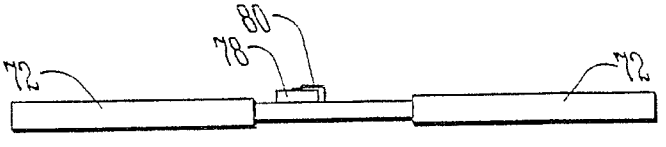


FIG.4A

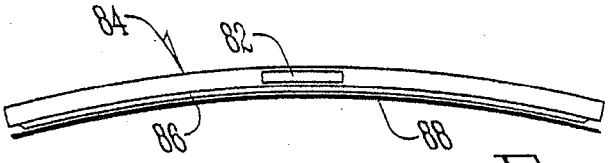


FIG.5

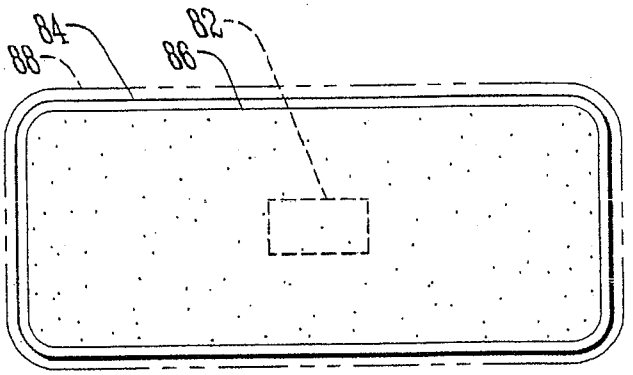


FIG.5A

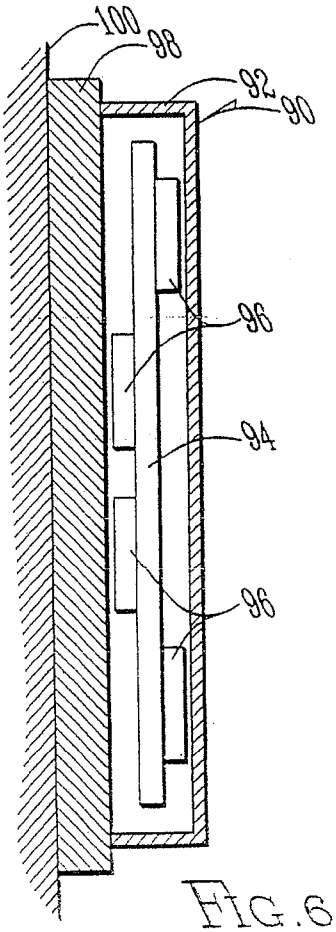


FIG.6

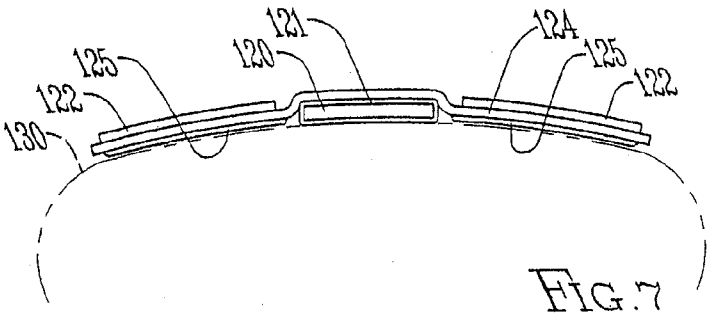


FIG. 7

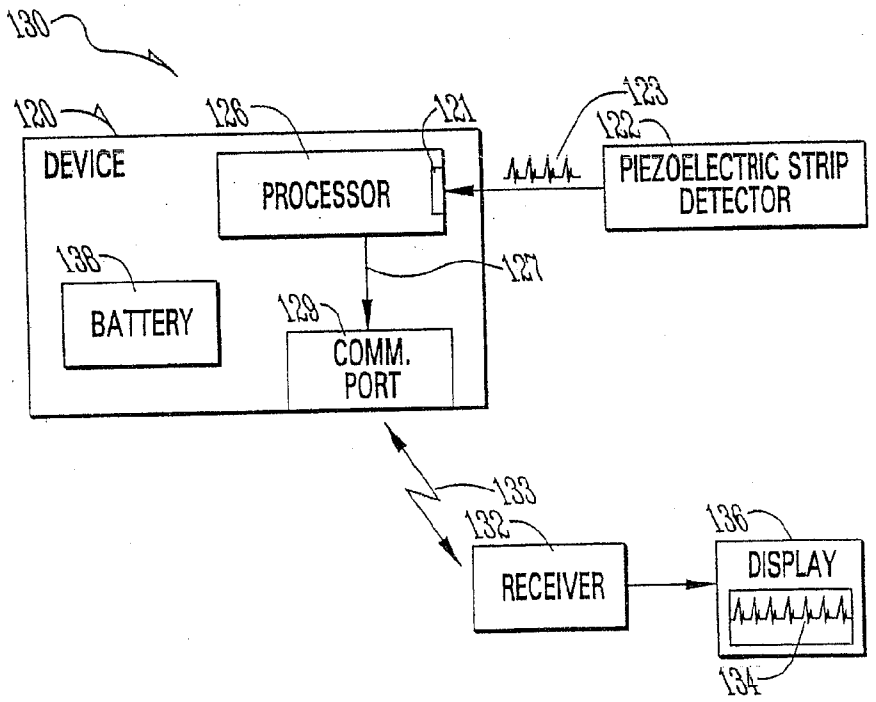


FIG. 7A

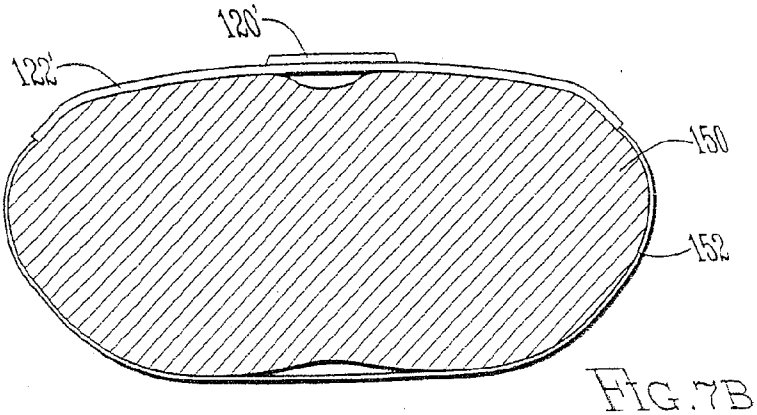


FIG. 7B

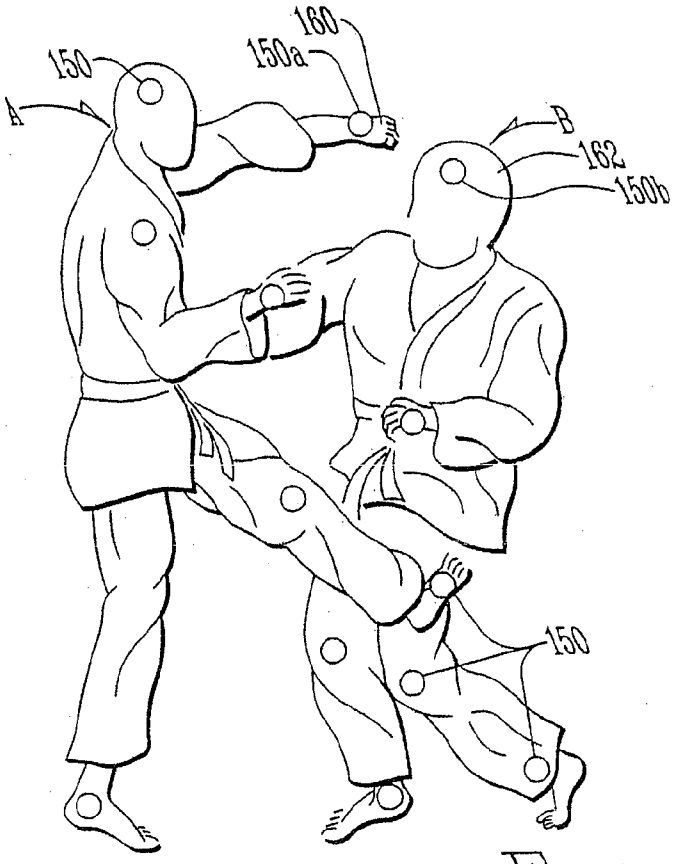

160
150a
150
A
B
162
150b
150

FIG. 8

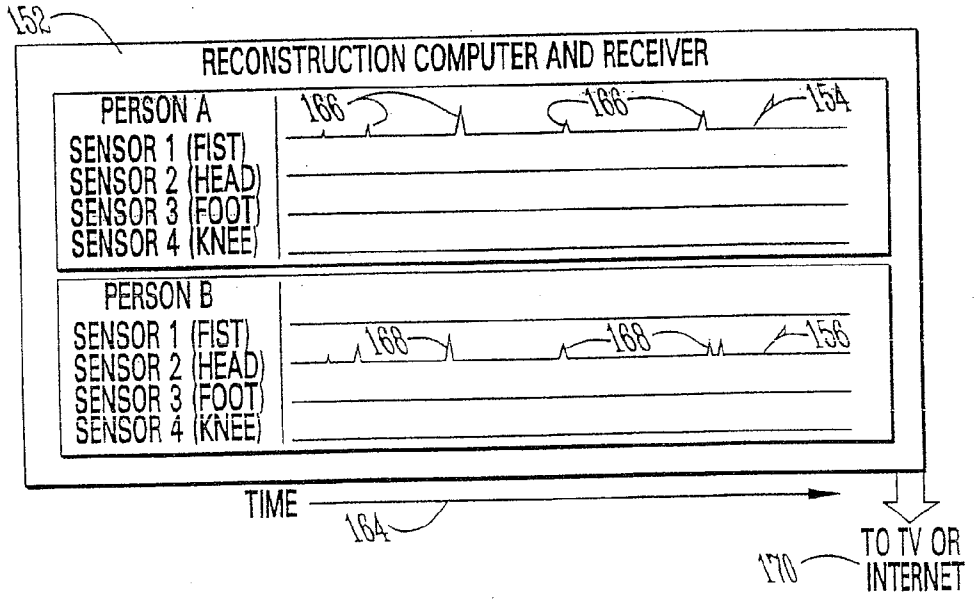

152
RECONSTRUCTION COMPUTER AND RECEIVER
PERSON A
SENSOR 1 (FIST)
SENSOR 2 (HEAD)
SENSOR 3 (FOOT)
SENSOR 4 (KNEE)
166
166
154
PERSON B
SENSOR 1 (FIST)
SENSOR 2 (HEAD)
SENSOR 3 (FOOT)
SENSOR 4 (KNEE)
168
168
156
TIME
164
TO TV OR INTERNET
170

FIG. 8A

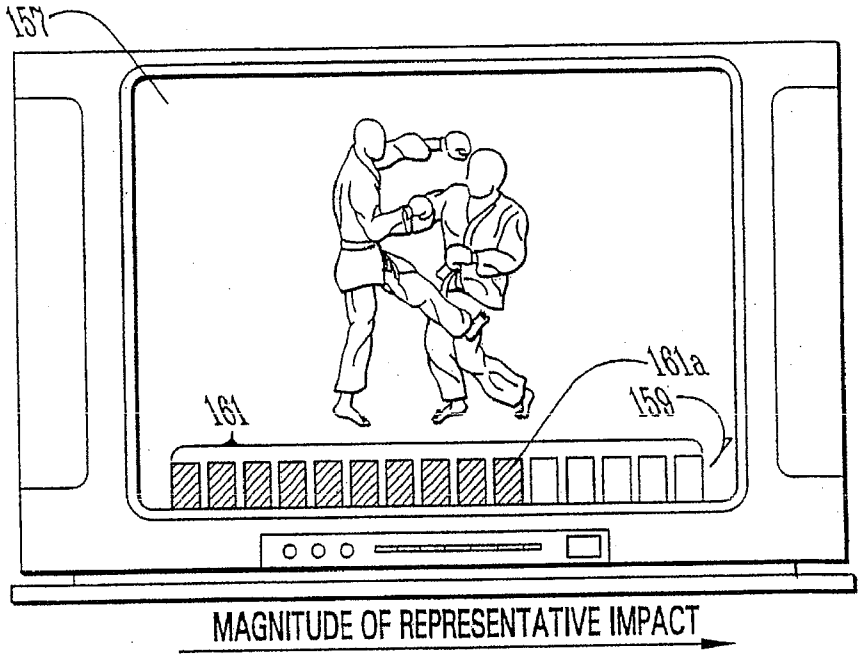

157
161a
159
161
MAGNITUDE OF REPRESENTATIVE IMPACT

FIG. 8B

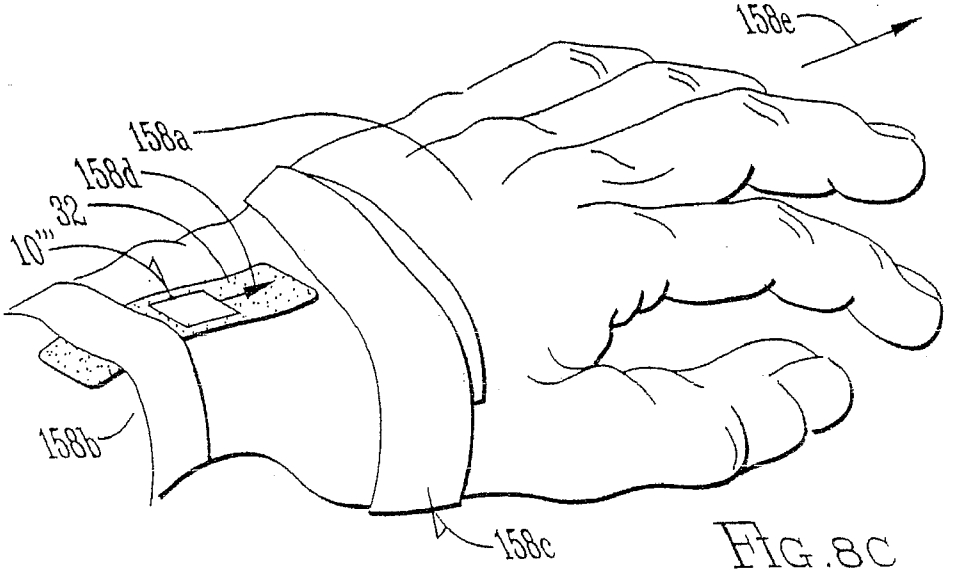

158e
158a
158d
32
10'''
158b
158c

FIG. 8C

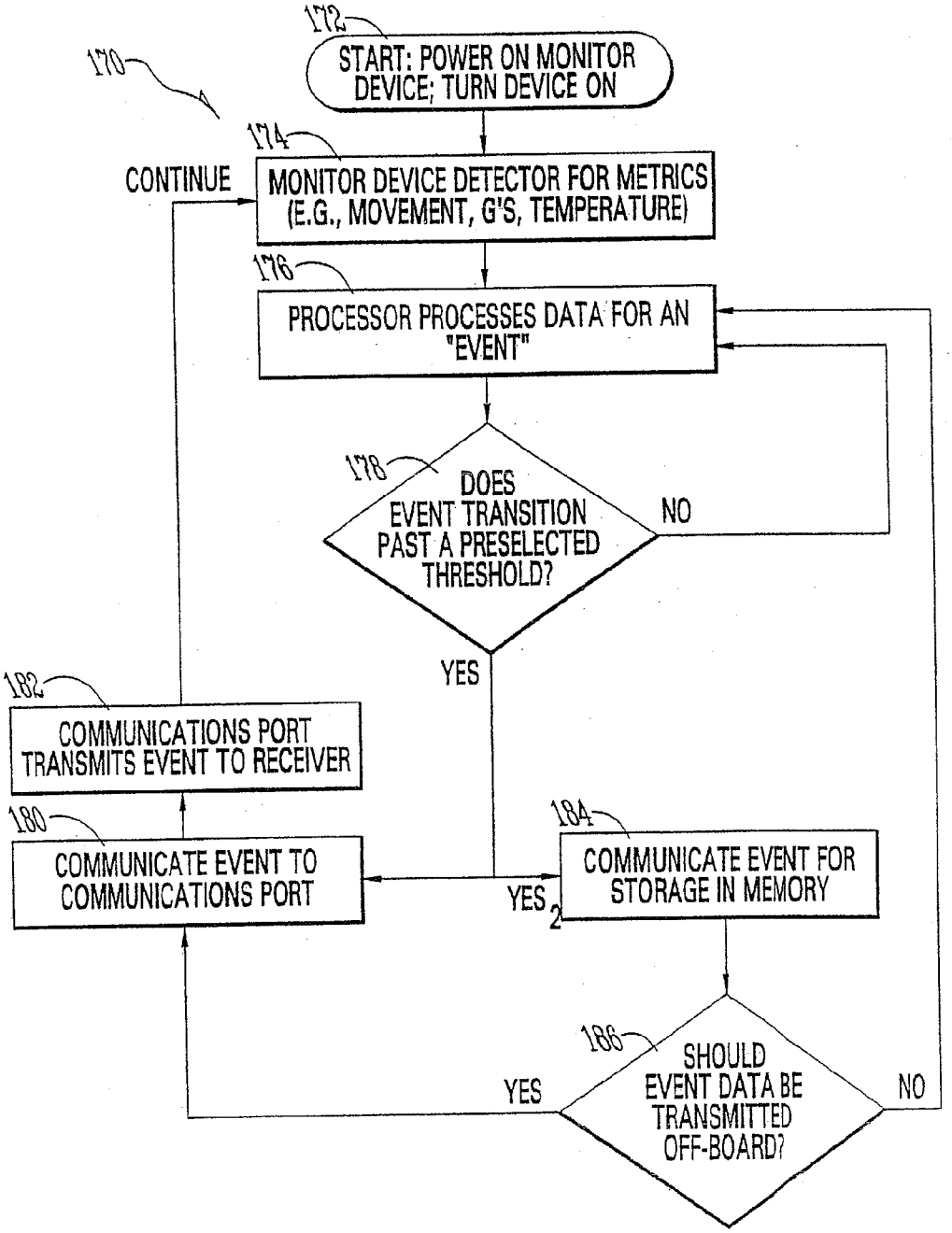

172
START: POWER ON MONITOR DEVICE; TURN DEVICE ON
170
174
CONTINUE
MONITOR DEVICE DETECTOR FOR METRICS (E.G., MOVEMENT, G'S, TEMPERATURE)
176
PROCESSOR PROCESSES DATA FOR AN "EVENT"
178
DOES EVENT TRANSITION PAST A PRESELECTED THRESHOLD?
NO
YES
182
COMMUNICATIONS PORT TRANSMITS EVENT TO RECEIVER
180
COMMUNICATE EVENT TO COMMUNICATIONS PORT
184
COMMUNICATE EVENT FOR STORAGE IN MEMORY
YES
2
186
SHOULD EVENT DATA BE TRANSMITTED OFF-BOARD?
YES
NO

FIG. 9

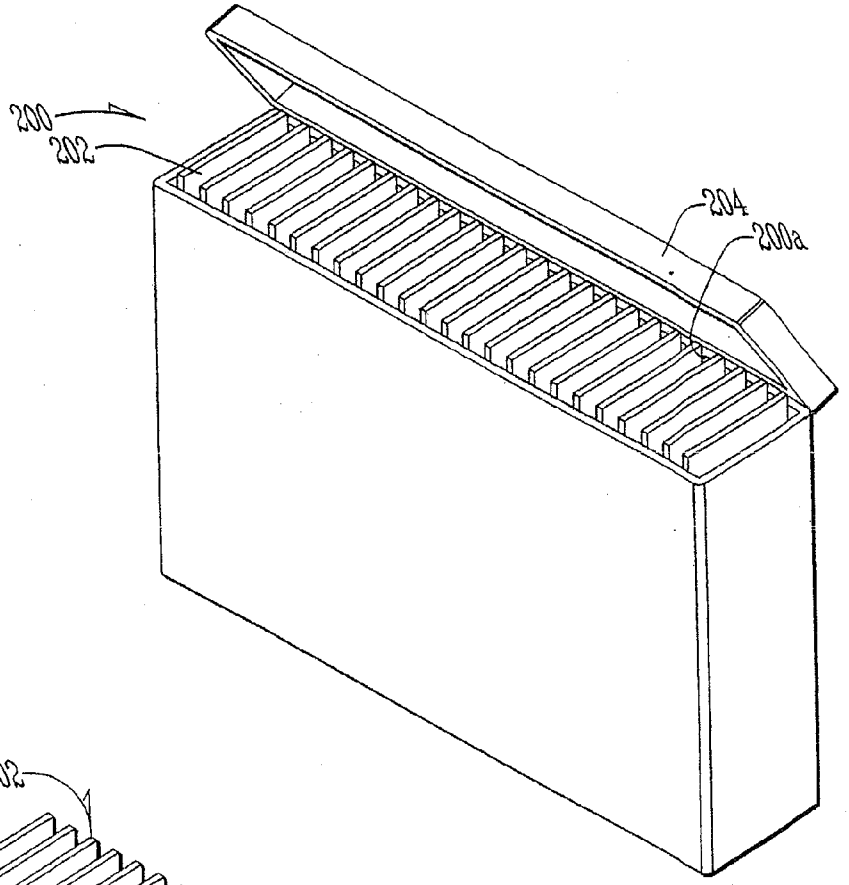


FIG.10

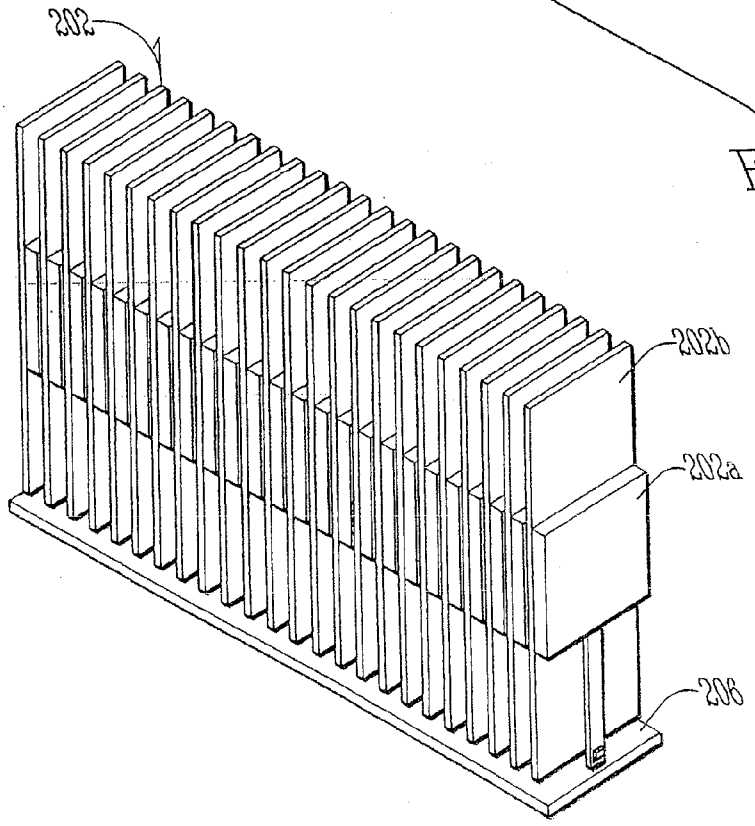


FIG.10A

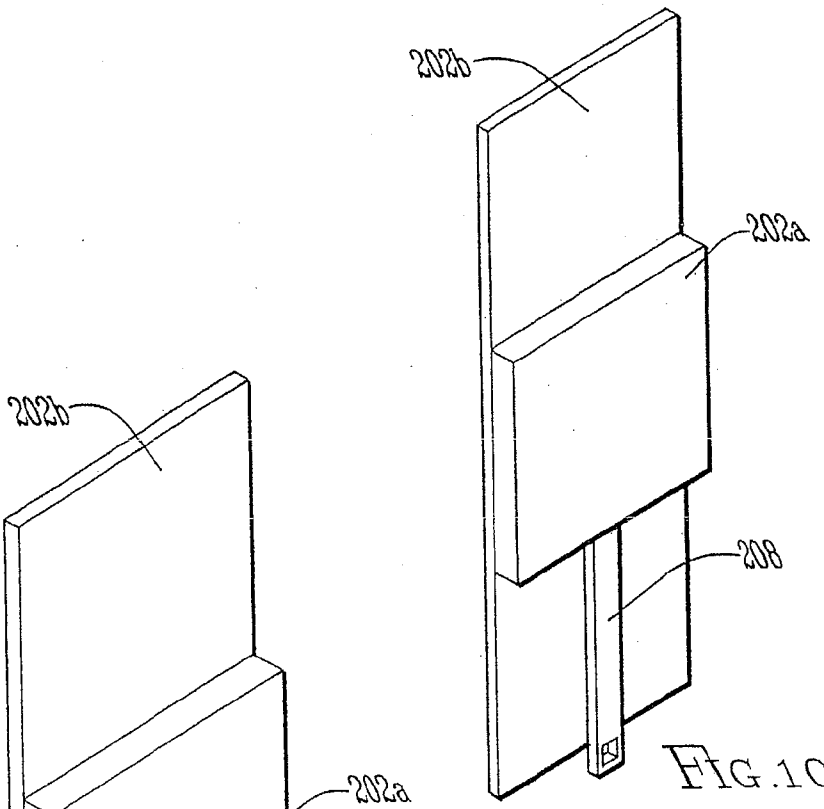


FIG.10B

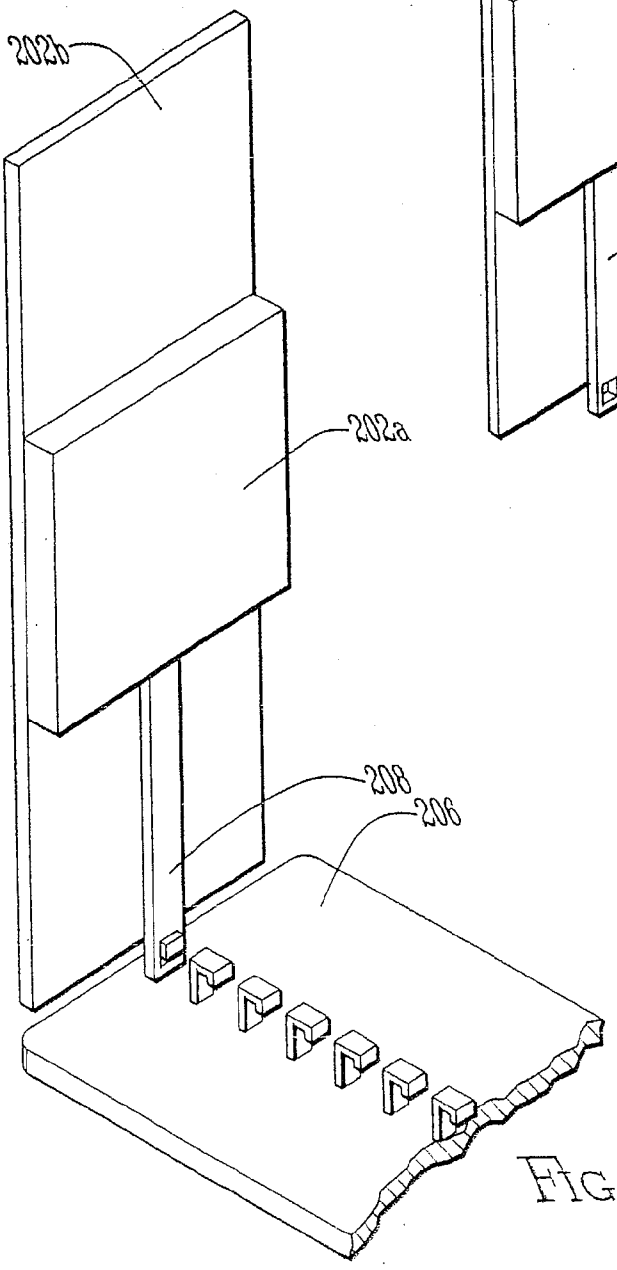


FIG.10C

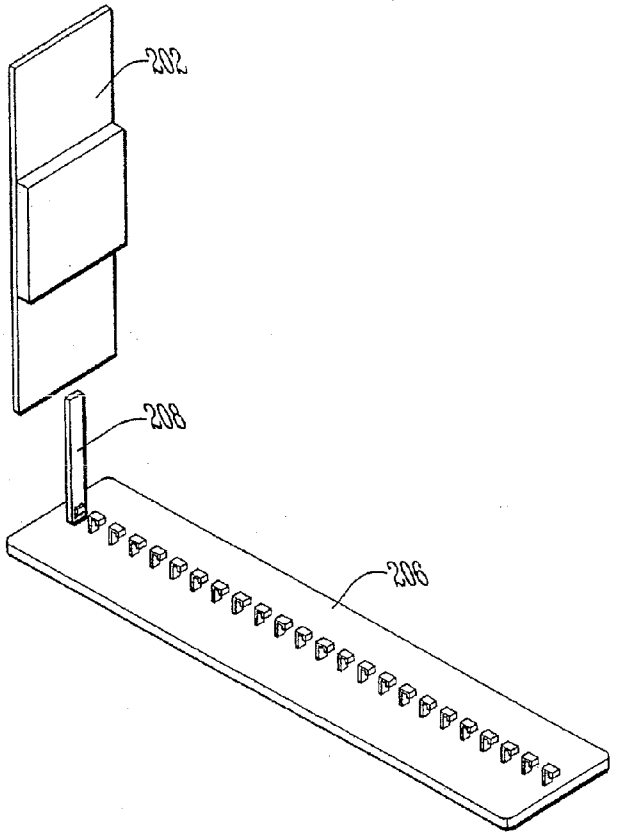


FIG. 10D

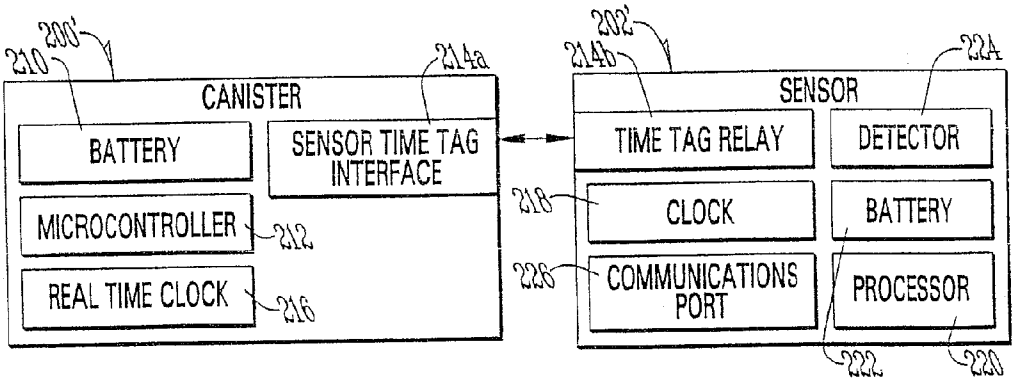


FIG. 10E

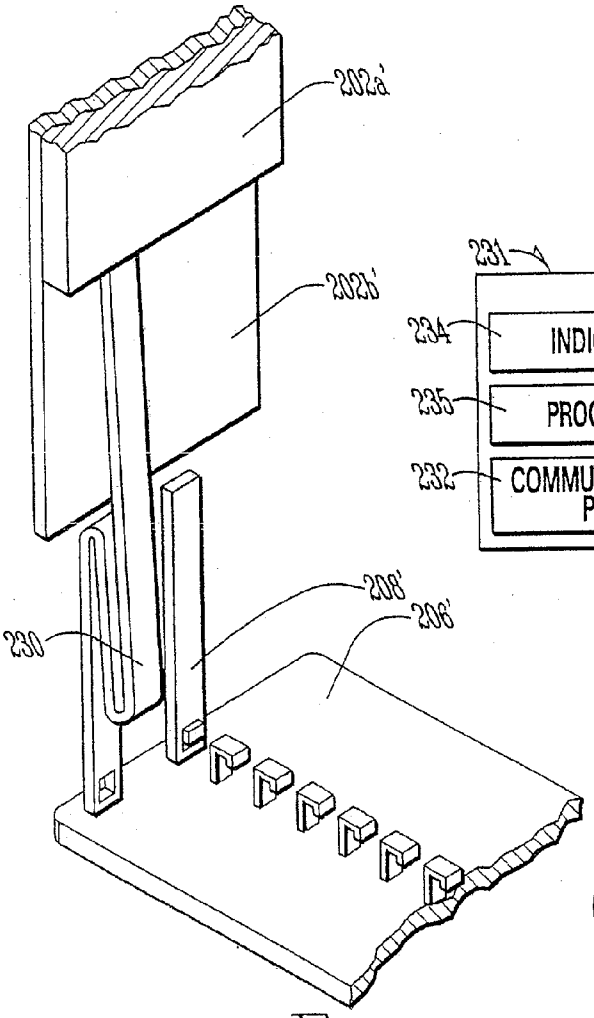


FIG.10F

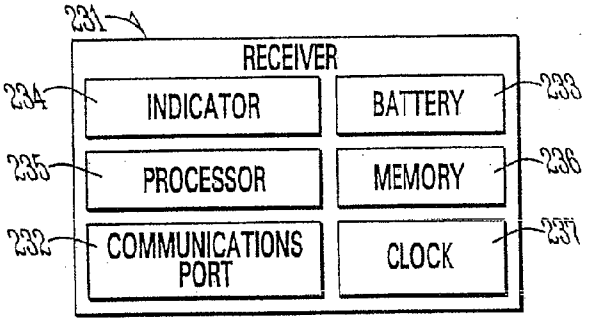


FIG.10G

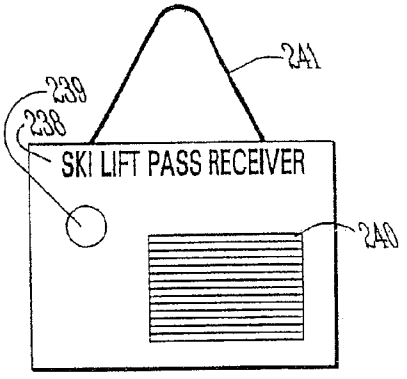


FIG.10H

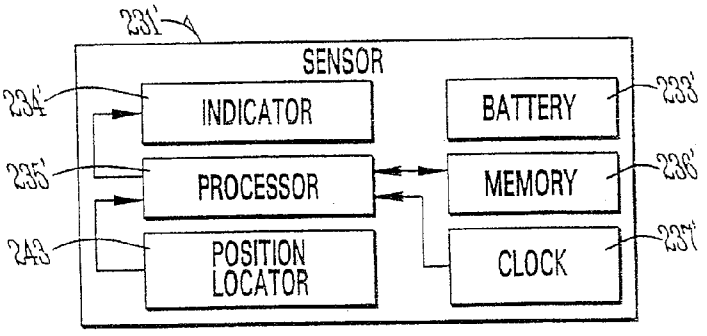


FIG.10I

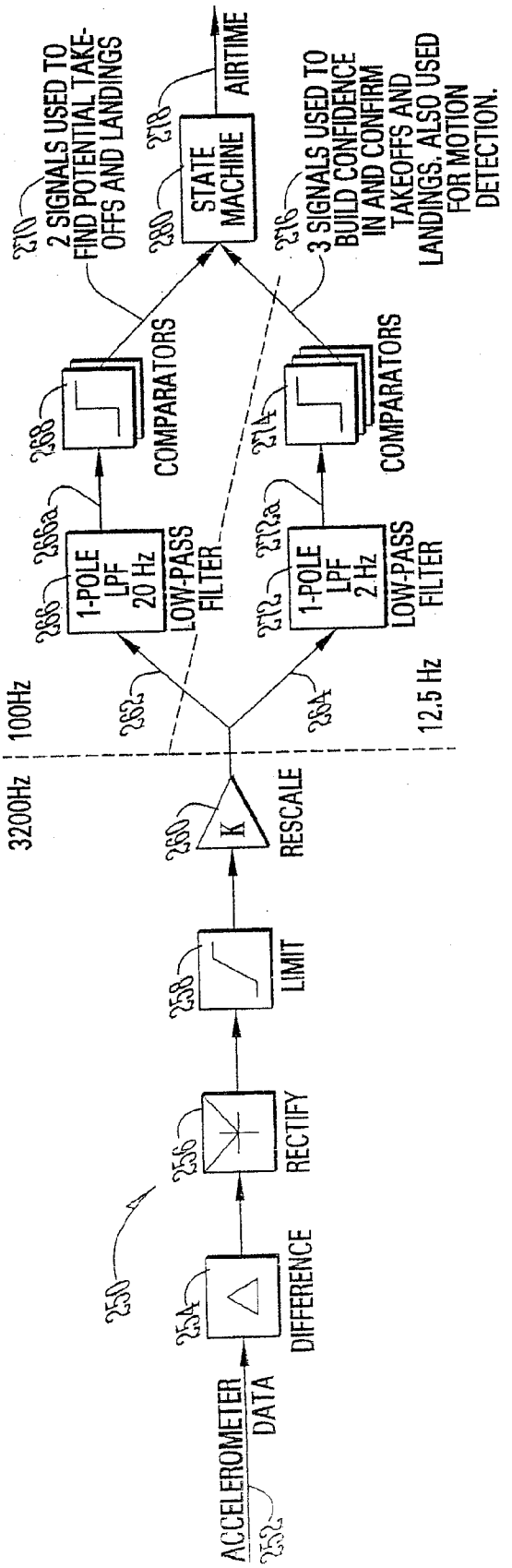

ACCELEROMETER DATA
252
250
254
DIFFERENCE
256
RECTIFY
258
LIMIT
260
K
RESCALE
3200Hz
100Hz
12.5 Hz
262
264
266
1-POLE LPF 20 Hz
266a
LOW-PASS FILTER
268
COMPARATORS
210
2 SIGNALS USED TO FIND POTENTIAL TAKE-OFFS AND LANDINGS
212
1-POLE LPF 2 Hz
212a
LOW-PASS FILTER
214
COMPARATORS
216
3 SIGNALS USED TO BUILD CONFIDENCE IN AND CONFIRM TAKEOFFS AND LANDINGS. ALSO USED FOR MOTION DETECTION.
280
STATE MACHINE
218
AIRTIME

FIG.11

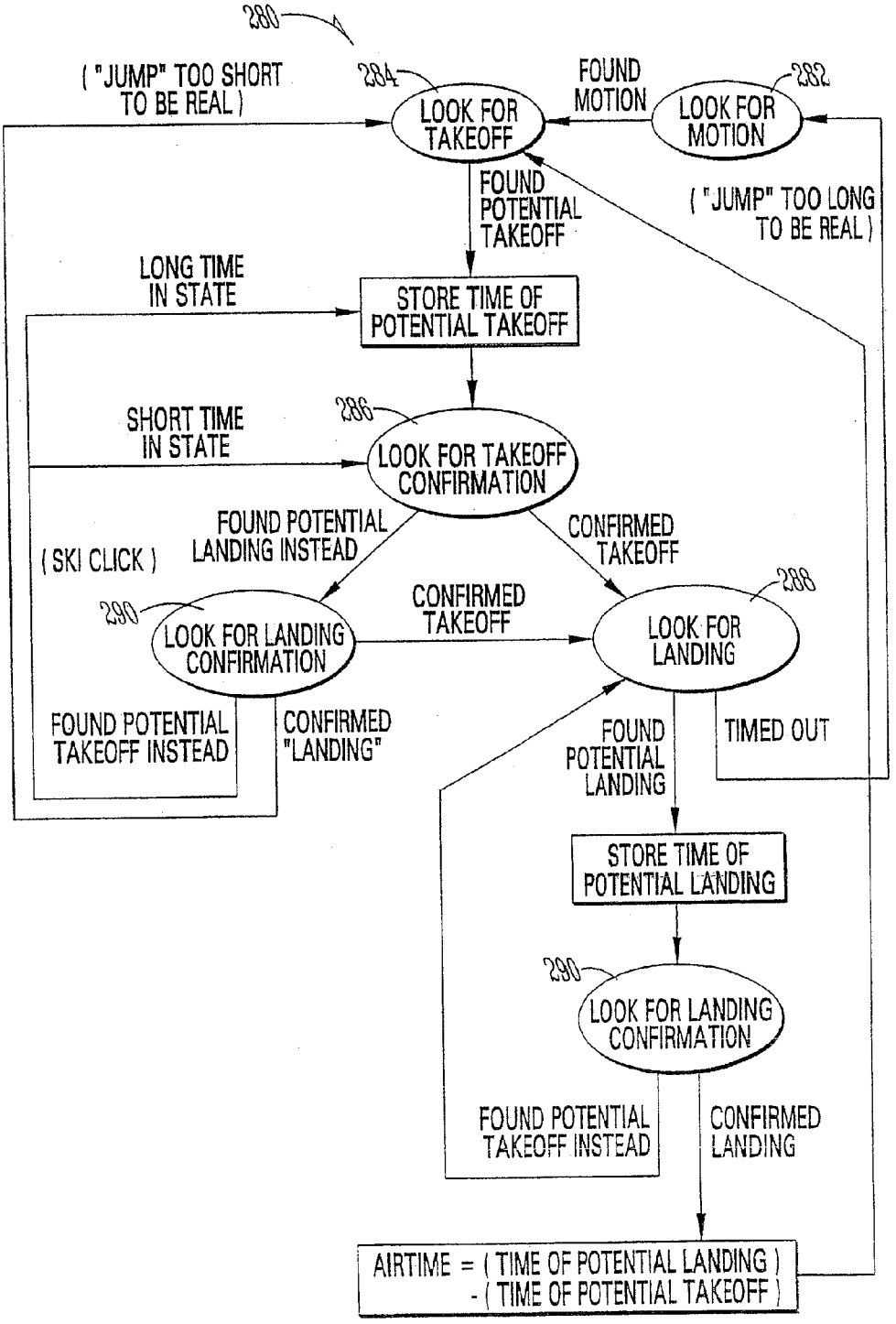

280
("JUMP" TOO SHORT TO BE REAL)
284
LOOK FOR TAKEOFF
FOUND MOTION
282
LOOK FOR MOTION
FOUND POTENTIAL TAKEOFF
("JUMP" TOO LONG TO BE REAL)
LONG TIME IN STATE
STORE TIME OF POTENTIAL TAKEOFF
SHORT TIME IN STATE
286
LOOK FOR TAKEOFF CONFIRMATION
(SKI CLICK)
FOUND POTENTIAL LANDING INSTEAD
CONFIRMED TAKEOFF
290
LOOK FOR LANDING CONFIRMATION
CONFIRMED TAKEOFF
288
LOOK FOR LANDING
FOUND POTENTIAL TAKEOFF INSTEAD
CONFIRMED "LANDING"
FOUND POTENTIAL LANDING
TIMED OUT
STORE TIME OF POTENTIAL LANDING
290
LOOK FOR LANDING CONFIRMATION
FOUND POTENTIAL TAKEOFF INSTEAD
CONFIRMED LANDING
AIRTIME = (TIME OF POTENTIAL LANDING) - (TIME OF POTENTIAL TAKEOFF)

FIG. 12

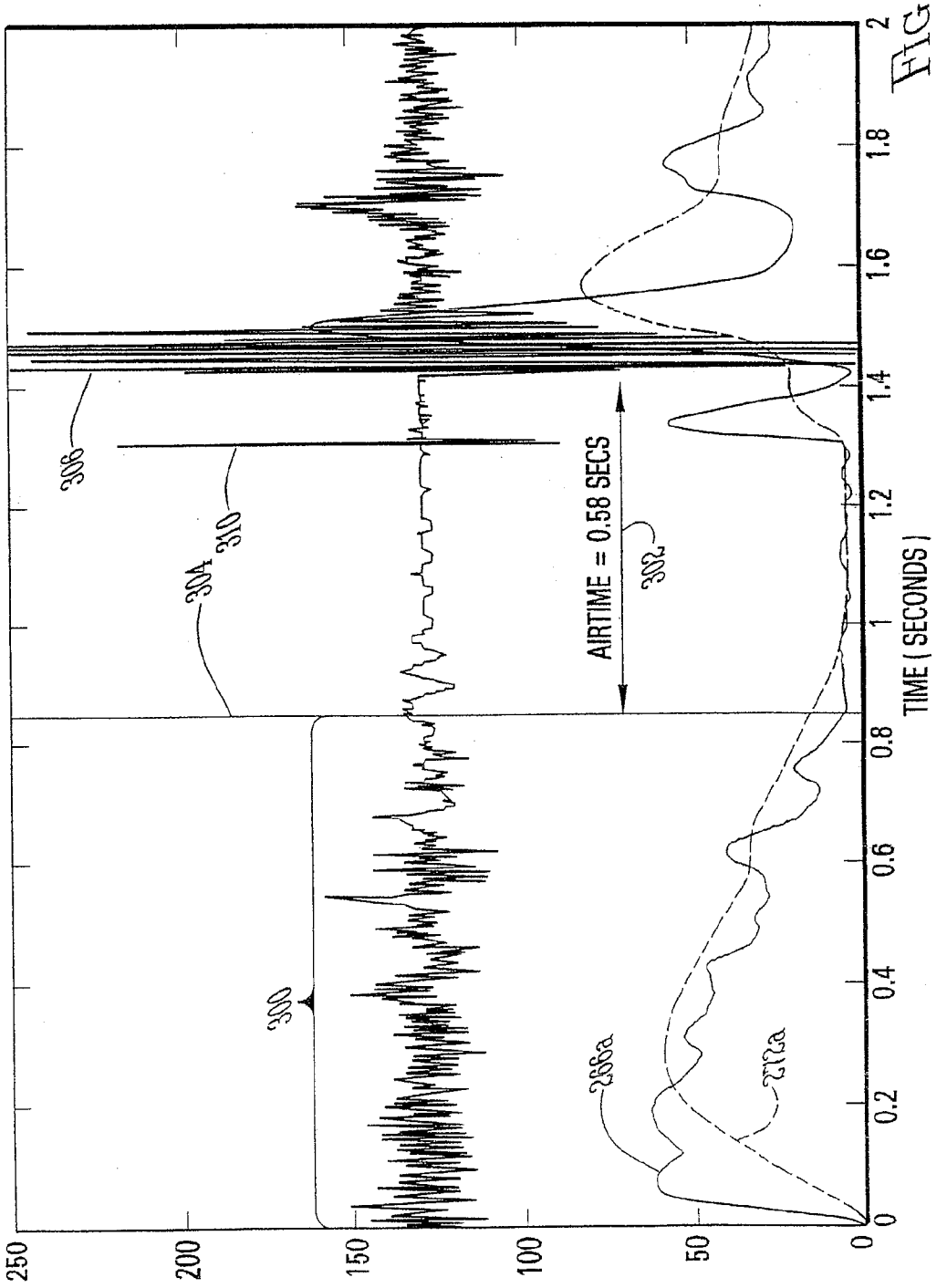

250
200
150
100
50
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
TIME (SECONDS)
AIRTIME = 0.58 SECS
300
306
310
304
302
288a
272a

FIG.13

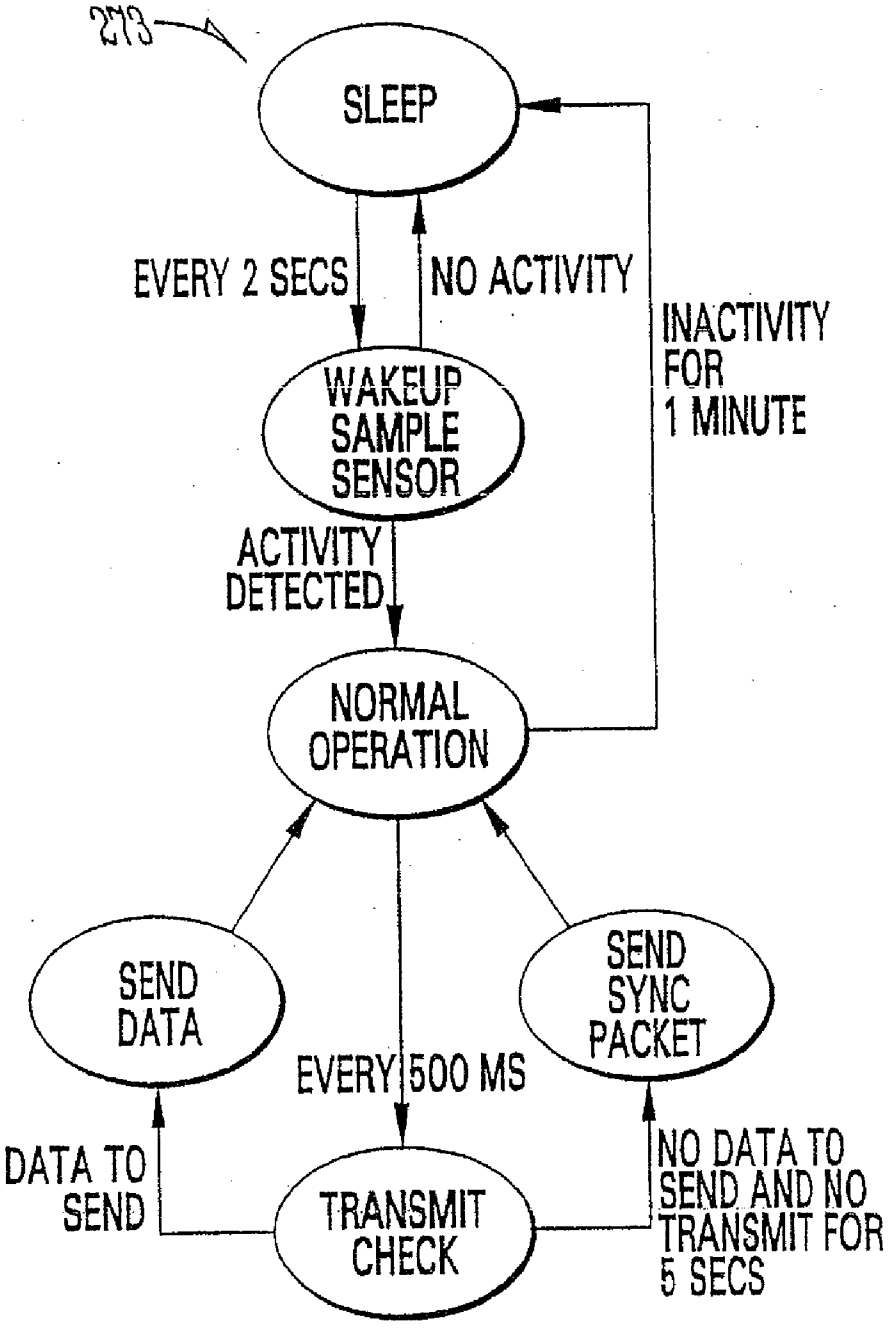

273
SLEEP
EVERY 2 SECS
NO ACTIVITY
INACTIVITY FOR 1 MINUTE
WAKEUP SAMPLE SENSOR
ACTIVITY DETECTED
NORMAL OPERATION
SEND DATA
SEND SYNC PACKET
EVERY 500 MS
DATA TO SEND
NO DATA TO SEND AND NO TRANSMIT FOR 5 SECS
TRANSMIT CHECK

FIG.14

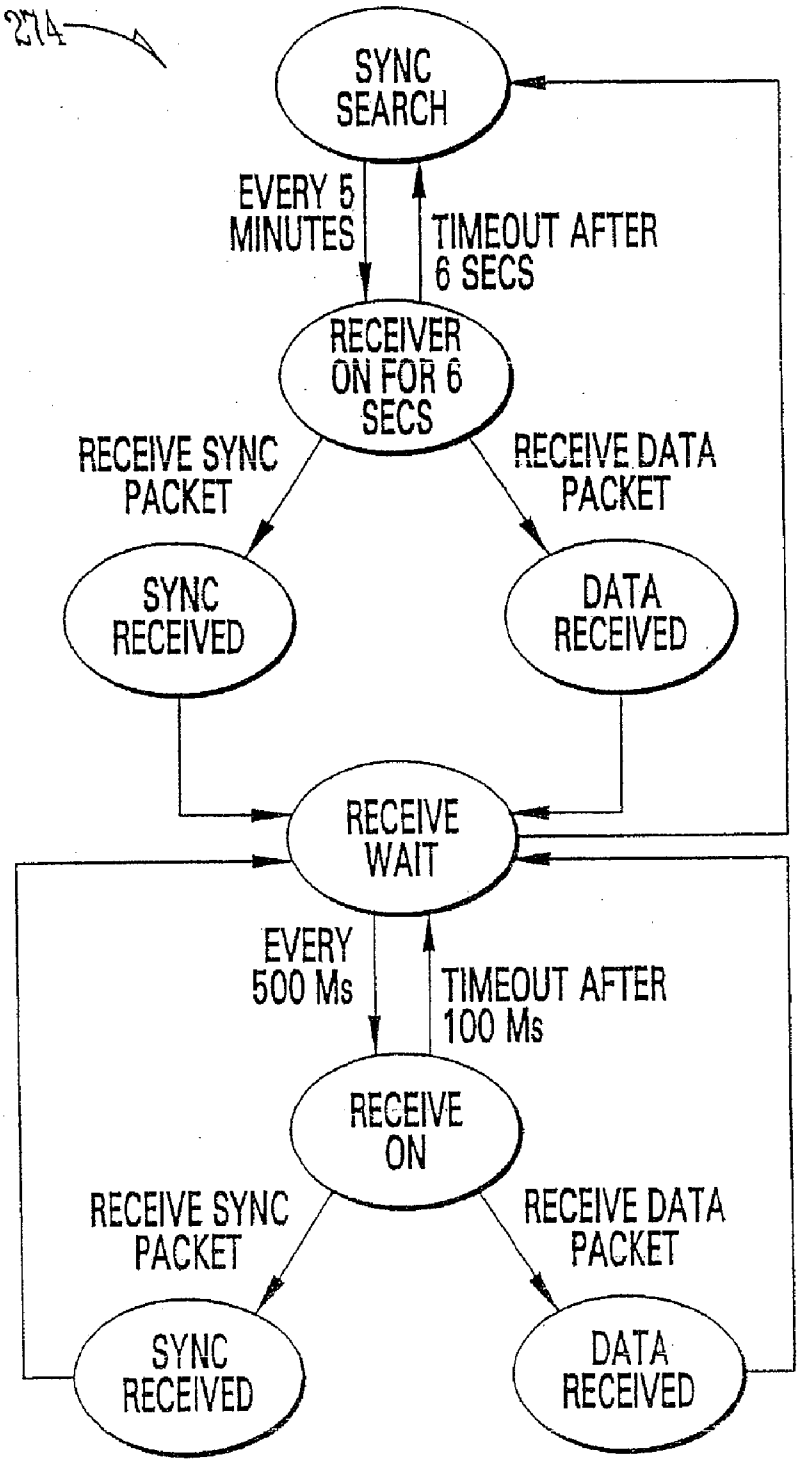

274
SYNC SEARCH
EVERY 5 MINUTES
TIMEOUT AFTER 6 SECS
RECEIVER ON FOR 6 SECS
RECEIVE SYNC PACKET
RECEIVE DATA PACKET
SYNC RECEIVED
DATA RECEIVED
RECEIVE WAIT
EVERY 500 Ms
TIMEOUT AFTER 100 Ms
RECEIVE ON
RECEIVE SYNC PACKET
RECEIVE DATA PACKET
SYNC RECEIVED
DATA RECEIVED

FIG.14A

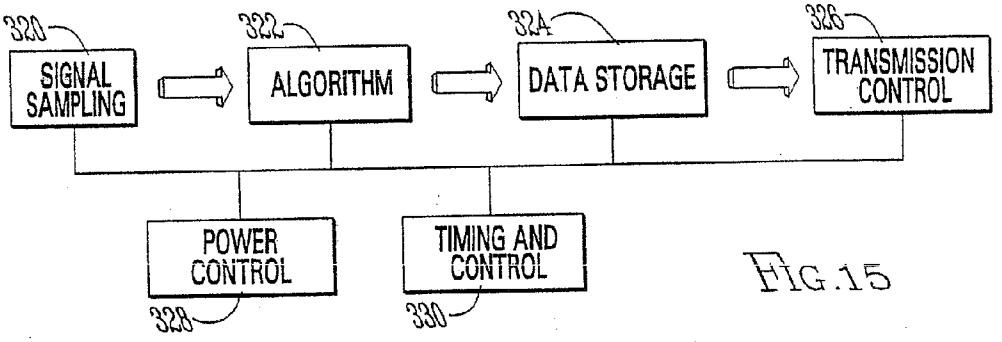

320
SIGNAL SAMPLING
322
ALGORITHM
324
DATA STORAGE
326
TRANSMISSION CONTROL
POWER CONTROL
328
TIMING AND CONTROL
330

FIG.15

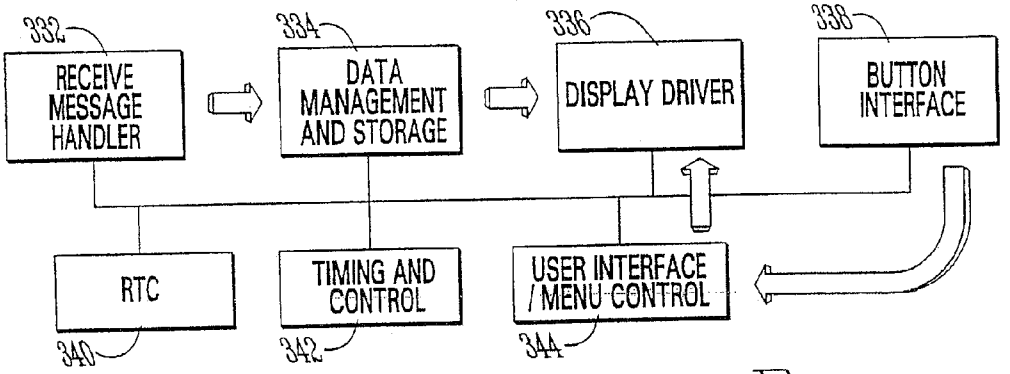

332
RECEIVE MESSAGE HANDLER
334
DATA MANAGEMENT AND STORAGE
336
DISPLAY DRIVER
338
BUTTON INTERFACE
RTC
340
TIMING AND CONTROL
342
USER INTERFACE / MENU CONTROL
344

FIG.16

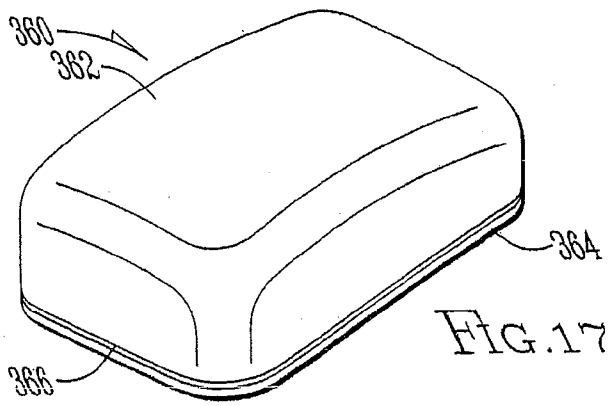


FIG.17

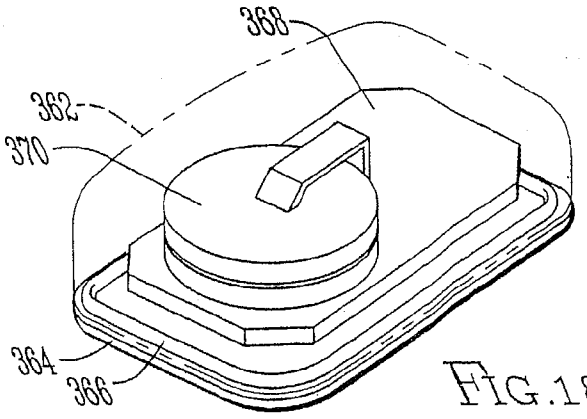


FIG.18

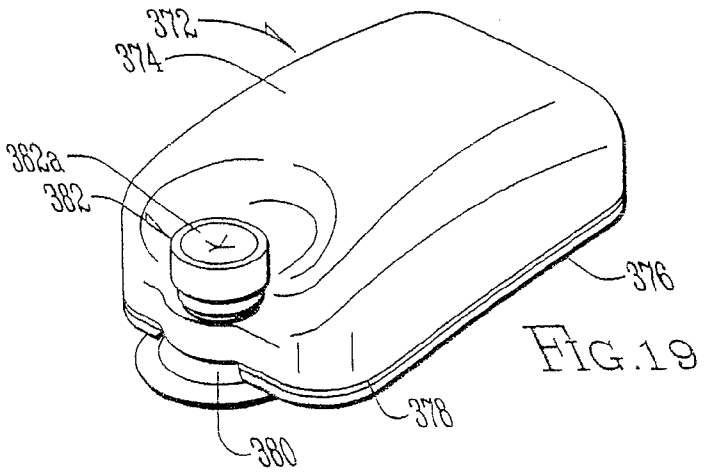


FIG.19

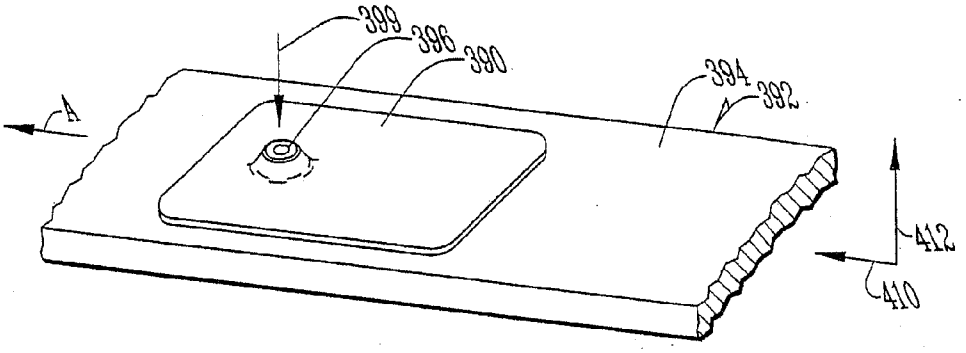


FIG. 20

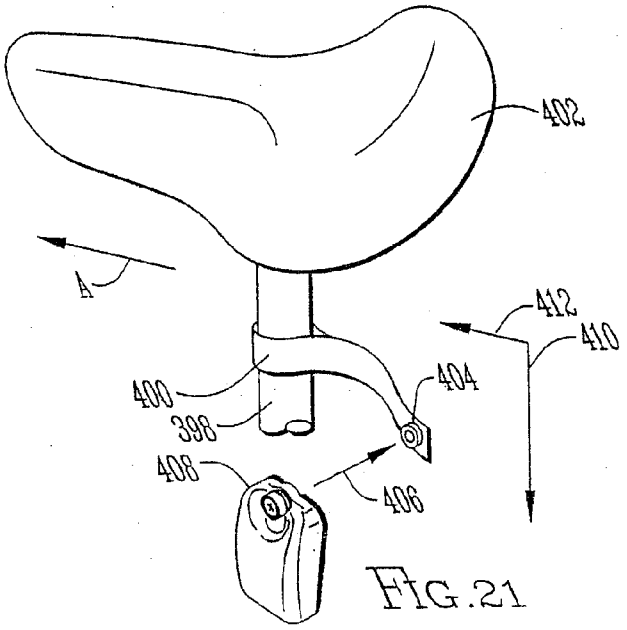


FIG. 21

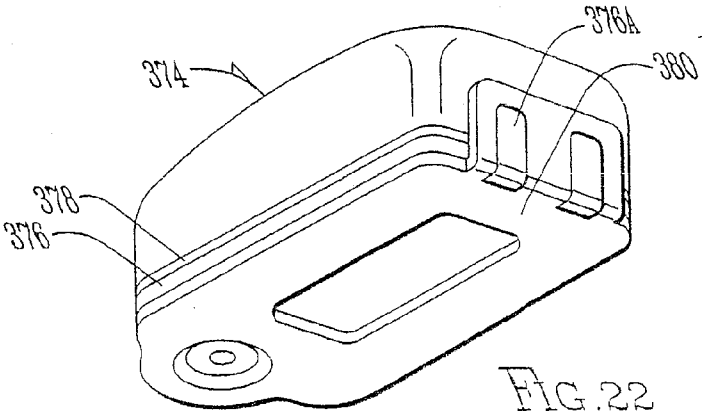


FIG. 22

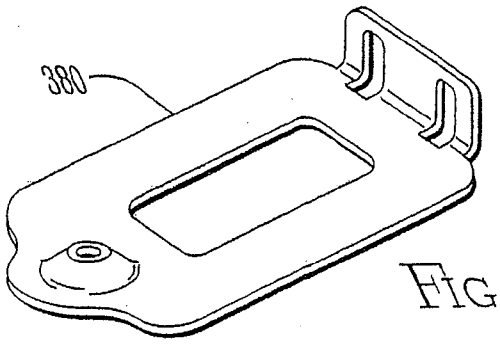


FIG. 23

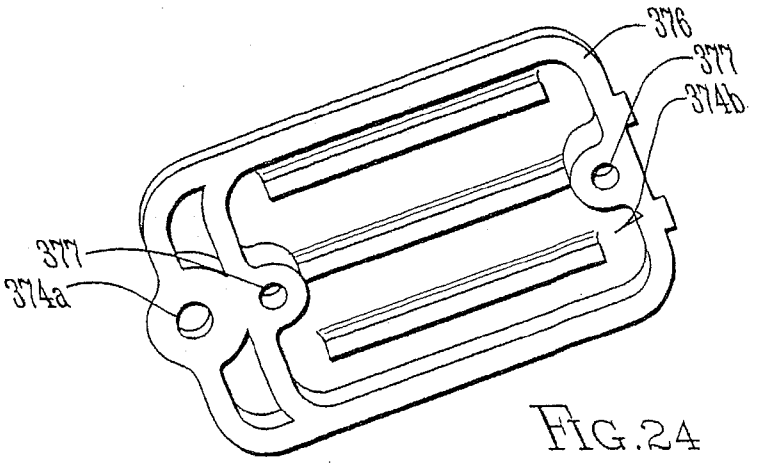


FIG. 24

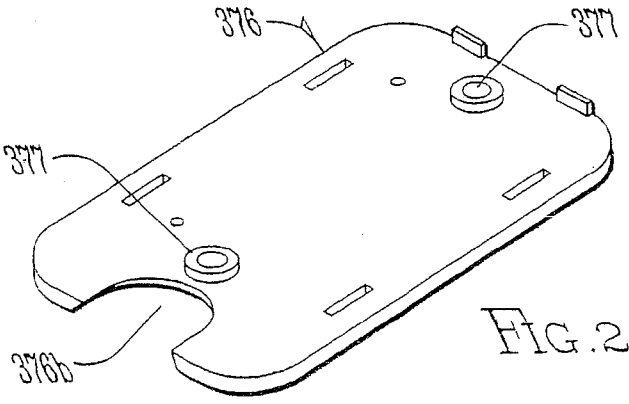


FIG. 25

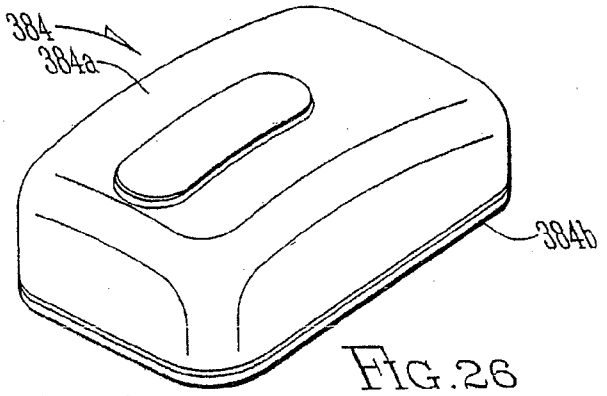


FIG. 26

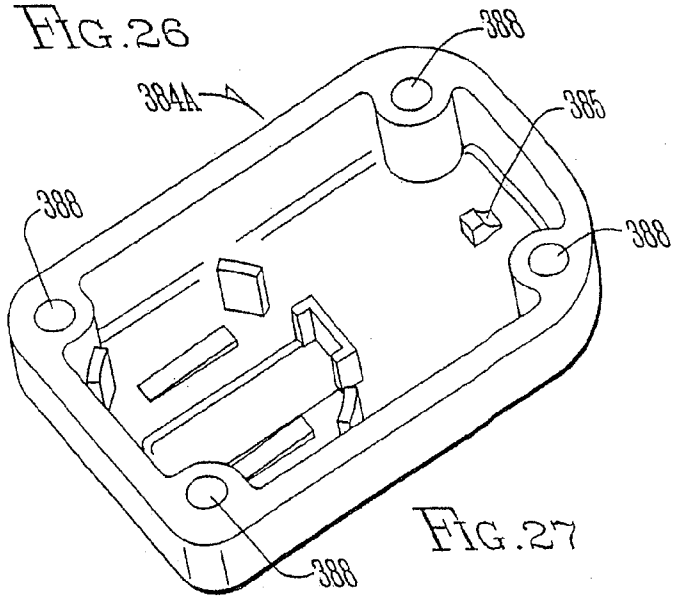


FIG. 27

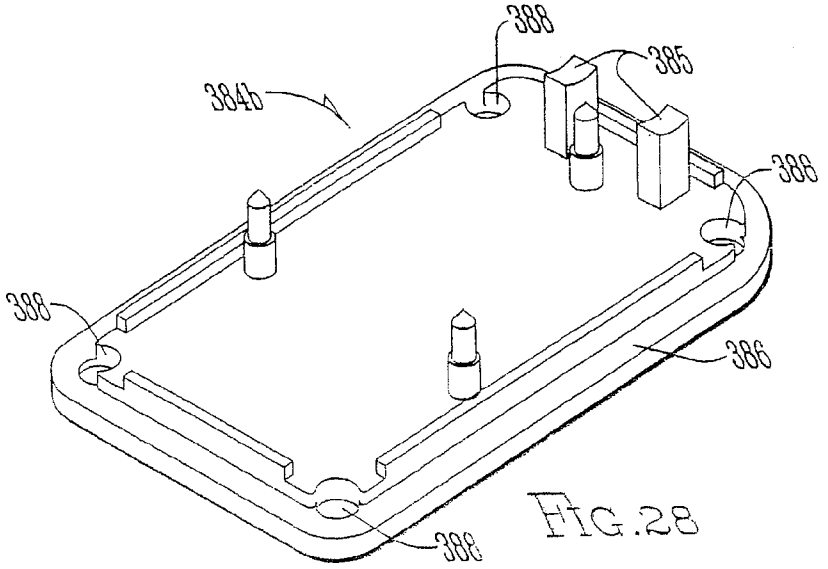


FIG. 28

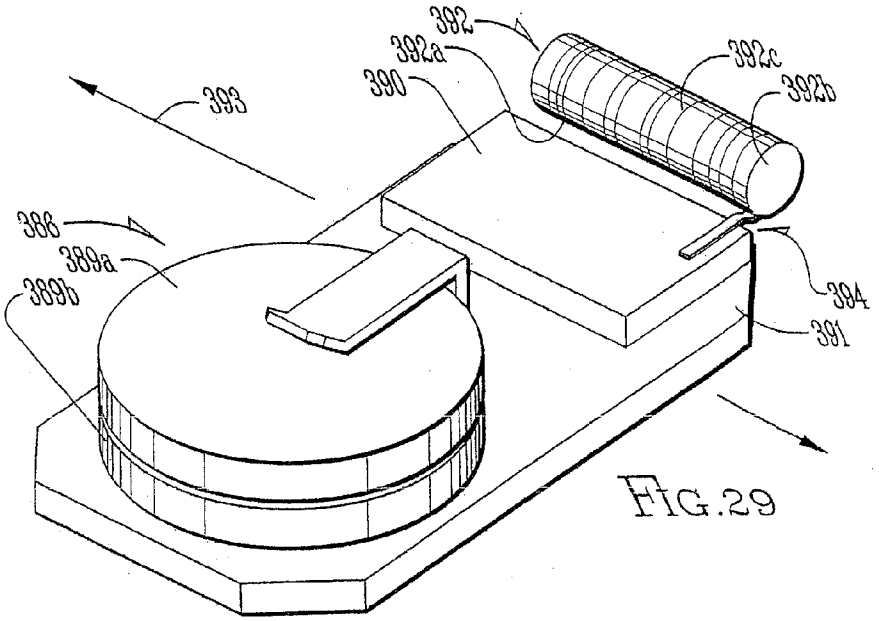


FIG.29

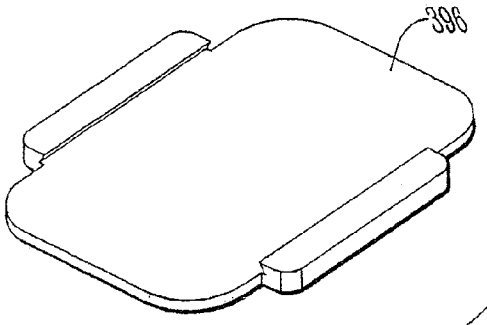


FIG.30

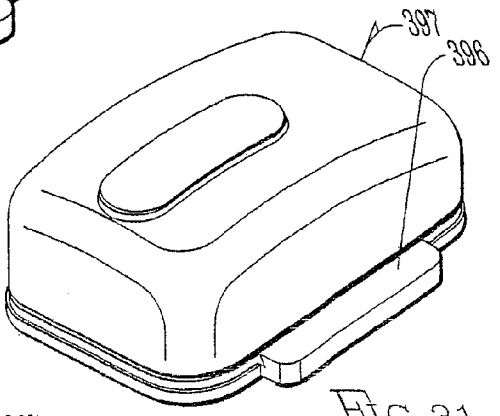


FIG.31

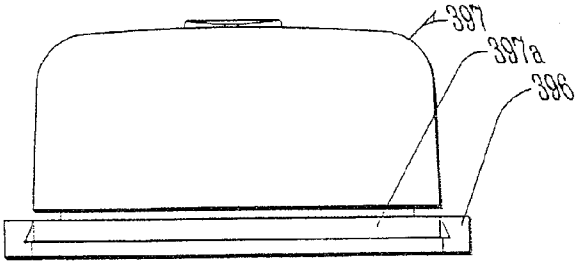


FIG.32

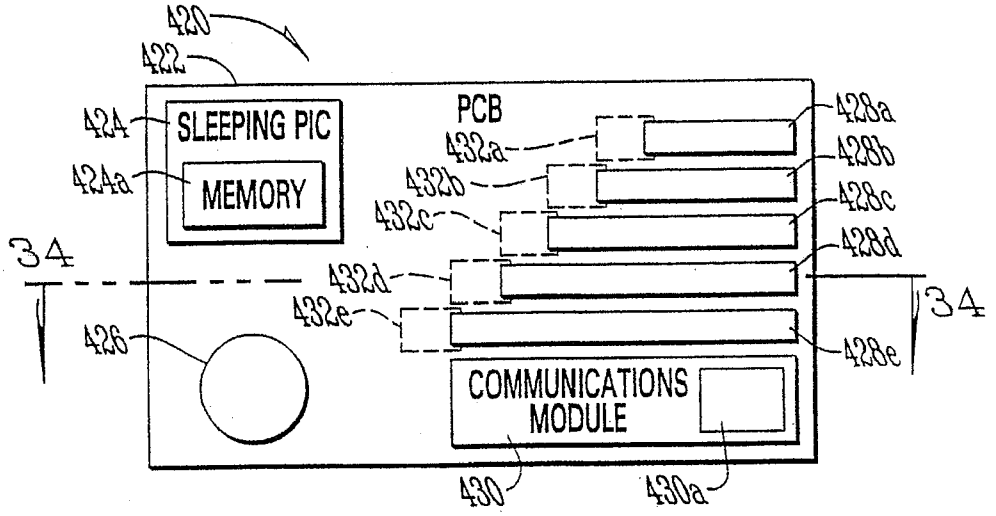


FIG.33

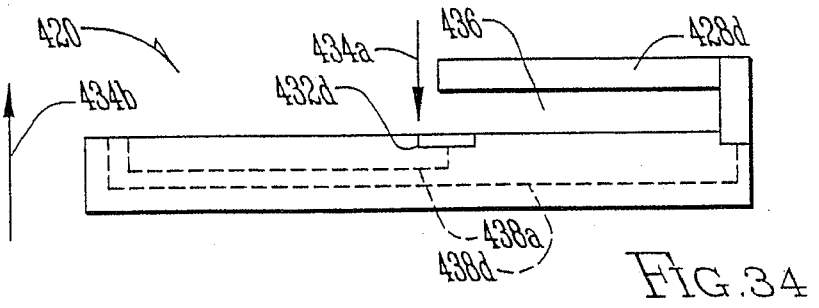


FIG.34

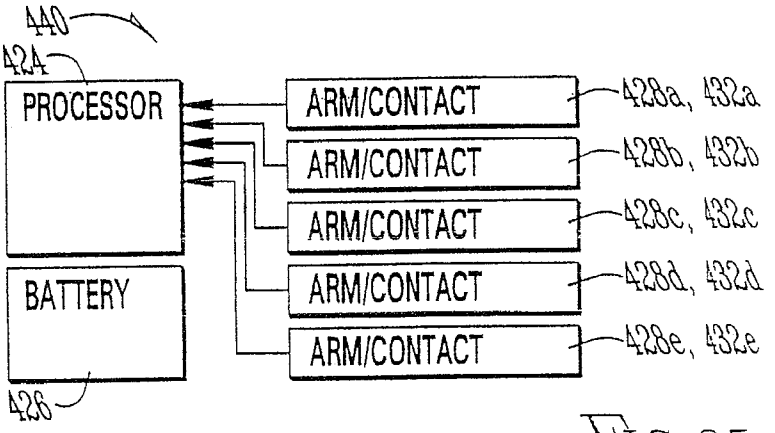


FIG.35

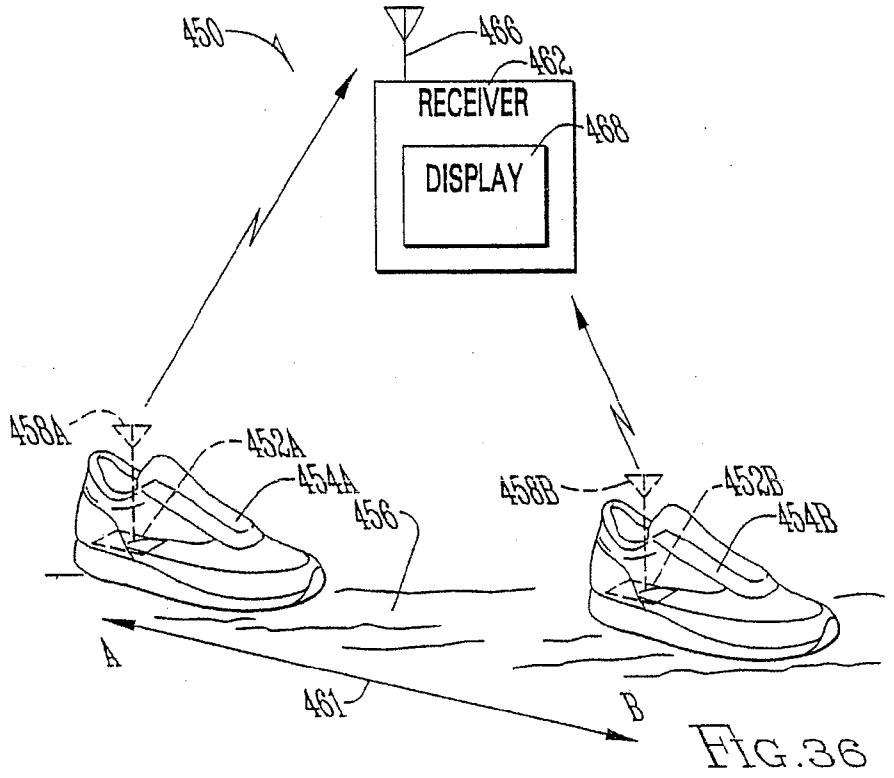

450
466
462
RECEIVER
468
DISPLAY
458A
452A
454A
456
458B
452B
454B
A
461
B

FIG.36

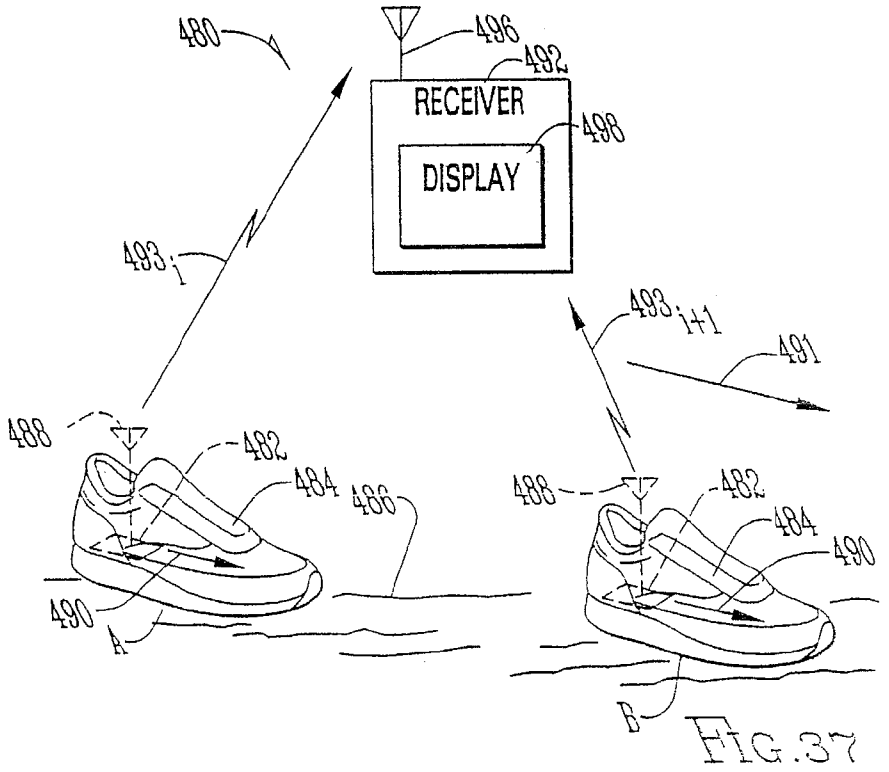

480
496
492
RECEIVER
498
DISPLAY
493;1
493;1+1
491
488
482
484
486
490
A
B

FIG.37

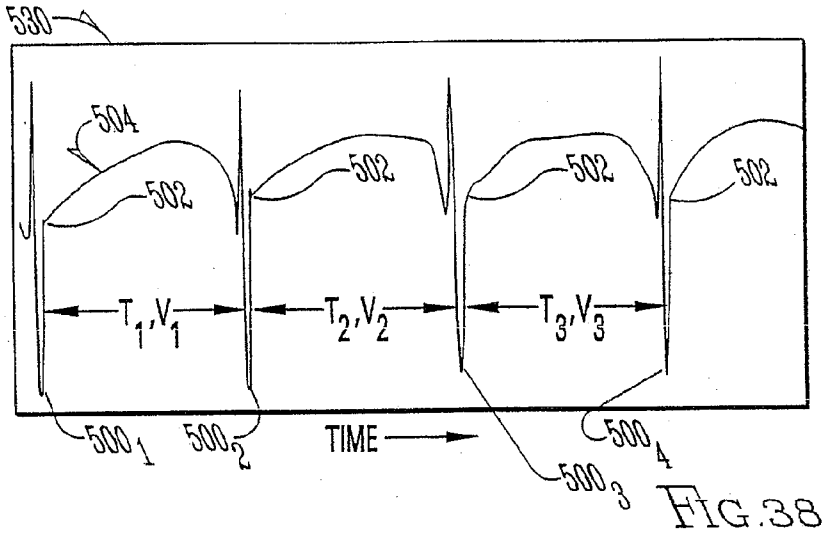

530
504
502
502
502
502
T_1, V_1
T_2, V_2
T_3, V_3
500_1
500_2
TIME
500_3
500_4

FIG.38

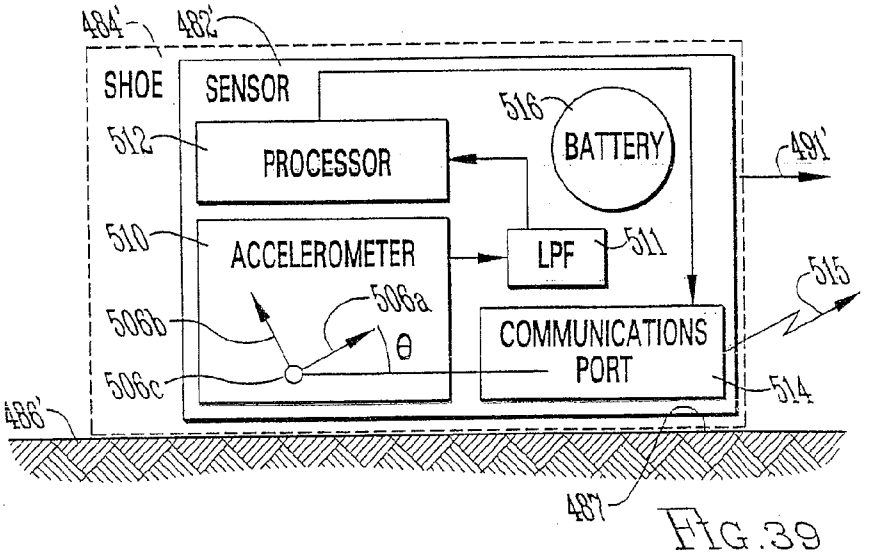

484'
482'
SHOE
SENSOR
516
BATTERY
512
PROCESSOR
491'
510
ACCELEROMETER
LPF
511
515
506a
506b
θ
COMMUNICATIONS PORT
506c
514
486'
487

FIG.39

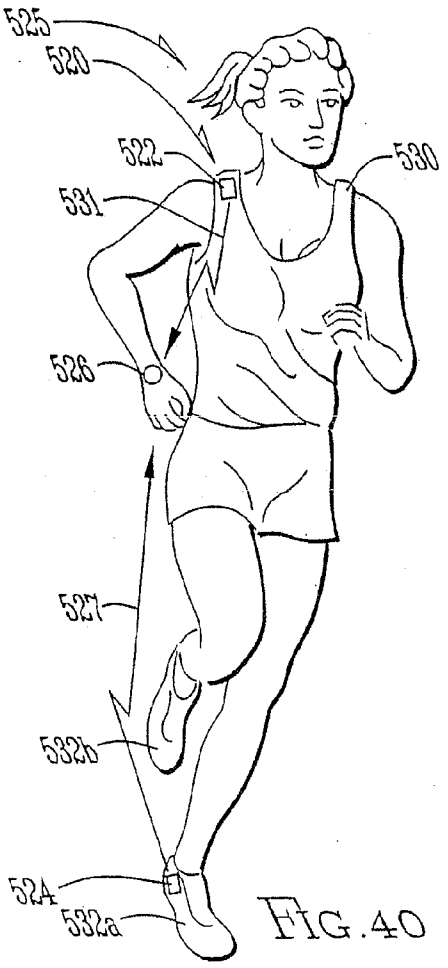

525
520
522
530
531
526
527
532b
524
532a

FIG.40

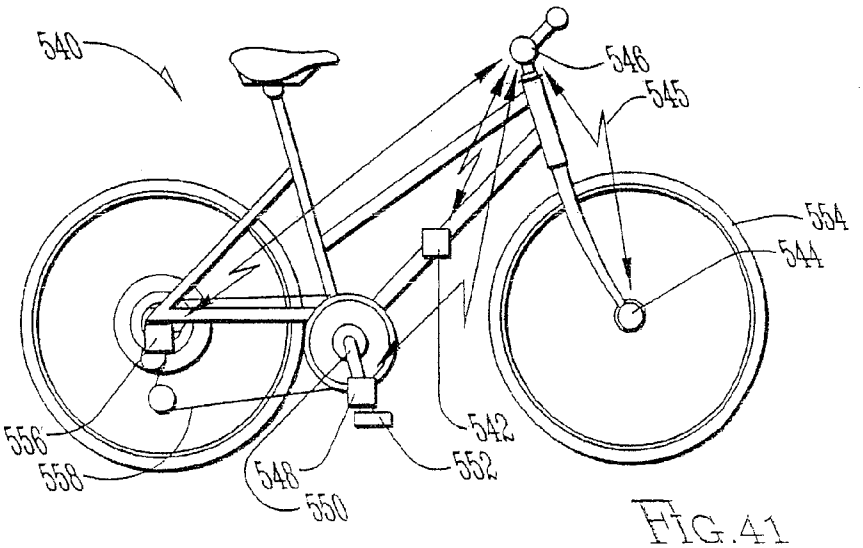

540
546
545
554
544
556
558
548
550
542
552

FIG.41

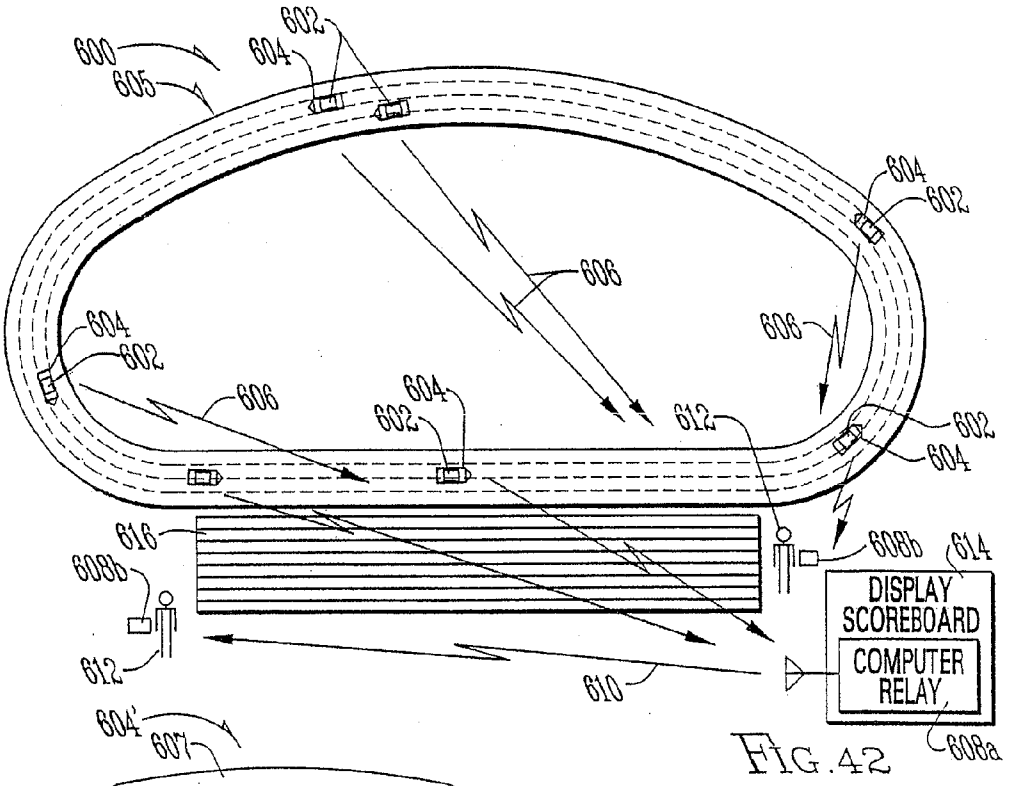


FIG. 42

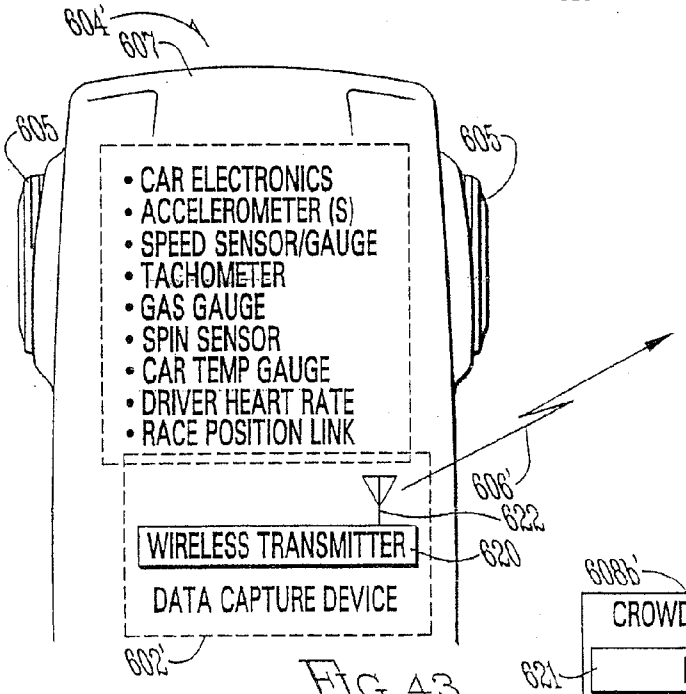


FIG. 43

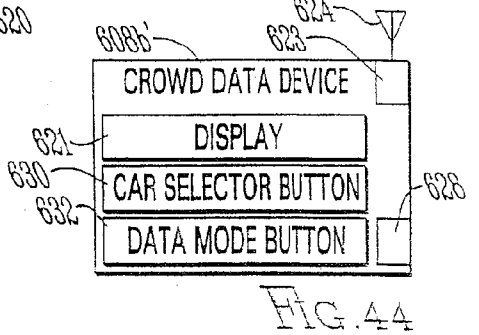


FIG. 44

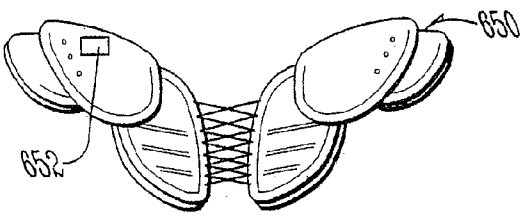


FIG.45

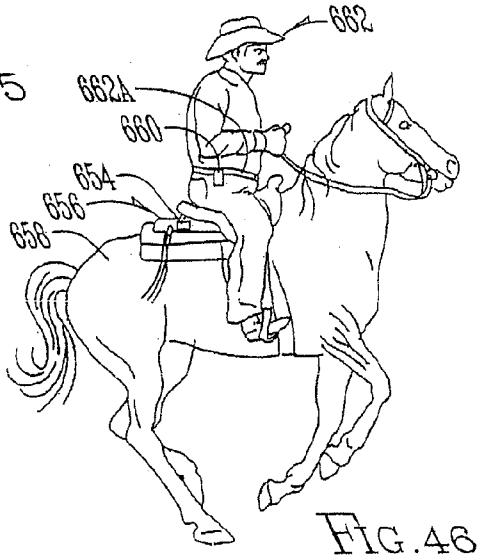


FIG.46

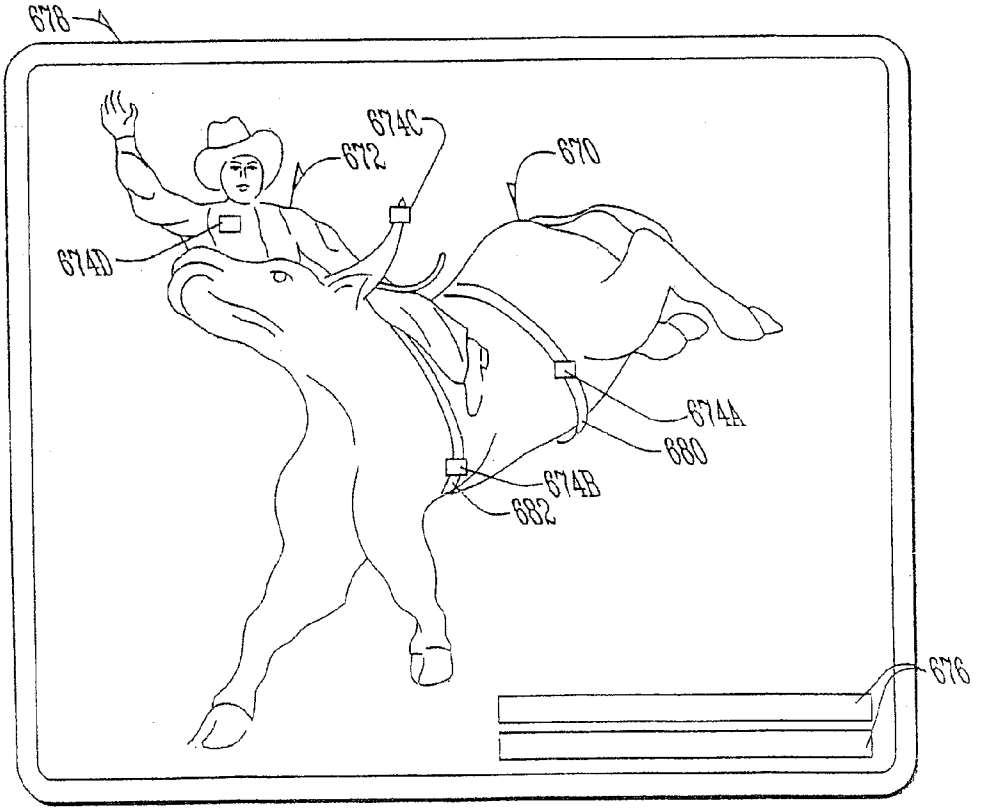


FIG.47

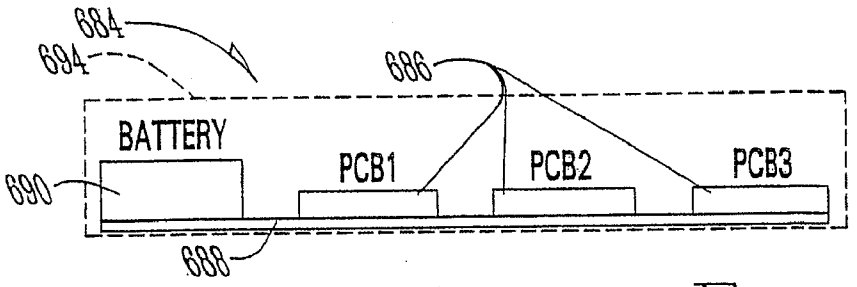

684
694
686
BATTERY
PCB1
PCB2
PCB3
690
688

FIG.48

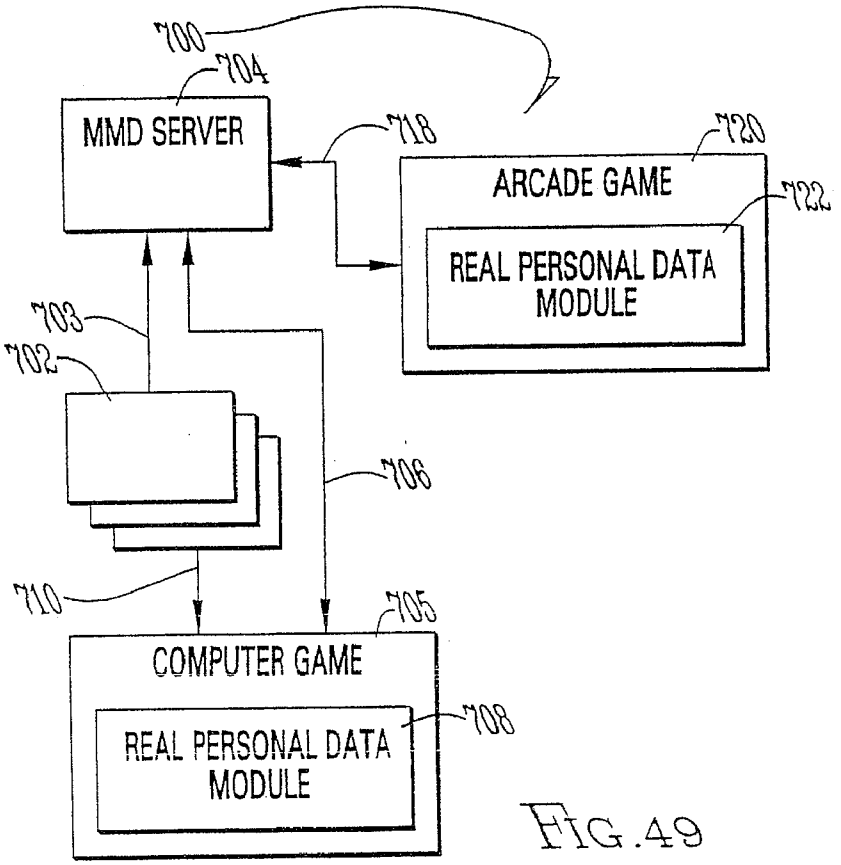

700
704
MMD SERVER
718
720
ARCADE GAME
722
REAL PERSONAL DATA MODULE
703
702
706
710
705
COMPUTER GAME
708
REAL PERSONAL DATA MODULE

FIG.49

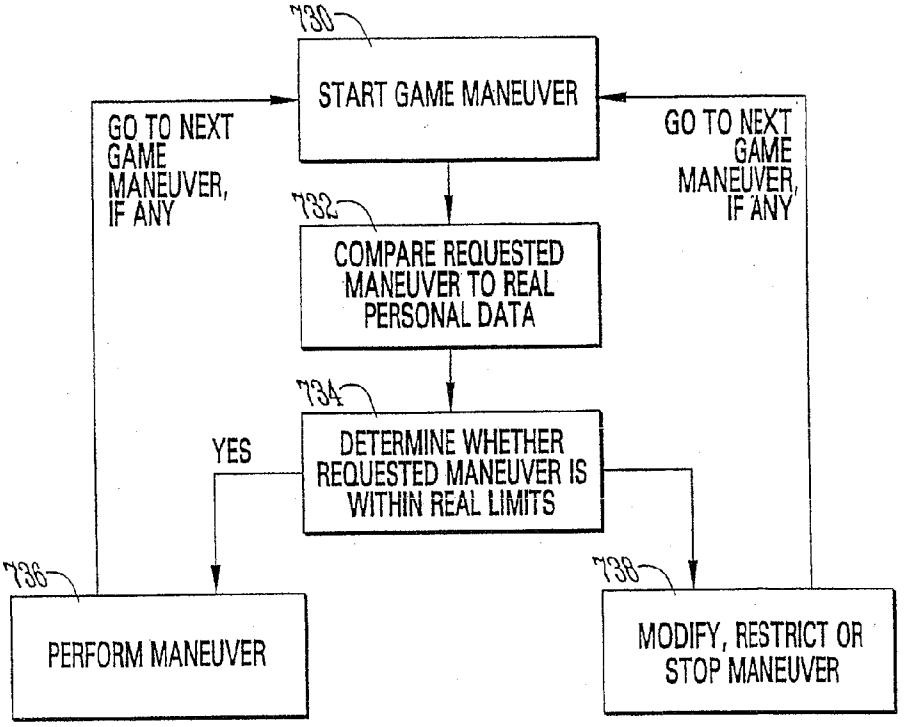

730
START GAME MANEUVER
GO TO NEXT GAME MANEUVER, IF ANY
GO TO NEXT GAME MANEUVER, IF ANY
732
COMPARE REQUESTED MANEUVER TO REAL PERSONAL DATA
734
DETERMINE WHETHER REQUESTED MANEUVER IS WITHIN REAL LIMITS
YES
736
PERFORM MANEUVER
738
MODIFY, RESTRICT OR STOP MANEUVER

FIG.50

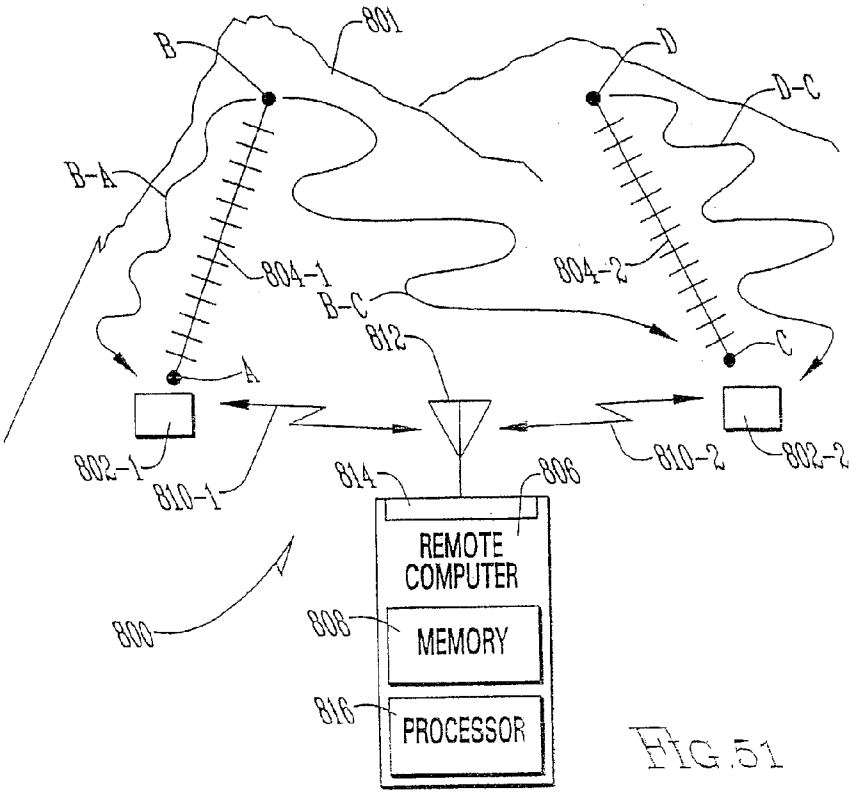

B
801
D
D-C
B-A
804-1
804-2
B-C
812
A
C
802-1
810-1
810-2
802-2
814
806
REMOTE COMPUTER
800
808
MEMORY
816
PROCESSOR

FIG.51

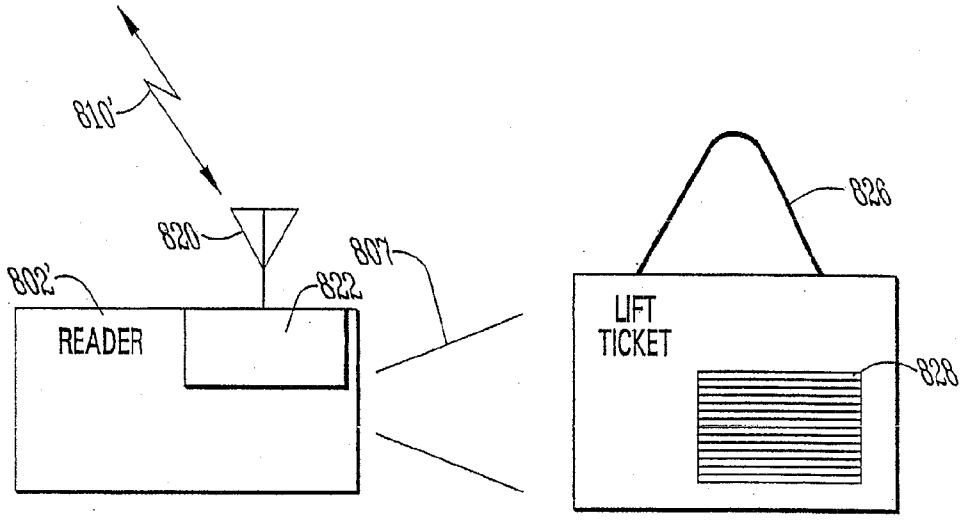

810'
820
807'
802'
822
READER
826
LIFT
TICKET
828

FIG.52

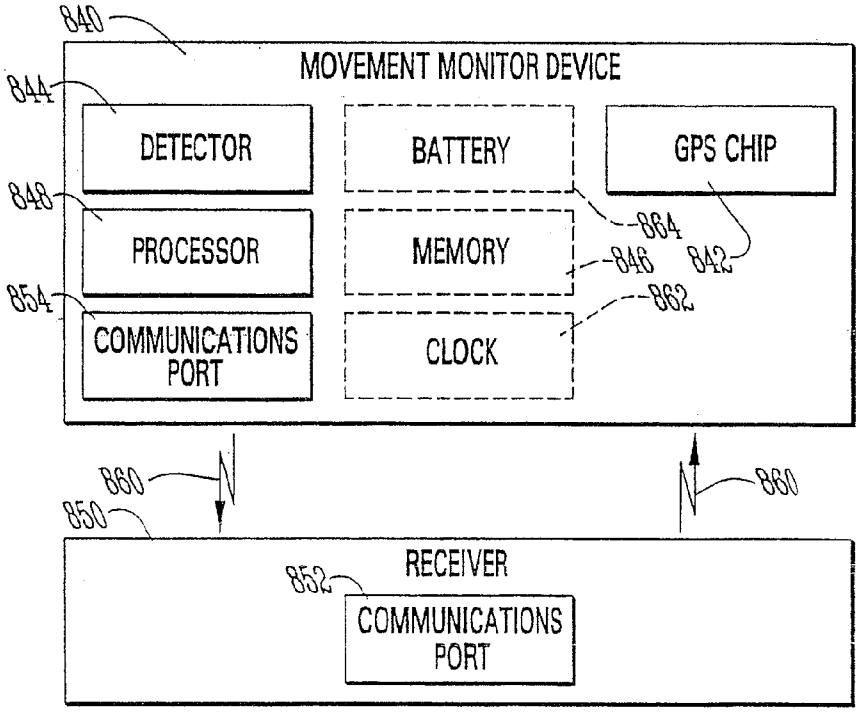

840
MOVEMENT MONITOR DEVICE
844
DETECTOR
BATTERY
GPS CHIP
848
PROCESSOR
MEMORY
864
842
846
854
COMMUNICATIONS PORT
CLOCK
862
860
860
850
RECEIVER
852
COMMUNICATIONS PORT

FIG.53

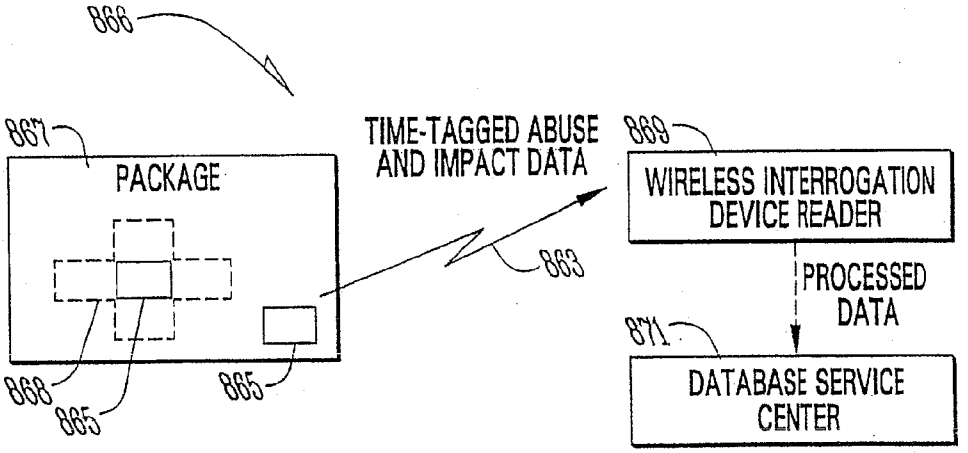

866
867
PACKAGE
TIME-TAGGED ABUSE AND IMPACT DATA
869
WIRELESS INTERROGATION DEVICE READER
863
PROCESSED DATA
871
DATABASE SERVICE CENTER
868
865
865

FIG.54

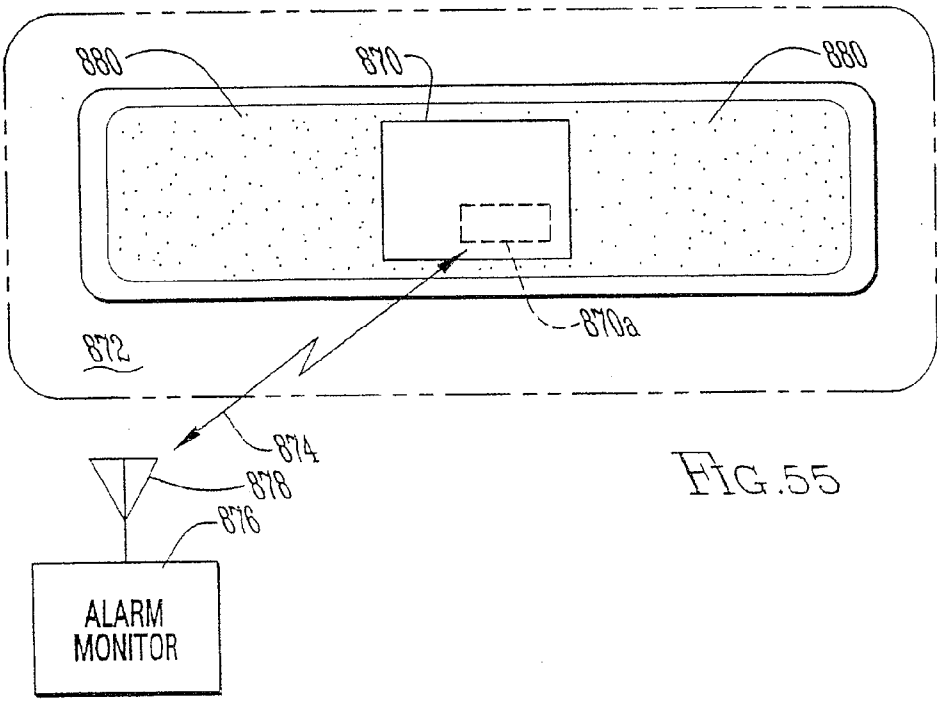

880
870
880
870a
872
874
878
876
ALARM MONITOR

FIG.55

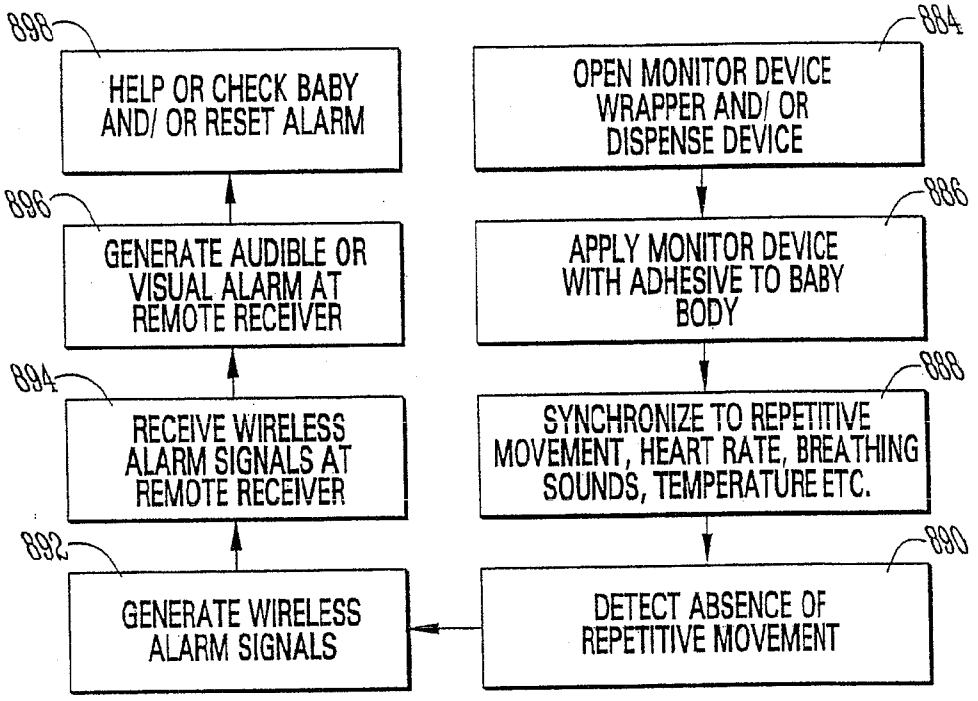

898
HELP OR CHECK BABY AND/ OR RESET ALARM
896
GENERATE AUDIBLE OR VISUAL ALARM AT REMOTE RECEIVER
894
RECEIVE WIRELESS ALARM SIGNALS AT REMOTE RECEIVER
892
GENERATE WIRELESS ALARM SIGNALS
884
OPEN MONITOR DEVICE WRAPPER AND/ OR DISPENSE DEVICE
886
APPLY MONITOR DEVICE WITH ADHESIVE TO BABY BODY
888
SYNCHRONIZE TO REPETITIVE MOVEMENT, HEART RATE, BREATHING SOUNDS, TEMPERATURE ETC.
890
DETECT ABSENCE OF REPETITIVE MOVEMENT

FIG.56

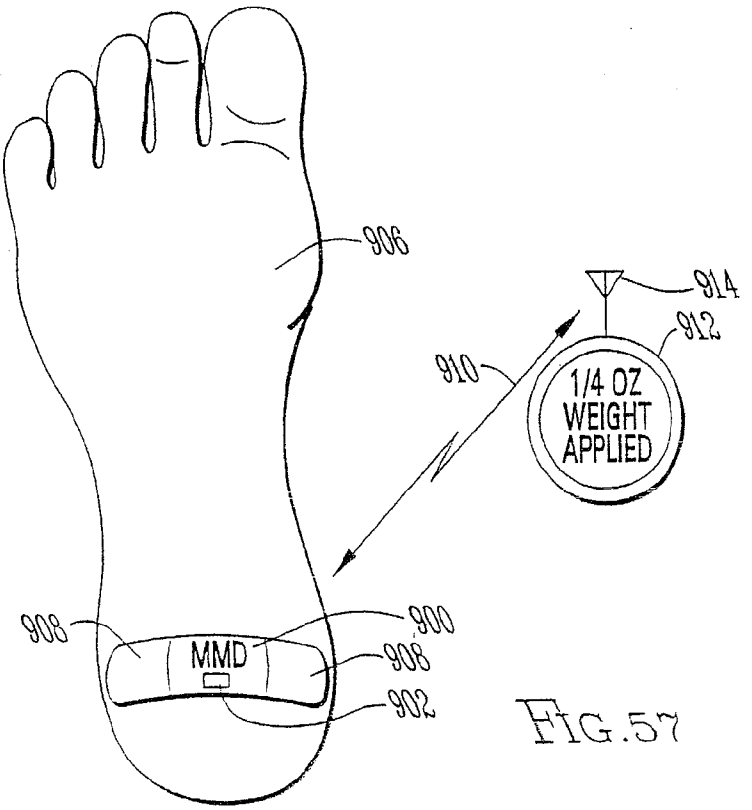

906
914
912
910
1/4 OZ WEIGHT APPLIED
908
MMD
900
908
902

FIG.57

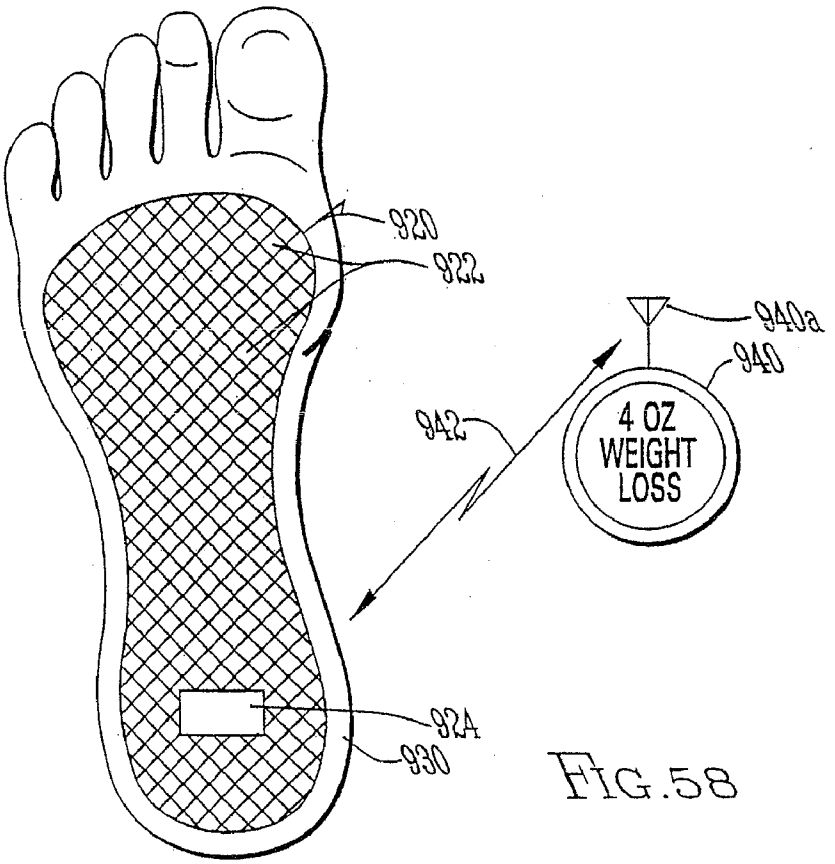

920
922
940a
940
942
4 OZ
WEIGHT
LOSS
92A
930

FIG.58

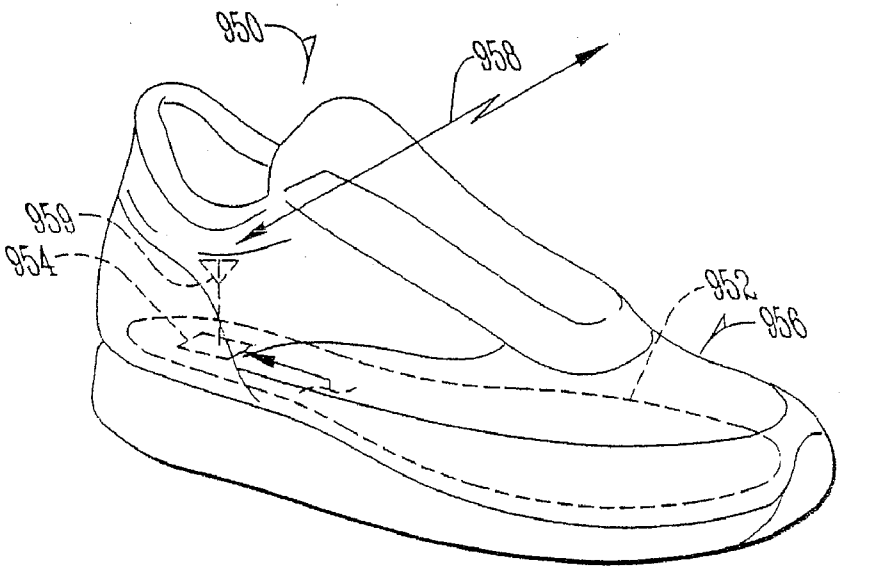

950
958
959
954
952
956

FIG.59

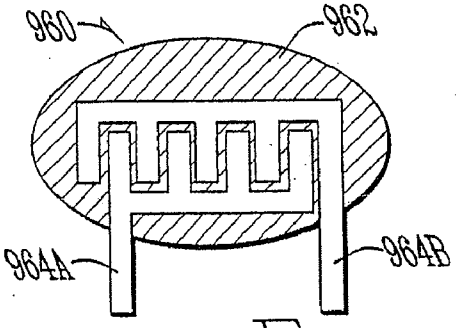


FIG. 60

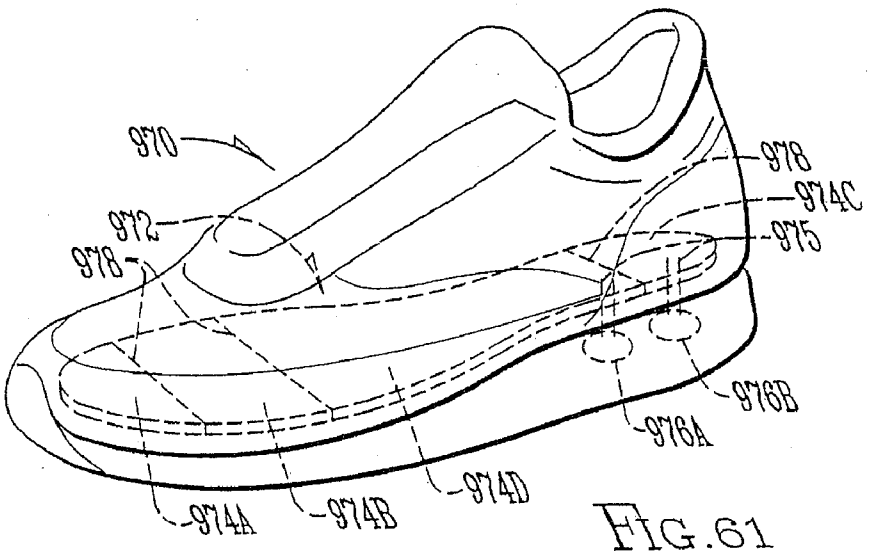


FIG. 61

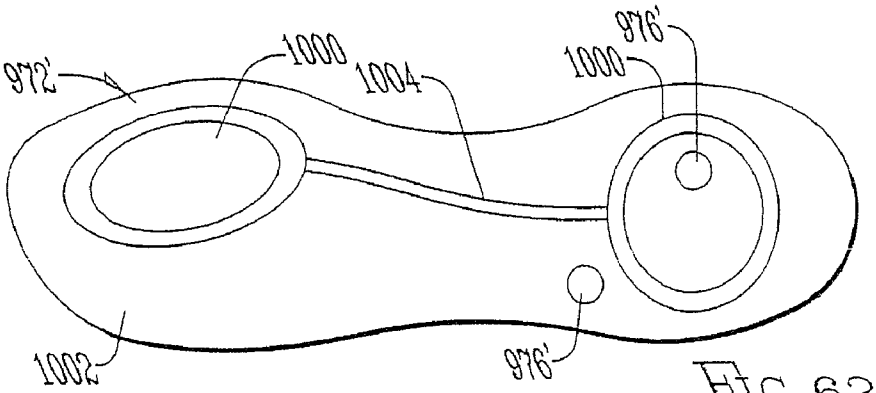


FIG. 62

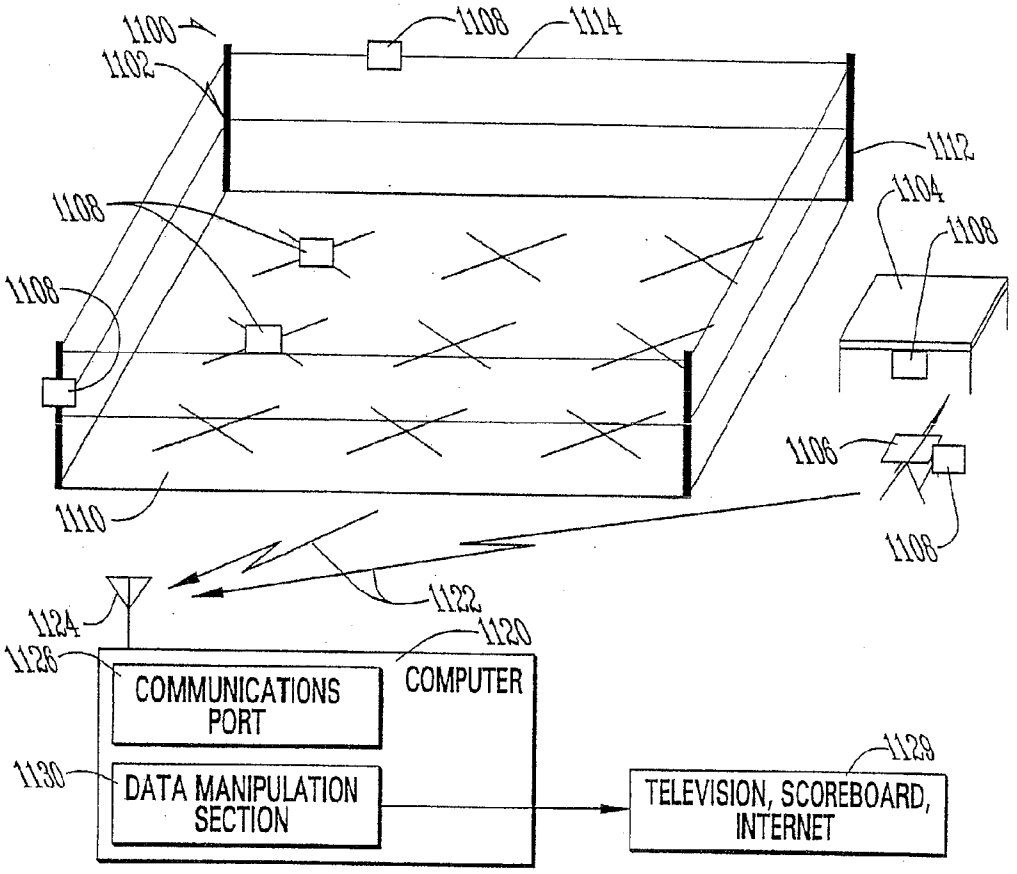

1100
1102
1108
1114
1112
1104
1108
1108
1108
1106
1110
1108
1122
1124
1120
1126
COMMUNICATIONS PORT
COMPUTER
1130
DATA MANIPULATION SECTION
1129
TELEVISION, SCOREBOARD, INTERNET

FIG.63

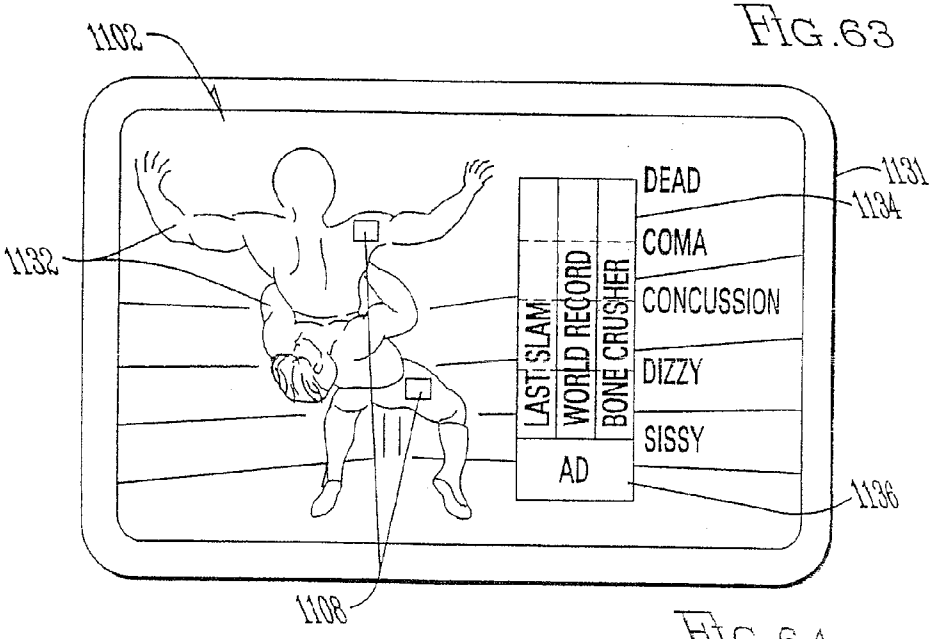

1102
1132
1131
1134
DEAD
COMA
CONCUSSION
DIZZY
SISSY
AD
LAST SLAM
WORLD RECORD
BONE CRUSHER
1136
1108

FIG.64

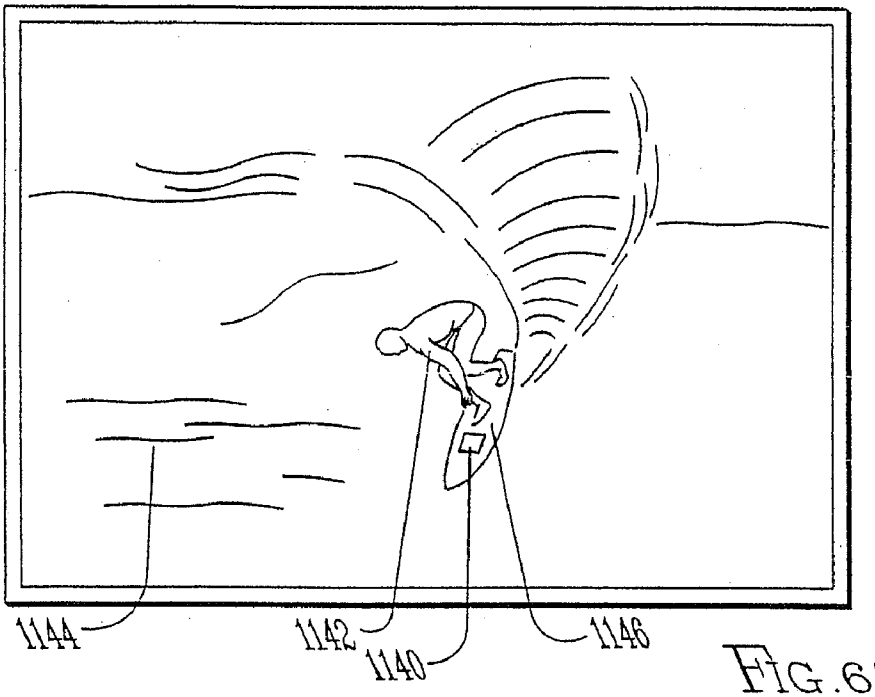


FIG. 65

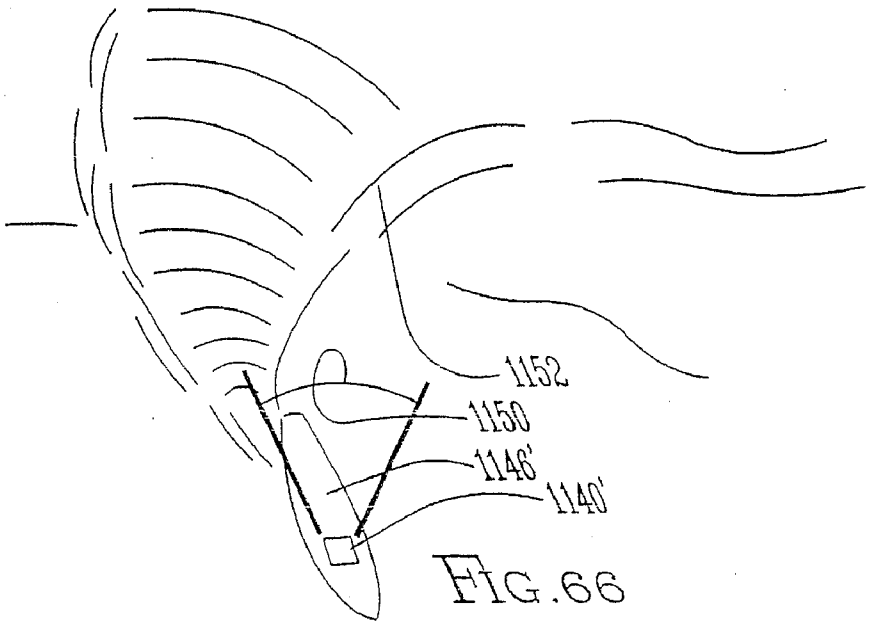


FIG. 66

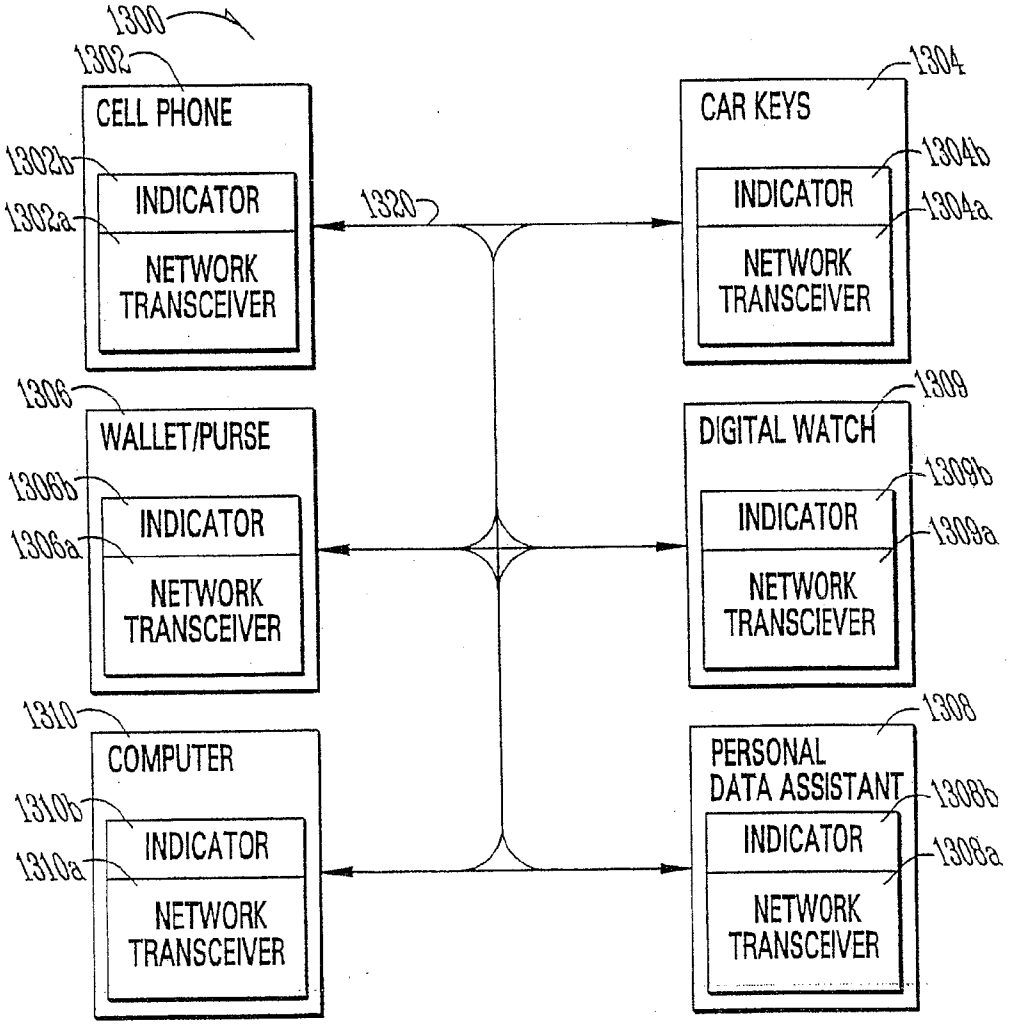

1300
1302
CELL PHONE
1302b
INDICATOR
1302a
NETWORK TRANSCEIVER
1320
1304
CAR KEYS
1304b
INDICATOR
1304a
NETWORK TRANSCEIVER
1306
WALLET/PURSE
1306b
INDICATOR
1306a
NETWORK TRANSCEIVER
1309
DIGITAL WATCH
1309b
INDICATOR
1309a
NETWORK TRANSCIEVER
1310
COMPUTER
1310b
INDICATOR
1310a
NETWORK TRANSCEIVER
1308
PERSONAL DATA ASSISTANT
1308b
INDICATOR
1308a
NETWORK TRANSCEIVER

FIG.67

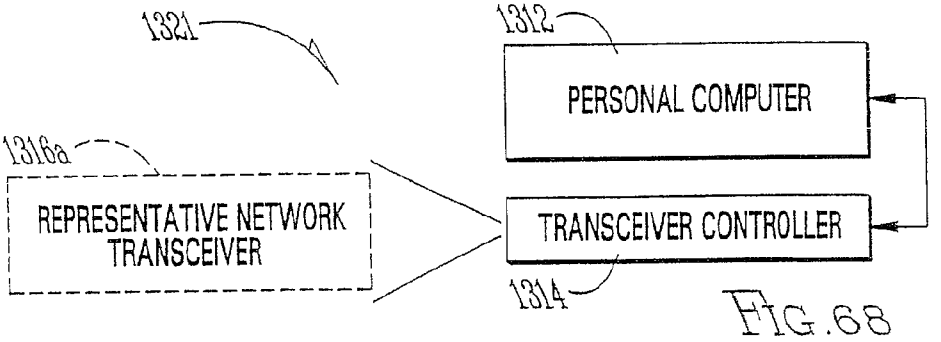

1321
1312
PERSONAL COMPUTER
1316a
REPRESENTATIVE NETWORK TRANSCEIVER
TRANSCEIVER CONTROLLER
1314

FIG.68

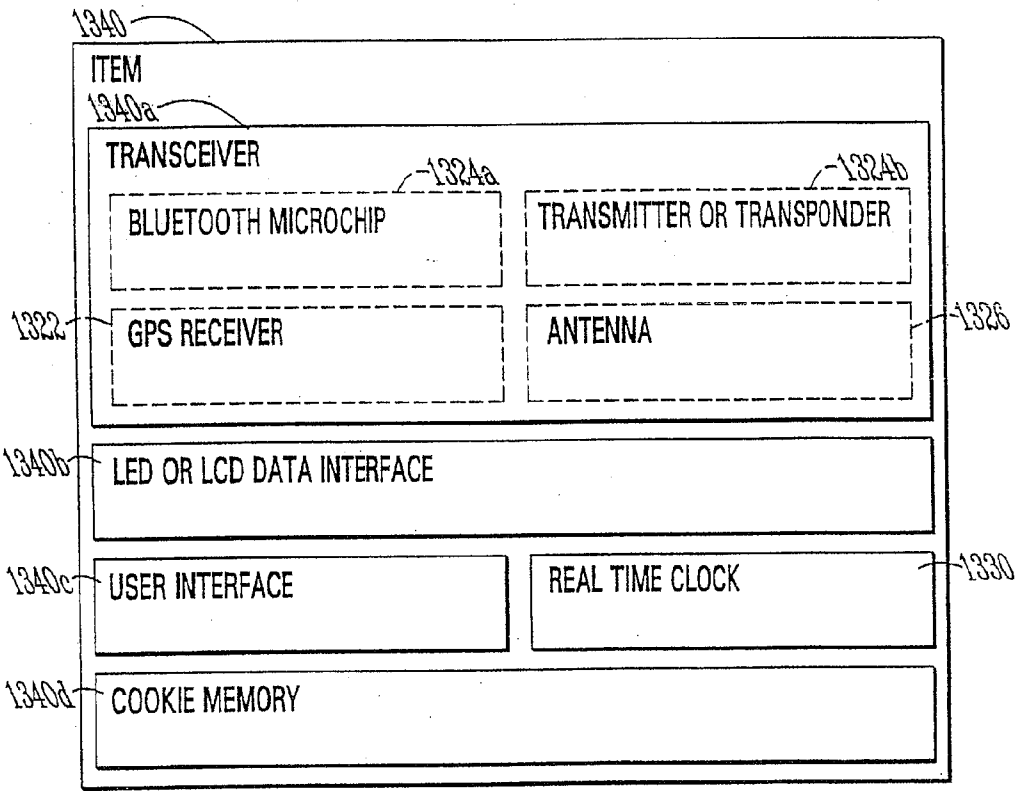

1340
ITEM
1340a
TRANSCEIVER
1324a
BLUETOOTH MICROCHIP
1324b
TRANSMITTER OR TRANSPONDER
1322
GPS RECEIVER
ANTENNA
1326
1340b
LED OR LCD DATA INTERFACE
1340c
USER INTERFACE
REAL TIME CLOCK
1330
1340d
COOKIE MEMORY

FIG.69

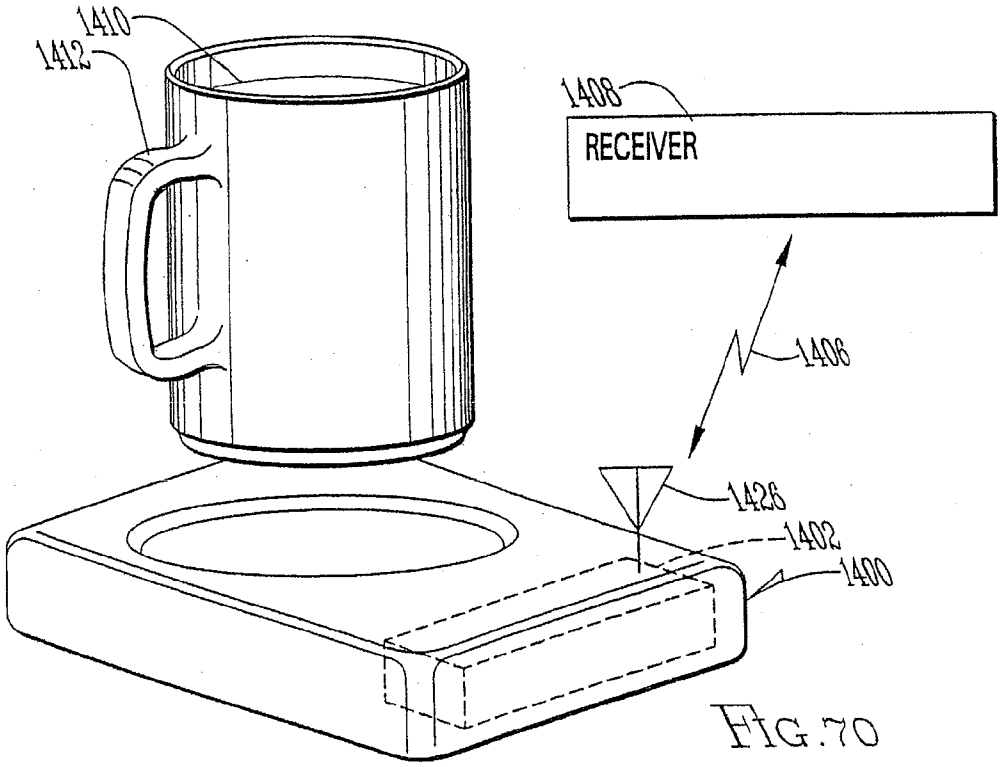

1410
1412
1408
RECEIVER
1406
1426
1402
1400

FIG. 70

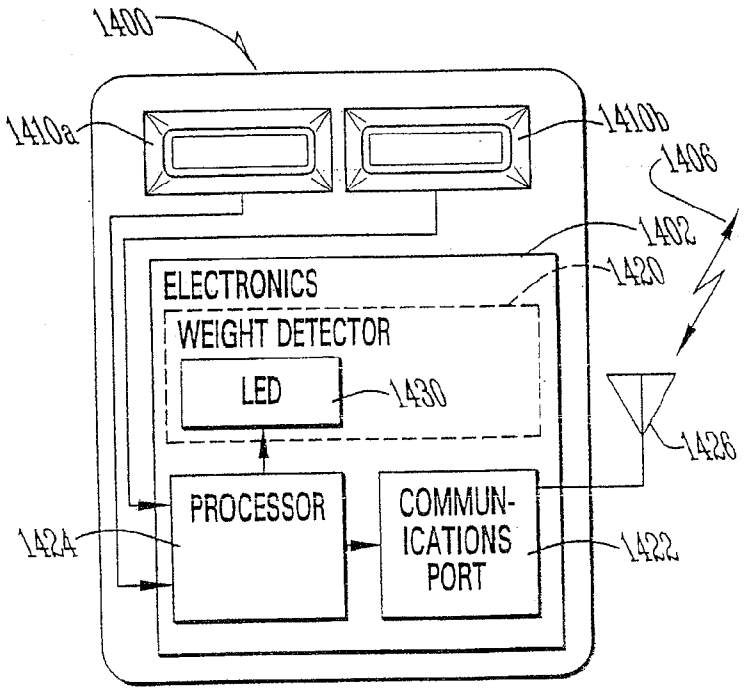

1400
1410a
1410b
1406
1402
1420
ELECTRONICS
WEIGHT DETECTOR
LED
1430
1426
PROCESSOR
COMMUN-
ICATIONS
PORT
1424
1422

FIG. 71

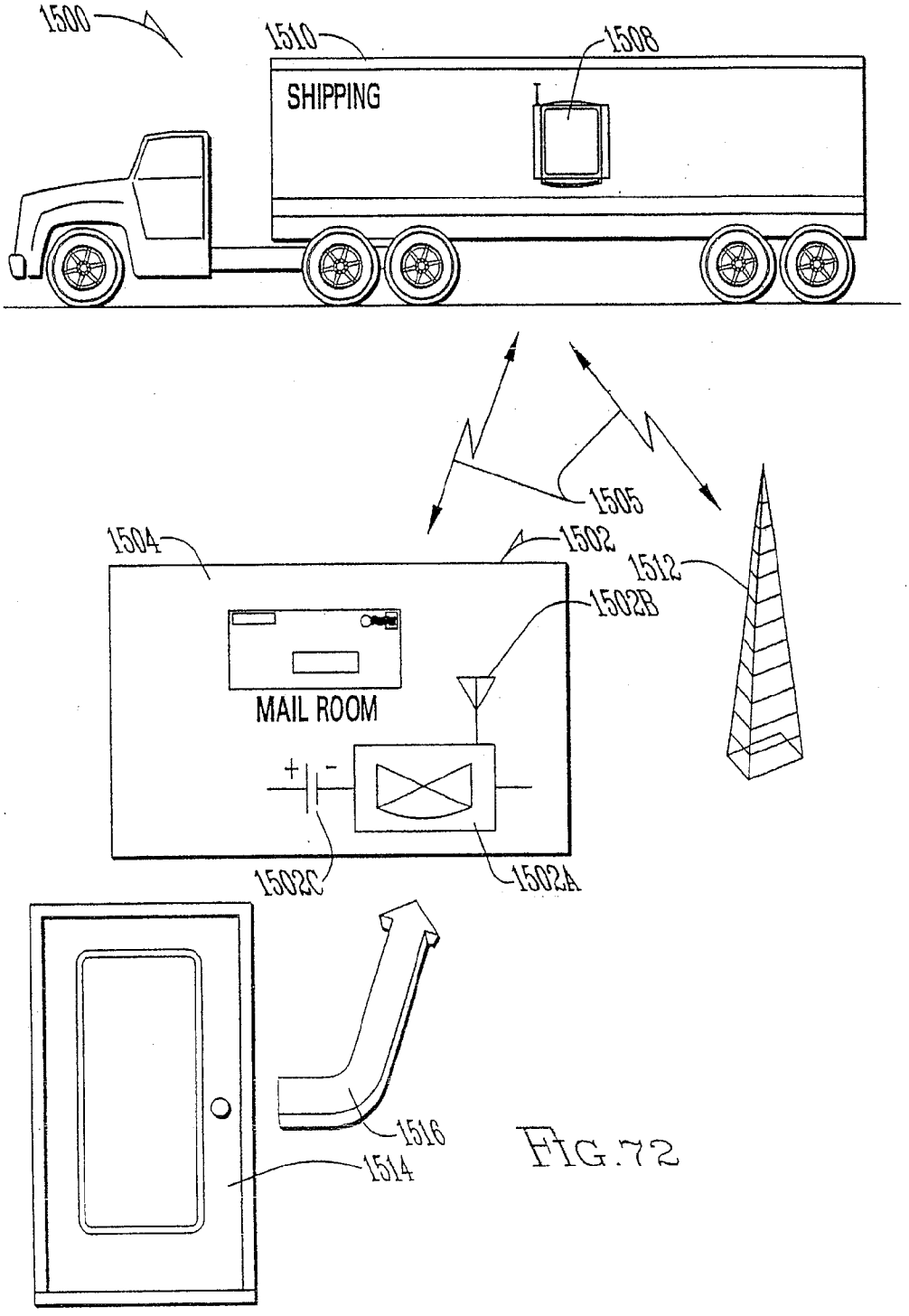

1500
1510
1508
SHIPPING
1505
1504
1502
1512
1502B
MAIL ROOM
+
-
1502C
1502A
1516
1514

FIG. 72

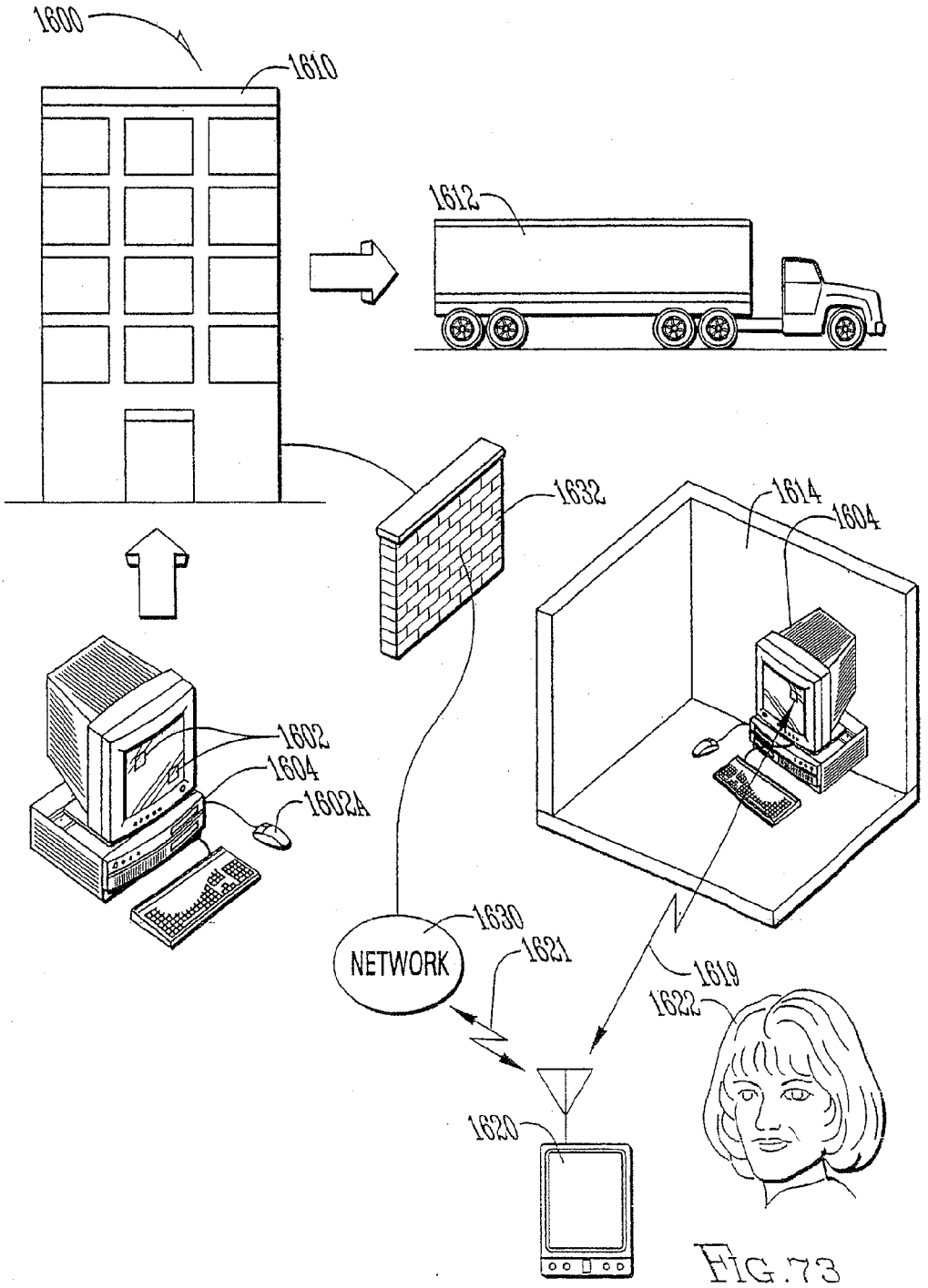

1600
1610
1612
1632
1614
1604
1602
1604
1602A
1630
NETWORK
1621
1619
1622
1620

FIG.73

MOVEMENT AND EVENT SYSTEMS AND ASSOCIATED METHODS

RELATED APPLICATIONS

[0001] This application is a continuation of U.S. Ser. No. 10/297,270, filed Dec. 4, 2002, which is a National Stage Entry of Patent Cooperation Treaty Application No. PCT/US01/51620, filed Dec. 17, 2001, which claims priority to U.S. Provisional Application Nos. 60/256,069, filed Dec. 15, 2000; 60/257,386, filed Dec. 22, 2000; U.S. 60/259,271, filed Dec. 29, 2000; 60/261,359, filed Jan. 13, 2001; 60/285,032, filed Apr. 19, 2001, and 60/323,601, filed Sep. 20, 2001. Each of the aforementioned applications is expressly incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The invention relates to sensing systems monitoring applications in sports, shipping, training, medicine, fitness, wellness and industrial production. The invention specifically relates to sensing and reporting events associated with movement, environmental factors such as temperature, health functions, fitness effects, and changing conditions.

BACKGROUND

[0003] The movement of objects and persons occurs continuously but is hardly quantified. Rather, typically only the result of the movement is known (i.e., object X moved from point A to point B; or, person Y ran to the store). Advances in technology have provided some quantification of movement. For example, GPS products now assist in determining the location of golf carts, vehicles and persons.

[0004] However, the detail of movement, minute to minute, second to second, is still not generally determinable in the prior art. For example, the movement of tangible objects typically involves (a) the shipment or carrying of goods and (b) electromechanical or motorized apparatus (e.g., planes, trains, automobiles, robots). The exact movements of such objects, and the conditions that they are subjected to, from point to point, are only qualitatively known. By way of example, a package is moved from location to location through delivery services like FEDERAL EXPRESS or UPS; however what occurred during transportation, and what transpired to the package, is anyone's guess.

[0005] Occasionally, an object within the package is broken, indicating that the package experienced excessive abuse; but whose fault it is, or how or when it happened, are not known. What environments the package experienced is also not readily known.

[0006] The movement of persons, on the other hand, typically involves human-powered transportation, e.g., facilitated by biking, a wheelchair, or a motorized vehicle, e.g., a car. Body movement involved in transportation is subjected to many forces, some of which are dangerous. But the prior art does not provide for this knowledge; there is no effective way, currently, to efficiently quantify human movement. In sports, physical fitness, and training, precise information about movement would assist in many ways. By way of example, how effective a hand strike is in karate or boxing is, today, only qualitatively known. Quantitative feedback would be beneficial.

[0007] It is, accordingly, one feature of the invention to provide systems and methods addressing the afore-mentioned difficulties. A further feature of the invention is to provide methods and devices to quantify movement in a number of applications. Another feature of the invention is to monitor and report meaningful environment information such as temperature and humidity. These and other features will be apparent in the description that follows.

SUMMARY OF THE INVENTION

Movement Monitoring Devices

[0008] In one aspect, the invention provides a movement monitor device ("MMD") including an adhesive strip, a processor, a detector, and a communications port. In another aspect, two or more of the processor, port and detector are combined in a single application specific integrated circuit ("ASIC"). In one aspect the detector is an accelerometer, and preferably an accelerometer embedded into silicon within the ASIC. In other aspects, the detector is one of a strain gauge, force-sensing resistor, and piezoelectric strip. In still another aspect, the MMD includes a battery. In the preferred aspect of the invention, the MMD and battery are packaged in a protective wrapper. Preferably, the battery is packaged with the MMD in such a way that it does not "power" the MMD until the wrapper is removed. Preferably, the MMD includes a real time clock so that the MMD tags "events" (as hereinafter defined) with time and/or date information.

[0009] In yet another aspect, the MMD with adhesive strip collectively take a form similar to an adhesive bandage. More particularly, the adhesive strip of the invention is preferably like or similar to the adhesive of the adhesive bandage; and the processor (or protective wrapper) is embedded with the strip much the way the cotton is with the adhesive bandage. Preferably, a soft material (e.g., cotton or cloth) is included to surround the processor so as to (a) soften contact of rigid MMD components with a person and/or (b) protect the processor (and/or other components of the MMD). In still another aspect, the battery is also coupled with the soft material. In still another aspect, the processor and other elements of the MMD are combined into a single system-on-chip integrated circuit. A protective cover may surround the chip to protect the MMD from breakage.

[0010] In one aspect, one MMD of the invention takes a form similar to a smart label, with an adhesive substantially disposed with the label, e.g., on one side of the label. The adhesive strip of this MMD includes all or part of the back of the label with adhesive or glue permitting attachment of the label to other objects (or to a person).

[0011] In still another aspect, the MMD of the invention takes the form of a rigid monolithic that attaches to objects through one of known techniques. In this aspect, the device has a processor, communications port, and detector. A battery is typically included with the MMD. The MMD is attached to objects or persons by one of several techniques, including by glue or mechanical attachment (e.g., a pin or clip). An MMD of this aspect can for example exist in the form of a credit card, wherein the communications port is either a contact transponder or a contactless transponder. The MMD of one aspect includes a magnetic element that facilitates easily attaching the MMD to metal objects.

[0012] In operation, the MMD of the invention is typically interrogated by an interrogation device ("ID"). The MMD is

responsive to the ID to communicate information within the MMD and, preferably, over secure communications protocols. By way of example, one MMD of the invention releases internal data only to an ID with the correct passwords and/or data protocols. The ID can take many forms, including a cell phone or other electronic device (e.g., a MP3 player, pager, watch, or PDA) providing communications with the MMD transmitter.

[0013] However, in another aspect, the MMD communicates externally to a remote receiver ("RR"). The RR listens for data from the MMD and collects that data for subsequent relay or use. In one aspect, the MMD's communications port is a one-way transmitter. Preferably, the MMD communicates data from the MMD to the RR either (a) upon the occurrence of an "event" or (b) in repeated time intervals, e.g., once every ten minutes. Alternatively, the MMD's communication port is a transceiver that handshakes with the RR to communicate data from the MMD to the RR. Accordingly, the MMD responds to data requests from the RR, in this aspect. In still another aspect, the RR radiates the MMD with transponder frequencies; and the MMD "reflects" movement data to the RR.

[0014] Accordingly, the communications port of one aspect is a transponder responsive to one or more frequencies to relay data back to an ID. By way of example, these frequencies can be one of 125 kHz and 13.56 MHz, the frequencies common with "contactless" RFID tags known in the art. In other aspects, communications frequencies are used with emission power and frequencies that fall within the permissible "unlicensed" emission spectrum of part 15 of FCC regulations, Title 47 of the Code of Federal Regulations. In particular, one desirable feature of the invention is to emit low power, to conserve battery power and to facilitate use of the MMD in various environments; and therefore an ID is placed close to the MMD to read the data. In other words, in one aspect, wireless communications from the MMD to the ID occurs over a short distance of a fraction of an inch to no more than a few feet. By way of example, as described herein, one ID of the invention takes the form of a cell phone, which communicates with the MMD via one or more secure communications techniques. Data acquired from the MMD is then communicated through cellular networks, if desired, to relay MMD data to end-users.

[0015] Or, in another aspect, the ID has a larger antenna to pick up weak transmission signals from an MMD at further distances separation.

[0016] In another aspect, the communications port is an infrared communications port. Such a port, in one aspect, communicates with the cell phone in secure communication protocols. In other aspects, an ID communicates with the infrared port to obtain the data within the MMD.

[0017] In yet another aspect, the communications port includes a transceiver. The MMD listens for interrogating signals from the RR and, in turn, relays movement "event" data from the MMD to the RR. Alternatively, the MMD relays movement "event" data at set time intervals or when the MMD accumulates data close to an internal storage limit. In one aspect, thereby, the MMD include internal memory; and the MMD stores one or more "event" data, preferably with time-tag information, in the memory. When the memory is nearly full, the MMD transmits the stored data wirelessly to a RR.

[0018] Alternatively, stored data is transmitted to an IR when interrogated. In a third alternative, the MMD transmits stored data at set intervals, e.g., once per ½ hour or once per hour, to relay stored data to a RR. Other transmission protocols can be used without departing from the scope of the invention.

[0019] In still another aspect, data from the MMD is relayed to an ID through "contact" communication between the ID and the communications port. In one aspect, the MMD includes a small conductive plate (e.g., a gold plate) that contacts with the ID to facilitate data transfer. Smart cards from the manufacturer GEMPLUS may be used in such aspects of the invention.

[0020] In one aspect, the MMD includes a printed circuit board "PCB"). A battery—e.g., a 2032 or 1025 Lithium coin cell—is also included, in another aspect of the invention. To make the device small, the PCB preferably has multilayers—and two of the internal layers have a substantial area of conducting material forming two terminals for the battery. Specifically, the PCB is pried apart at one edge, between the terminals, and the battery is inserted within the PCB making contact and providing voltage to the device. This advantageously removes then need for a separate and weighty battery holder.

[0021] In another aspect, the PCB has first and second terminals on either side of the PCB, and a first side of the battery couples to the first terminal, while a clip connects the second side of the battery to the second terminal, making the powered connection. This aspect advantageously removes the need for a separate and weighty battery holder.

[0022] In still another aspect, a terminal is imprinted on one side of the PCB, and a first side of the battery couples to that terminal. A conductive force terminal connects to the PCB and the second side of the battery, forming a circuit between the battery and the PCB.

[0023] By way of background for transponder technology, the following U.S. patents are incorporated herein by reference: U.S. Pat. No. 6,091,342 and U.S. Pat. No. 5,541,604.

[0024] By way of background for smart card and smart tag technology, the following U.S. patents are incorporated herein by reference: U.S. Pat. No. 6,151,647; U.S. Pat. No. 5,901,303. U.S. Pat. No. 5,767,503; U.S. Pat. No. 5,690,773; U.S. Pat. No. 5,671,525; U.S. Pat. No. 6,043,747; U.S. Pat. No. 5,977,877; and U.S. Pat. No. 5,745,037.

[0025] By way of background for adhesive bandages, the following U.S. patents are incorporated herein by reference: U.S. Pat. No. 5,045,035; U.S. Pat. No. 5,947,917; U.S. Pat. No. 5,633,070; U.S. Pat. No. 4,812,541; and U.S. Pat. No. 3,612,265.

[0026] By way of background for pressure and altitude sensing, the following U.S. patents are incorporated herein by reference: U.S. Pat. No. 5,178,016; U.S. Pat. No. 4,317,126; U.S. Pat. No. 4,813,272; U.S. Pat. No. 4,911,016; U.S. Pat. No. 4,694,694; U.S. Pat. No. 4,911,016; U.S. Pat. No. 3,958,459.

[0027] By way of background for rotation sensors, the following U.S. patents are incorporated herein by reference: U.S. Pat. No. 5,442,221; U.S. Pat. No. 6,089,098; and U.S. Pat. No. 5,339,699. Magnetorestrictive elements are further

discussed in the following patents, also incorporated herein by reference: U.S. Pat. No. 5,983,724 and U.S. Pat. No. 5,621,316.

[0028] In accord with one aspect of the invention, the communications port is one of a transponder (including a smart tag or RFID tag), transceiver, or one-way transmitter. In other aspects, data from the MMD is communicated off-board (i.e., away from the MMD) by one of several techniques, including: streaming the data continuously off-board to get a real-time signature of data experienced by the MMD; transmission triggered by the occurrence of an "event" as defined herein; transmission triggered by interrogation, such as interrogation by an ID with a transponder; transmission staggered in "bursts" or "batches," such as when internal storage memory is full; and transmission at predetermined intervals of time, such as every minute or hour.

[0029] In one preferred aspect of the invention, the above-described MMDs are packaged like an adhesive bandage. Specifically, in one aspect, one or more protective strips rest over the adhesive portion of the device so as to protect the adhesive until the protective strips are removed. The strips are substantially stick-free so that they are easily removed from the adhesive prior to use. In another aspect, a "wrapper" is used to surround the MMD; the wrapper for example similar to wrappers of adhesive bandages. In accord with one preferred aspect, the battery electrically couples with the electronics of the MMD when the wrapper is opened and/or when the protective strips are removed. In this way, the MMD can be "single use" with the battery energizing the electronics only when the MMD is opened and applied to an object or person; the battery power being conserved prior to use by a decoupling element associated with the wrapper or protective strips. Those skilled in the art should appreciate that other techniques can be used without departing from the scope of the invention.

[0030] The MMDs of the invention are preferably used to detect movement "metrics," including one or more of airtime, speed, power, impact, drop distance, jarring and spin. WO9854581A2 is incorporated herein by reference as background to measuring speed, drop distance, jarring, impact and airtime. U.S. Pat. Nos. 6,157,898, 6,151,563, 6,148,271 and 6,073,086, relating to spin and speed measurement, are incorporated herein by reference. In one aspect, the detector and processor of the MMD collectively detect and determine "airtime," such as set forth in U.S. Pat. No. 5,960,380, incorporated herein by reference. By way of example, one detector is an accelerometer, and the processor analyzes acceleration data from the accelerometer as a spectrum of information and then detects the absence of acceleration data (typically in one or more frequency bands of the spectrum of information) to determine airtime. In another aspect, the detector and processor of the MMD collectively detect and determine drop distance. By way of example, one drop distance detector is a pressure sensor, and the processor analyzes data from the pressure sensor to determine changes in pressure indicating altitude variations (a) over a preselected time interval, (b) between a maximum and minimum altitude to assess overall vertical travel, and/or (c) between local minimums and maximums to determine jump distance. By way of a further example, a drop distance detector is an accelerometer, and the processor analyzes data from the accelerometer to determine distance, or changes in distance, in a direction perpendicular to ground, or perpendicular to forward movement, to determine drop distance.

[0031] In one preferred aspect, the accelerometer has "free fall" capability (e.g., with near zero hertz detection) to determine drop distance (or other metrics described herein) based, at least on part, on free fall physics. This aspect is for example useful in detecting dropping events of packages in shipment.

[0032] In another aspect, the detector and processor of the MMD collectively detect and determine spin. By way of example, one detector is a magnetorestrictive element ("MRE"), and the processor analyzes data from the MRE to determine spin (rotation per second, number of degrees, and/or degrees per second) based upon the MRE's rotation through the earth's magnetic fields. By way of a further example, another detector is a rotational accelerometer, and the processor analyzes data from the rotational accelerometer to determine spin. In another aspect, the detector and processor of the MMD collectively detect and determine jarring, power and/or impact. By way of example, one detector is an accelerometer, and the processor analyzes data from the accelerometer to determine the jarring, impact and/or power. As used herein, jarring is a function a higher power of velocity in a direction approximately perpendicular to forward movement (typically in a direction perpendicular to ground, a road, or a floor). As used herein, power is an integral of filtered (and preferably rectified) acceleration over some preselected time interval, typically greater than about ½ second. As used herein, impact is an integral of filtered (and preferably rectified) acceleration over a time interval less than about ½ second. Impact is often defined as immediately following an "airtime" event (i.e., the "thump" of a landing).

[0033] In one aspect, the MMD continuously relays a movement metric by continuous transmission of data from the detector to a RR. In this way, an MMD attached to a person may beneficially track movement, in real time, of that person by recombination of the movement metrics at a remote computer. In one aspect, multiple MMDs attached to a person quantify movement of a plurality of body parts or movements, for example to assist in athletic training (e.g., for boxing or karate). In another aspect, multiple MMDs attached to an object quantify movement of a plurality of object parts or movements, for example to monitor or assess different components or sensitive parts of an object. For example, multiple MMDs can be attached to an expensive medical device to monitor various critical components during shipment; when the device arrives at the customer, these MMDs are interrogated to determine whether any of the critical components experienced undesirable conditions—e.g., a high impact or temperature or humidity.

[0034] By way of background for moisture sensing, the following U.S. patents are incorporated herein by reference: U.S. Pat. No. 5,486,815; U.S. Pat. No. 5,546,974; and U.S. Pat. No. 6,078,056.

[0035] By way of background for humidity sensing, the following U.S. patents are incorporated herein by reference: U.S. Pat. No. 5,608,374; U.S. Pat. No. 5,546,974; and U.S. Pat. No. 6,078,056.

[0036] By way of background for temperature sensing, the following U.S. patents are incorporated herein by reference:

U.S. Pat. No. 6,074,089; U.S. Pat. No. 4,210,024; U.S. Pat. No. 4,516,865; U.S. Pat. No. 5,088,836; and U.S. Pat. No. 4,955,980.

[0037] In accord with further aspects of the invention, the MMD measures one or more of the following environmental metrics: temperature, humidity, moisture, altitude and pressure. These environmental metrics are combined into the MMD with a detector that facilitates the monitoring of movement metrics such as described above. For temperature, the detector of one aspect is a temperature sensor such as a thermocouple or thermister. For altitude, the detector of one aspect is an altimeter. For pressure, the detector of one aspect is a pressure sensor such as a surface mount semiconductor element made by SENSYM.

[0038] In accord with one aspect, an MMD monitors one or more movement metrics for "events," where data is acquired that exceeds some predetermined threshold or value. By way of example, in one aspect the detector is a triaxial accelerometer and the processor coupled to the accelerometer seeks to determine impact events that exceed a threshold, in any or all of three axes. In another aspect, a single axis accelerometer is used as the detector and a single axis is monitored for an impact event. In another example, the detector and processor collectively monitor and detect spin events, where for example it is determined that the device rotated more than 360 degrees in ½ second or less (an exemplary "event" threshold). In still another aspect, the detector is a force detector and the processor and detector collectively determine a change of weight of an object resting on the MMD over some preselected time period. In one specific object, the invention provides for an MMD to monitor human weight to report that weight, on demand, to individuals. Preferably, such an MMD is in a shoe.

[0039] In one aspect, the movement metric of rotation is measured by an MMD with a Hall effect detector. Specifically, one aspect of the Hall effect detector with an MMD of the invention monitors when the MMD is inverted. In one other aspect, the Hall effect detector is used with the processor to determine when an object is inverted or rotated through about 180 degrees. An "event" detected by this aspect can for example be one or more inversions of the MMD of about 180 degrees.

[0040] In still another aspect, the MMD has an MRE as the detector, and the MMD measures spin or rotation experienced by the MRE.

[0041] In one aspect, a plurality of MMDs are collated and packaged in a single container, preferably similar to the cans or boxes containing adhesive bandages. Preferably, in another aspect, MMDs of the invention are similarly programmed within the container. By way of example, one container carries 100 MMDs that each respond to an event of "10 g's." In another example, another container carries 200 MMDs that respond to an event of "100 g's." Packages of MMDs can be in any suitable number N greater than or equal to two; typically however MMDs are packaged together in groups of 50, 100, 150, 200, 250, 500 or 1000. A variety pack of MMDs are also provided, in another aspect, for example containing ten 5 g MMDs, ten 10 g MMDs, ten 15 g MMDs, ten 20 g MMDs, ten 25 g MMDs, ten 30 g MMDs, ten 35 g MMDs, ten 40 g MMDs, ten 45 g MMDs, and ten 50 g MMDs. Another variety package can for example include groups of MMDs spaced at 1 g or 10 g intervals.

[0042] In one preferred aspect, the MMD of the invention includes internal memory. Preferably the memory is within the processor or ASIC. Event data is stored in the memory, in accord with one aspect, until transmitted off-board. In this way, the MMD monitors and stores event data (e.g., an "event" occurrence where the MMD experiences 10 g's). Preferably, the event data is time tagged with data from a real-time clock; and thus a real time clock is included with the MMD (or made integral with the processor or ASIC). A crystal or other clocking mechanism may also be used.

[0043] In one aspect, the MMD is programmed with a time at the initial time of use (i.e., when the device is powered). In one other aspect, the MMD is packaged with power so that real time clock data is available when the product is used. In this aspect, therefore, a container of MMDs will typically have a "stale" date when the MMD's battery power is no longer usable. In one aspect, the MMD has a replaceable battery port so that a user can replace the battery.

[0044] The invention has certain advantages. An MMD of the invention can practically attach to almost anything to obtain movement information. By way of example, an MMD of the invention can attach to furniture to monitor shipping of furniture. If the furniture were dropped, an impact event occurs and is recorded within the MMD, or transmitted wirelessly, with an associated time tag. When the furniture is damaged prior to delivery, a reader (e.g., an ID) reads the MMD to determine when the damage occurred—leading to the responsible party who may then have to pay for the damage.

[0045] In a further example, if furniture is rated to "10 g's", an MMD (programmed and enabled to detect 10 g events) is attached to the furniture when leaving the factory, so that any 10 g event before delivery is recorded and time-stamped, again leading to a responsible party. Similarly, in other aspects, devices of the invention are attached to packages (e.g., FED EX or UPS shipments) to monitor handling. By way of example, fragile objects may be rated to 5 g; and an appropriately programmed MMD of the invention is attached to the shipment to record and time-tag 5 g events. In another aspect, fragile objects that should be maintained at a particular orientation (i.e., packages shipped within "this Side Up" instructions) are monitored by an MMD detecting inversions of about 180 degrees, such as through a Hall Effect detector.

[0046] In one aspect, the MMD includes a tamper proof detector that ensures the MMD is not removed or tampered with once applied to an object or person, until an authorized person removes the MMD. In one aspect the tamper proof detector is a piezoelectric strip coupled into or with the adhesive strip. Once the MMD is powered and applied to an object or person, a quiescent period ensues and the MMD continually monitors the tamper proof detector (in addition to the event detector) to record tampering activity. In the case of the piezoelectric strip, removal of the MMD from a person or object after the quiescent period provides a relatively large voltage spike, indicating removal. That spike is recorded and time stamped. If there are more than one such records (i.e., one record represents the final removal), then tampering may have occurred. Since date and time are tagged with the event data, the tamper time is determined, leading to identify the tampering person (i.e., the person responsible for the object when the tamper time was tagged).

[0047] In one aspect, the invention provides an ID in the form of a cell phone. Nearly one in three Americans use a cell phone. According to the teachings of the invention, data movement "metrics" are read from an MMD through the cell phone. Preferably, data communicated from the MMD to the cell phone is made only through secure communications protocols so that only authorized cell phones can access the MMD. In one specific aspect, MMD events are communicated to a cell phone or cellular network, and from that point are relayed to persons or additional computer networks for use at a remote location.

[0048] Miniature tension or compression load cells are used in certain aspects of the invention. By way of example, an MMD incorporating such cells are used in measuring and monitoring tension and/or compression between about fifty grams and 1000 lbs, depending upon the application. In one aspect, the MMD generates a warning signal when the load cell exceeds a preselected threshold.

[0049] In accord with the invention, several advantages are apparent. The following lists some of the non-limiting movement events monitored and captured by select MMDs of the invention, in accord to varied aspects of the invention:

[0050] impact or "g's" experienced by the MMD that exceed a predetermined threshold, e.g., 10 or 50 g's;

[0051] accumulated or integrated rectified acceleration experienced by the MMD over a predetermined time interval;

[0052] rotations experienced by the MMD in increments of 90 degrees, such as 90, 180, 270, 360 degrees, or multiples thereof;

[0053] frequency-filtered, rectified, and low-pass filtered acceleration detecting impact events, by the MMD, exceeding thresholds such as 5, 10, 20, 25, 50 and 100 g's, preferably after an airtime event;

[0054] rotational velocities experienced by the MMD exceeding some preselected "degrees per second" or "revolutions per minute" threshold;

[0055] airtime events experienced by the MMD exceeding ¼, ⅓, or ½ second, or multiples thereof;

[0056] speed events experienced by the MMD exceeding miles per hour thresholds of 10, 20, 30, 40, 50, 60 mph (those skilled in the art should appreciate that other "speed" units can be used, e.g., km/hour, m/s or cm/s);

[0057] drop distance events experienced by the MMD exceeding set distances such as 1, 2, 3, 4, 5, 10, 20, 50 and 100 feet (or inches, centimeters or meters);

[0058] altitude variation events between maximum and minimum values over a daily time interval; and

[0059] jerk variations proportional to V^n or $\partial^n V/\partial^n t$, where V is velocity in a direction perpendicular to movement along a surface (e.g., ground), where n is some integer greater than or equal to 2, and where t is time.

[0060] The above movement events may be combined for a variety of metrics useful to users of the invention. For example, in one aspect, altitude variations are used to accurately gauge caloric burn through the variations. Such information is particularly useful for mountain bikers and in mountain sports.

[0061] The invention of one aspect provides a quantizing accelerometer that detects one or more specific g-levels in a manner particularly useful as a detector in an MMD of the invention.

[0062] There are thus several applications of the invention, including the monitoring of movement for people, patients, packages, athletes, competitors, shipments, furniture, athletes in training (e.g., karate), and industrial robotics. The benefits derived by such monitoring can be used by insurance companies and manufacturers, which, for example, insure shipments and packages for safe delivery to purchasers. Media broadcasters, including Internet content providers, can also benefit by augmenting information associated with a sporting event (e.g., airtime of a snowboarder communicated in real time to the Internet, impact of a football or soccer ball during a game, boxing glove strike force during a fight, tennis racquet strike force during a match). The MMD of the invention is small, and may be attached to practically any object—so ease of use is clearly another advantage. By way of example, an MMD can be mounted to the helmet or body armor of each football player or motocross competitor to monitor movement and jerk of the athlete. In such applications, data from the MMD preferably transmits event data in real time to a RR in the form of a network, so that MMD data associated with each competitor is available for broadcast to a scoreboard, TV or the Internet. Other advantages should be apparent in the description within.

Event Monitoring Devices

[0063] The invention also provides certain sensors and devices used to monitor and report temperature, humidity, chemicals, heart rate, pulse, pressure, stress, weight, environmental factors and hazardous conditions.

[0064] In one aspect, the invention provides a event monitor device ("EMD") including an adhesive strip, a processor, a detector, and a communications port. In another aspect, two or more of the processor, port and detector are combined in a single application specific integrated circuit ("ASIC"). In one aspect the detector is an humidity or temperature sensor, and preferably that detector is embedded into silicon within the ASIC. In other aspects, the detector is one of an EKG sensing device, weight-sensing detector, and chemical detector. In still another aspect, the EMD includes a battery. In the preferred aspect of the invention, the EMD and battery are packaged in a protective wrapper. Preferably, the battery is packaged with the EMD in such a way that it does not "power" the EMD until the wrapper is removed. Preferably, the EMD includes a real time clock so that the EMD tags "events" with time and/or date information.

[0065] In yet another aspect, the EMD with adhesive strip collectively take a form similar to an adhesive bandage. More particularly, the adhesive strip of the invention is preferably like or similar to the adhesive of the adhesive bandage; and the processor is embedded with the strip much the way the cotton is with the adhesive bandage. Preferably, a soft material (e.g., cotton or cloth) is included to surround the processor so as to (a) soften contact of rigid EMD components with a person and/or (b) protect the processor

(and/or other components of the EMD). In still another aspect, the battery is also coupled with the soft material. In still another aspect, the processor and other elements of the EMD are combined into a single system-on-chip integrated circuit. A protective cover may surround the chip to protect the EMD from breakage.

[0066] In one aspect, one EMD of the invention takes a form similar to a smart label, with an adhesive substantially disposed with the label, e.g., on one side of the label. The adhesive strip of this EMD includes all or part of the back of the label with adhesive or glue permitting attachment of the label to other objects (or to a person).

[0067] In still another aspect, the EMD of the invention takes the form of a rigid monolithic that attaches to objects through one of known techniques. In this aspect, the device has a processor, communications port, and detector. A battery is typically included with the EMD. The EMD is attached to objects or persons by one of several techniques, including by glue or mechanical attachment (e.g., a pin or clip). An EMD of this aspect can for example exist in the form of a credit card, wherein the communications port is either a contact transponder or a contactless transponder. The EMD of one aspect includes a magnetic element that facilitates easily attaching the EMD to metal objects.

[0068] In operation, the EMD of the invention is typically interrogated by an ID. The EMD is responsive to the ID to communicate information within the EMD and, preferably, over secure communications protocols. By way of example, one EMD of the invention releases internal data only to an ID with the correct passwords and/or data protocols. The ID can take many forms, including a cell phone or other electronic device (e.g., a MP3 player, pager, watch, or PDA) providing communications with the EMD transmitter.

[0069] However, in another aspect, the EMD communicates externally to a RR. The RR listens for data from the EMD and collects that data for subsequent relay or use. In one aspect, the EMD's communications port is a one-way transmitter. Preferably, the EMD communicates data from the EMD to the RR either (a) upon the occurrence of an "event" or (b) in repeated time intervals, e.g., once every minute or more. Alternatively, the EMD's communication port is a transceiver that handshakes with the RR to communicate data from the EMD to the RR. Accordingly, the EMD responds to data requests from the RR, in this aspect. In still another aspect, the RR radiates the EMD with transponder frequencies; and the EMD "reflects" the data to the RR.

[0070] Accordingly, the communications port of one EMD is a transponder responsive to one or more frequencies to relay data back to an ID. By way of example, these frequencies can be one of 125 kHz and 13.56 MHz, the frequencies common with "contactless" RFID tags known in the art. In other aspects, communications frequencies are used with emission power and frequencies that fall within the pennissible "unlicensed" emission spectrum of part 15 of FCC regulations, Title 47 of the Code of Federal Regulations. In particular, one desirable feature of the invention is to emit low power, to conserve battery power and to facilitate use of the EMD in various environments; and therefore an ID is placed close to the EMD to read the data. In other words, in one aspect, wireless communications from the EMD to the ID occurs over a short distance of a fraction of an inch to no more than a few feet. By way of example, as described herein, one ID of the invention takes the form of a cell phone, which communicates with the EMD via one or more secure communications techniques. Data acquired from the EMD is then communicated through cellular networks, if desired, to relay EMD data to end-users. Or, in another aspect, or sensitive or directional antenna is used to increase the distance to detect data of the EMD.

[0071] In another aspect, the communications port is an infrared communications port. Such a port, in one aspect, communicates with the cell phone in secure communication protocols. In other aspects, an ID communicates with the infrared port to obtain the data within the EMD.

[0072] In yet another aspect, the communications port includes a transceiver. The EMD listens for interrogating signals from the RR and, in turn, relays "event" data from the EMD to the RR. Alternatively, the EMD relays "event" data at set time intervals or when the EMD accumulates data close to an internal storage limit. In one aspect, thereby, the EMD include internal memory; and the EMD stores one or more "event" data, preferably with time-tag information, in the memory. When the memory is nearly full, the EMD transmits the stored data wirelessly to a RR. Alternatively, stored data is transmitted to an IR when interrogated. In a third alternative, the EMD transmits stored data at set intervals, e.g., once per ½ hour or once per hour, to relay stored data to a RR. Other transmission protocols can be used without departing from the scope of the invention.

[0073] In still another aspect, data from the EMD is relayed to an ID through "contact" communication between the ID and the communications port. In one aspect, the EMD includes a small conductive plate (e.g., a gold plate) that contacts with the ID to facilitate data transfer. Smart cards from the manufacturer GEMPLUS may be used in such aspects of the invention.

[0074] In one aspect, the EMD includes a printed circuit board "PCB"). A battery—e.g., a 2032 or 1025 Lithium coin cell—is also included, in another aspect of the invention. To make the device small, the PCB preferably has multilayers—and two of the internal layers have a substantial area of conducting material forming two terminals for the battery. Specifically, the PCB is pried apart at one edge, between the terminals, and the battery is inserted within the PCB making contact and providing voltage to the device. This advantageously removes then need for a separate and weighty battery holder. Flex circuit boards may also be used.

[0075] In another aspect, the PCB has first and second terminals on either side of the PCB, and a first side of the battery couples to the first terminal, while a clip connects the second side of the battery to the second terminal, making the powered connection. This aspect advantageously removes then need for a separate and weighty battery holder.

[0076] In still another aspect, a terminal is imprinted on one side of the PCB, and a first side of the battery couples to that terminal. A conductive force terminal connects to the PCB and the second side of the batter, forming a circuit between the battery and the PCB.

[0077] In accord with one aspect of the invention, the communications port is one of a transponder (including a smart tag or RFID tag), transceiver, or one-way transmitter. In other aspects, data from the EMD is communicated

off-board (i.e., away from the EMD) by one of several techniques, including: streaming the data continuously off-board to get a real-time signature of data experienced by the EMD; transmission triggered by the occurrence of an "event" as defined herein; transmission triggered by interrogation, such as interrogation by an ID with a transponder; transmission staggered in "bursts" or "batches," such as when internal storage memory is full; and transmission at predetermined intervals of time, such as every minute or hour.

[0078] In one preferred aspect of the invention, the above-described EMDs are packaged like an adhesive bandage. Specifically, in one aspect, one or more protective strips rest over the adhesive portion of the device so as to protect the adhesive until the protective strips are removed. The strips are substantially stick-free so that they are easily removed from the adhesive prior to use. In another aspect, a "wrapper" is used to surround the EMD; the wrapper being similar to existing wrappers of adhesive bandages. In accord with one preferred aspect, the battery electrically couples with the electronics of the EMD when the wrapper is opened and/or when the protective strips are removed. In this way, the EMD can be "single use" with the battery energizing the electronics only when the EMD is opened and applied to an object or person; the battery power being conserved prior to use by a decoupling element associated with the wrapper or protective strips. Those skilled in the art should appreciate that other techniques can be used without departing from the scope of the invention.

[0079] In one aspect, the EMD continuously relays an environmental metric (e.g., temperature, humidity, or chemical content) by continuous transmission of data from the detector to a RR. In this way, a EMD attached to a person or object may beneficially track conditions, in real time, of that person or object by recombination of the environmental metrics at a remote computer. In one aspect, multiple EMDs attached to a person or object quantify data for a plurality of locations, for example to monitor sub-parts of an object or person.

[0080] In accord with further aspects of the invention, the EMD measures one or more of the following environmental metrics: temperature, humidity, moisture, altitude and pressure. For temperature, the detector of one aspect is a temperature sensor such as a thermocouple or thermister. For altitude, the detector of one aspect is an altimeter. For pressure, the detector of one aspect is a pressure sensor such as a surface mount semiconductor element made by SENSYM.

[0081] In accord with one aspect, an EMD monitors one or more metrics for "events," where data is acquired that exceeds some predetermined threshold or value. By way of example, in one aspect the detector is a temperature sensor and the processor coupled to the temperature sensor seeks to determine temperature events that exceed a threshold. In another aspect, a humidity sensor is used as the detector and this sensor is monitored for a humidity event (e.g., did the EMD experience 98% humidity conditions). In another example, the detector and processor collectively monitor stress events, where for example it is determined that the EMD attached to a human senses increased heart rate of over 180 beats per minute (an exemplary "event" threshold). In still another aspect, the detector is a chemical (or pH) detector and the processor and detector collectively determine a change of chemical composition of an object connected with the EMD over some preselected time period.

[0082] In one aspect, a plurality of EMDs are collated and packaged in a single container, preferably similar to the cans or boxes containing adhesive bandages. Preferably, in another aspect, EMDs of the invention are similarly programmed within the container. By way of example, one container carries 100 EMDs that each respond to an event of "5 degrees" variation from some reference temperature. In another example, another container carries 200 EMDs that respond to an event of "90 degrees" change absolute. Temperature sensors may be programmed to determine actual temperatures, e.g., 65 degrees, or changes in temperature from some reference point, e.g., 10 degrees from reference.

[0083] Packages of EMDs can be in any suitable number N greater than or equal to two; typically however EMDs are packaged together in groups of 50, 100, 150, 200, 250, 500 or 1000.

[0084] In one preferred aspect, the EMD of the invention includes internal memory. Preferably the memory is within the processor or ASIC. Event data is stored in the memory, in accord with one aspect, until transmitted off-board. In this way, the EMD monitors and stores event data (e.g., an "event" occurrence where the EMD experiences 100 degree temperatures). Preferably, the event data is time tagged with data from a real-time clock; and thus a real time clock is included with the EMD (or made integral with the processor or ASIC). In one aspect, the EMD is programmed with a time at the initial time of use (i.e., when the device is powered). In one other aspect, the EMD is packaged with power so that real time clock data is available when the product is used. In this aspect, therefore, a container of EMDs will typically have a "stale" date when the EMD's battery power is no longer usable. In one aspect, the EMD has a replaceable battery port so that a user can replace the battery.

[0085] The invention has certain advantages. An EMD of the invention can practically attach to almost anything to obtain event information. By way of example, an EMD of the invention can attach to patients to track health and conditions in real time and with remote monitoring capability.

[0086] In one aspect, the EMD includes a tamper proof detector that ensures the EMD is not removed or tampered with once applied to an object or person, until an authorized person removes the EMD. In one aspect, the tamper proof detector is a piezoelectric strip coupled into or with the adhesive strip. Once the EMD is powered and applied to an object or person, a quiescent period ensues and the EMD continually monitors the tamper proof detector (in addition to the event detector) to record tampering activity. In the case of the piezoelectric strip, removal of the EMD from a person or object after the quiescent period provides a relatively large voltage spike, indicating removal. That spike is recorded and time stamped. If there are more than one such records (i.e., one record represents the final removal), then tampering may have occurred. Since date and time are tagged with the event data, the tamper time is determined, leading to identify the tampering person (i.e., the person responsible for the object when the tamper time was tagged).

[0087] In one aspect, the invention provides an ID in the form of a cell phone. Nearly one in three Americans use a cell phone. According to the teachings of the invention, data event "metrics" are read from an EMD through the cell phone. Preferably, data communicated from the EMD to the cell phone is made only through secure communications protocols so that only authorized cell phones can access the EMD. In one specific aspect, EMD events are communicated to a cell phone or cellular network, and from that point are relayed to persons or additional computer networks for use at a remote location.

[0088] In accord with the invention, several advantages are apparent. The following lists some of the non-limiting events monitored and captured by select EMDs of the invention, in accord to varied aspects of the invention:

[0089] absolute or relative temperatures;

[0090] heart rate or other fitness characteristics;

[0091] stress characteristics;

[0092] humidity or relative humidity; and

[0093] fitness or patient health characteristics.

[0094] The invention will next be described in connection with preferred embodiments. In addition to those described above, certain advantages should be apparent in the description which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0095] FIG. **1** shows a monitor device (e.g., an "MMD" or "EMD") and receiver (ID or RR) constructed according to the invention;

[0096] FIG. **1**A shows an alternative monitor device of the invention, and in data communication with a receiver via "contact" transponder technology;

[0097] FIG. **2** shows a front view of one monitor device of the invention and formed with an adhesive strip and padding to soften physical connection to persons or objects;

[0098] FIG. **2**A shows a cross-sectional top view of the monitor device and strip of FIG. **2**;

[0099] FIG. **2**B shows a cross-sectional top view of one monitor device of the invention integrated with (a) a battery and (b) protective non-stick strips over the adhesive strip, all enclosed within a protective wrapper;

[0100] FIG. **2**C shows a front view of the monitor device of FIG. **2**B, without a protective wrapper;

[0101] FIG. **2**D shows an alternative monitor device of the invention and integrated directly with the adhesive strip to ensure detector contact;

[0102] FIG. **2**E shows one monitor device of the invention used to detect and/or track heart rate, in accord with the invention;

[0103] FIG. **3** shows a cross-sectional view (not to scale) of one monitor device of the invention for integrating a battery with a printed circuit board;

[0104] FIG. **3**A is a cross-sectional top view of part of the monitor device of FIG. **3**;

[0105] FIG. **3**B shows an operational view of the monitor device of FIG. **3**, with a battery inserted between layers of the printed circuit board;

[0106] FIG. **3**C shows a cross-sectional view (not to scale) of one monitor device of the invention for integrating a battery with a printed circuit board;

[0107] FIG. **3**D shows an operational view of the monitor device of FIG. **3**C, with a battery attached to sides of the underlying printed circuit board;

[0108] FIG. **3**E shows an operational view of another monitor device of the invention, with a battery attached to one side of the underlying printed circuit board;

[0109] FIG. **3**F shows one battery attachment mechanism, including batteries, for use with a monitor device of the invention;

[0110] FIG. **3**G shows the mechanism of FIG. **3**F without the batteries;

[0111] FIGS. **4** and **4**A illustrate one technique for powering a monitor device, in accord with the invention;

[0112] FIGS. **5** and **5**A illustrate one monitor device integrated within a label, in accord with the invention;

[0113] FIG. **6** shows a monolithic monitor device constructed according to the invention for attachment to an object by way of mechanical attachment;

[0114] FIG. **7** shows one monitor device of the invention used to monitor patient health characteristics;

[0115] FIG. **7**A shows a system of the invention used to monitor pulse characteristics for patient health, with the device of FIG. **7**;

[0116] FIG. **7**B shows an alternative monitor device of the invention used to monitor respiratory behavior such as with the system of FIG. **7**A;

[0117] FIG. **8** illustrates application of a plurality of MMDs, of the invention, to athletes to facilitate training and/or to provide excitement in broadcast media;

[0118] FIG. **8**A illustrates real time data acquisition, reconstruction and display for data wirelessly transmitted from the MMDs of FIG. **8**;

[0119] FIG. **8**B illustrates a television display showing data generated in accord with the teachings of the invention;

[0120] FIG. **8**C shows a one MMD applied to a human fist in accord with the invention;

[0121] FIG. **9** shows a flow-chart illustrating "event" based and timed sequence data transmissions between a monitor device and a receiver, in accord with the invention;

[0122] FIG. **10** shows a sensor dispensing canister constructed according to the invention;

[0123] FIG. **10**A shows an array of sensors arranged for mounting within the canister of FIG. **10**;

[0124] FIG. **10**B shows one sensor of the array of sensors of FIG. **10**A;

[0125] FIG. **10**C shows an interface between one sensor and a base assembly in the canister of FIG. **10**;

[0126] FIG. **10**D shows an operational disconnect of one sensor from the base assembly in FIG. **10**C;

[0127] FIG. **10**E schematically illustrates canister electronics and a sensor as part of the canister of FIG. **10**;

[0128] FIG. **10**F illustrates imparting time-tag information to a sensor through a canister such as in FIG. **10**;

[0129] FIG. **10**G shows one receiver constructed according to the invention;

[0130] FIG. **10**H shows one receiver in the form of a ski lift ticket constructed according to the invention;

[0131] FIG. **10**I shows one ticket sensor constructed according to the invention;

[0132] FIG. **11** schematically shows an electrical logic and process flow chart for use with determining "airtime" in accord with the invention;

[0133] FIG. **12** schematically shows a state machine used in association with determining airtime in association with an algorithm such as in FIG. **11**;

[0134] FIG. **13** graphically shows accelerometer data and corresponding process signals used to determine airtime in accord with preferred embodiments of the invention;

[0135] FIG. **14** and FIG. **14**A shows a state diagram illustrating one-way transmission protocols according to one embodiment of the invention;

[0136] FIG. **15** schematically illustrates functional blocks for one sensor of the invention;

[0137] FIG. **16** schematically illustrates functional blocks for one display unit of the invention;

[0138] FIG. **17** shows a perspective view of one sensor housing constructed according to the invention, for use with a sensor such as a monitor device;

[0139] FIG. **18** illustrates a sensor, such as an MMD, within the housing of FIG. **17**;

[0140] FIG. **19** shows a top perspective view of another housing constructed according to the invention, for use with a sensor such as an MMD and for mounting to a vehicle;

[0141] FIG. **20** shows one vehicle and vehicle attachment bracket to which the housing of FIG. **19** attaches;

[0142] FIG. **21** shows another vehicle and vehicle attachment bracket to which the housing of FIG. **19** attaches;

[0143] FIG. **22** shows a bottom perspective view of the housing of FIG. **19**;

[0144] FIG. **23** shows a bracket constructed according to the invention and made for attachment between the housing of FIG. **19** and a vehicle attachment bracket;

[0145] FIG. **24** shows a top element of the housing of FIG. **19**;

[0146] FIG. **25** shows a bottom element of the housing of FIG. **19**;

[0147] FIG. **26** shows a perspective view of one housing constructed according to the invention;

[0148] FIG. **27** shows a perspective view of a top portion of the housing of FIG. **26**;

[0149] FIG. **28** shows a perspective view of a bottom portion of the housing of FIG. **27**;

[0150] FIG. **29** shows a perspective view of one monitor device constructed according to the invention for operational placement within the housing of FIG. **26**;

[0151] FIG. **30** shows a mounting plate for attaching monitor devices to flat surfaces in accord with one embodiment of the invention;

[0152] FIG. **31** shows a perspective view of the plate of FIG. **30** with a monitor device coupled thereto;

[0153] FIG. **32** shows an end view of the plate and device of FIG. **31**;

[0154] FIG. **33** shows, in a top view, a low-power, long life accelerometer sensor constructed according to the invention;

[0155] FIG. **34** shows a cross-sectional view of one portion of the accelerometer sensor of FIG. **33**, illustrating operation of the moment arm quantifying g's in accord with the invention;

[0156] FIG. **35** shows a circuit illustrating operation of the accelerometer sensor of FIG. **33**;

[0157] FIG. **36** illustrates a runner speedometer system constructed according to the invention;

[0158] FIG. **37** illustrates an alternative runner speedometer system constructed according to the invention;

[0159] FIG. **38** illustrates data capture and analysis principles for determining speed with the system of FIG. **37**;

[0160] FIG. **39** illustrates one sensor for operation with a shoe in a speedometer system such as described in FIG. **37**;

[0161] FIG. **40** shows another runner speedometer system of the invention, including a GPS sensor.

[0162] FIG. **41** shows a biking work function system constructed according to the invention;

[0163] FIG. **42** shows one race-car monitoring system constructed according to the invention;

[0164] FIG. **43** shows one data capture device for operation with a racecar in a race monitoring system such as shown in FIG. **42**;

[0165] FIG. **44** shows one crowd data device for operation with spectators in a race monitoring system such as shown in FIG. **42**;

[0166] FIG. **45** shows one body-armor incorporating a monitor device in accord with the invention;

[0167] FIG. **46** shows one system for measuring rodeo and/or bull riders in accord with other embodiments of the invention;

[0168] FIG. **47** shows a representative television display of a bull and rider configured with a system monitoring characteristics of the bull and/or rider, in accord with the invention;

[0169] FIG. **48** shows one EMD of the invention utilizing flex strip as the "PCB" in accord with the invention;

[0170] FIG. **49** depicts one computerized gaming system of the invention;

[0171] FIG. **50** schematically shows one flow chart implanting game algorithms in accord with the invention;

[0172] FIG. **51** shows one speed detection system for a ski resort in accord with the invention;

[0173] FIG. **52** shows one bar code reader suitable for use in the system of FIG. **51**;

[0174] FIG. **53** shows one monitor device constructed according to the invention and incorporating a GPS receiver;

[0175] FIG. **54** shows a system suitable for use with the device of FIG. **53**;

[0176] FIG. **55** shows an infant monitoring system constructed according to the invention;

[0177] FIG. **56** schematically shows a flow chart of operational steps used in the system of FIG. **55**;

[0178] FIG. **57** shows one MMD of the invention used to gauge patient weight;

[0179] FIG. **58** shows a weight monitoring system constructed according to the invention;

[0180] FIG. **59** shows another weight monitoring system of the invention;

[0181] FIG. **60** shows a force-sensing resistor suitable for use in the weight monitoring systems of FIG. **58** and FIG. **59** and in the MMD of FIG. **57**;

[0182] FIG. **61** shows one weight-sensing device in the form of a shoe or shoe insert, in accord with the invention;

[0183] FIG. **62** illustrates fluid cavities suitable for use in a device of FIG. **61**;

[0184] FIG. **63** shows a wrestling performance monitoring system constructed according to the invention;

[0185] FIG. **64** shows a representative graphic output from the system of FIG. **63**;

[0186] FIG. **65** shows a surfing event system according to the invention;

[0187] FIG. **66** shows a Green Room surfing event system according to the invention;

[0188] FIG. **67** shows a personal item network constructed according to the invention;

[0189] FIG. **68** shows a communications interface between a computer and one of items of FIG. **67**;

[0190] FIG. **69** illustrates electronics for one of the items within the network of FIG. **67**;

[0191] FIG. **70** and FIG. **71** show an electronic drink coaster constructed according to the invention;

[0192] FIG. **72** shows a package management system of the invention; and

[0193] FIG. **73** shows a product integrity tracking system of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0194] FIG. **1** shows a monitor device **10** constructed according to the invention. Device **10** can for example operate as an MMD or EMD described above. Device **10** includes a detector **12**, processor **14**, communications port **16**, and battery **18**. Preferably, device **10** also includes solid-state memory **20**. Memory **20** can be integral with processor **14** (or other element of device **10**, including port **16**), or a stand-alone element within device **10**. As an MMD, for example, detector **12** senses movement experienced by device **10** and generates signals indicative of that movement. Processor **12** then processes the signals to extract desired movement metrics, as described herein. Typically, when the movement metrics exceed a predetermined threshold, processor **12** stores data as an "event" within memory **20**. Events are also preferably tagged with time information, typically date and time, as provided by clock **22**.

[0195] As an EMD, for example, detector **12** senses temperature experienced by device **10** and generates signals indicative of temperature (either absolute, or relative). Processor **12** then processes the signals to extract desired data. Preferably, data such as temperature are time tagged with date and/or time information so that a limited recording is made of environmental conditions.

[0196] Communications port **16** communicates event data from device **10** to a receiver **24** as wireless data **30***a*. Port **16** typically performs such communications in response to commands from processor **14**. Communications port **26** receives wireless data **30***a* for use within receiver **24**. If desired, communications port **26** can also communicate with port **16** to transmit wireless data **30***b* to device **10**. In such an embodiment, ports **16**, **26** are preferably radio-frequency, infrared or magnetically-inductive transceivers. Alternatively, port **26** is a transmitter that interrogates device **10**; and port **16** is a transponder that reflects event data to receiver **24**. In one preferred embodiment, receiver **24** is part of the circuitry and packaging of a cell phone, which relays events (e.g., a movement event) to a remote storage facility. In other embodiments, receiver **24** is part of the circuitry and packaging of a MP3 player, pager, watch, or electronic PDA. Receiver **24** may connect with headphones (not shown) to provide information to a user and corresponding to "event" data.

[0197] Data communication between device **10** and receiver **24** is preferably "secure" so that only a receiver with the correct identification codes can interrogate and access data from device **10**. In such a mode, receiver **24** is an interrogation device ("ID"); and wireless communications **30***a*, **30***b* between ports **16**, **26** can be through one of several electromagnetic communications spectrums, including radio-frequencies, microwave frequencies, ultrasound or infrared. However, communications between device **10** and receiver **24** can also be one way, e.g., wireless data **30***a* from device **10** to receiver **24**; and in such an embodiment receiver **24** preferably understands the communications protocols of data **30***a* to correctly interpret the data from device **10**. Receiver **24** in this embodiment "listens" for data transmitted from device **10**. Receiver **24** thus may function as a remote receiver ("RR") stationed some distance (e.g., tens or hundreds of feet or more) from device **10**.

[0198] FIG. **1**A shows an alternative communication scheme between device **10'** and receiver **24'**. Like numbered items in FIG. **1**A have like functions as in FIG. **1**; except that in FIG. **1**A, ports **16'**, **26'** function to transfer data from device **10'** to receiver **24'** as a "contact" transponder. Device **10'** and receiver **24'** are separate elements, though they

appear immediately adjacent. A conductive pad **17** with port **16'** facilitates communication with port **26'** via its conductive pad **19**. Accordingly, event data from device **10'** transfers data to receiver **24'** without "wireless" data **30** (FIG. **1**), but rather through the circuit formed between device **10'** and receiver **24'** when contact is made between pads **17**, **19**, as shown in FIG. **1**A.

[**0199**] A monitor device **10**, **10'** of the invention preferably includes an adhesive strip that provides for convenient attachment of the device to an object or person. As shown in FIG. **2**, one such device **10"** is shown coupled to adhesive strip **32** for just this purpose. Strip **32** is preferably flexible so as to bend and attach device **10"** to nearly any surface shape. Strip **32** includes an adhesive **34** that bonds strip **32** to a person or object, such that device **10"** attaches to that person or object in a substantially fixed location. FIG. **2** also shows that device **10"** preferably resides adjacent to padding **36**, to protect device **10"** from physical harm and to provide a cushion interface between device **10"** and a person or object. Padding **36** can for example be cotton or other soft material; and padding **36** can be made from soft material typically found with adhesive bandages of the prior art. Device **10"** preferably includes a protective housing **11** (FIG. **2**A) surrounding integrated circuits to protect the circuits from breakage.

[**0200**] FIG. **2**A shows a top cross-sectional view of monitor device **10"** and strip **32**. As illustrated, strip **32** is a flexible such that it can conform to a surface (e.g., curved surface **37**) for attachment thereto. Adhesive **34** is shown covering substantially all of the back of strip **32** to provide for complete attachment to surface **37**. Though padding **36** is not required, it preferably encapsulates device **10"** to provide for optimum protection for device **10"** when attached to surface **37**. Note that padding **36** also protects surface **37** from scratching by any rigid elements of device **10"** (e.g., battery **18**, FIG. **1**). Those skilled in the art should appreciate that padding **36** can be formed partially about device **10"** to achieve similar goals and without departing from the scope of the invention; for example, padding **36** can reside adjacent only one side of device **10"**.

[**0201**] Those skilled in the art should appreciate that two or more of elements **14**, **16**, **18**, **22** (FIG. **1**) can be, and preferably are, integrated within an ASIC. Further, in one preferred embodiment, the detector **12** is also integrated within the ASIC as a solid-state accelerometer (e.g., using MEM technology). However, detector **12** can be a standalone element such as a piezoelectric strip, strain gauge, force-sensing resistor, weight sensor, temperature sensor, humidity sensor, chemical sensor, or heart rate detector.

[**0202**] FIG. **2**B shows one monitor device **10***z*, with battery **18***z*, coupled within a protective wrapper **27**. Protective non-stick strips **29** are also shown to cover adhesive (e.g., adhesive **34**, FIG. **2**) on adhesive strips **32***z* until device **10***z* is operatively used and applied to a person or object. Preferably, wrapper **27** and non-stick strips **29** are similar in design to the wrapper and strips of a common adhesive bandage. Accordingly, users of device **10***z* intuitively know how to open and attach device **10***z* to an object or surface (e.g., surface **37**, FIG. **2**A)—by opening wrapper **27**, removing device **10***z* by pulling adhesive strip **32***z* from wrapper **27**, and then removing non-stick strips **29** so that adhesive strips **32***z* are exposed for application to the object or surface. FIG. **2**C illustrates device **10***z* in a back view with wrapper **27** removed, showing fuller detail of non-stick strips **29** covering and protecting the underlying adhesive (e.g., adhesive **34**, FIG. **2**) on strip **32***z*.

[**0203**] A device **10** can also integrate directly with the adhesive strip, as shown in FIG. **2**D. Specifically, device **10"** of FIG. **2**D couples directly with adhesive strip **32'**. In addition, there is no padding with device **10"**—as in certain circumstances it is desirable to have optimal fixation between device **10"** and strip **32'**. A housing **11'** preferably protects device **10"** from breakage. In one example, when the detector of device **10"** is an accelerometer, direct coupling between device **10"** and strip **32'** provides for more accurate data capture of accelerations of the object to which strip **32'** is adhered. As such, adhesive **34'** preferably extends across the whole width of strip **32'**, as shown, such that device **10"** is tightly coupled to the object adhered to by strip **32'**.

[**0204**] FIG. **2**E shows one heart-rate monitor **10***w* constructed according to the invention. Like device **10**, **10"**, device **10***w* preferably couples directly with an adhesive strip **32***w* with adhesive **34***w*. Monitor **10***w* includes a heart rate detector **12***w* that may for example detect EKG signals. By way of background, the following heart rate monitoring patents are incorporated herein by reference: U.S. Pat. No. 4,625,733; U.S. Pat. No. 5,243,993; U.S. Pat. No. 5,690,119; U.S. Pat. No. 5,738,104; U.S. Pat. No. 6,018,677; U.S. Pat. No. 3,807,388; U.S. Pat. No. 4,195,642; and U.S. Pat. No. 4,248,244. Two electrodes **15** electrically coupled to detector **12***w* with monitor **10***w* via conductive paths **13**. Electrodes **15** couple with human skin when adhesive strip **32***w* is applied to the skin such that electromagnetic pulses from the heart are detected by detector **12***w*. By way of example, detector **12***w* of one embodiment detects potential differences between electrodes **15** to determine heart rate. Once heart rate is detected, information is passed to other sections to process and/or retransmit the data as wireless data **17** to a remote receiver. For example, data from detector **12***w* may be transmitted to processor and/or communications port **14***w*, **16***w*; from there, data may be relayed off-board. In one embodiment, wireless data **17** is a signal indicative of the existence of heart rate—so that monitor **10***w* may be used in patient safety to warn of patient heart failure (i.e., the absence of a heart rate may mean that a patient went into cardiac arrest). In another embodiment, wireless data **17** is a signal indicative of actual heart rate, e.g., 100 beats per minute, such that monitor **10***w* may be used in fitness applications. Monitor **10***w* thus provides an alternative to "strap" heart rate monitors; users of the invention stick on monitor **10***w* via adhesive strip **32***w* to monitor heart rate in real time. Data **17** may be captured by a receiver such as a watch to display the data to the wearing user. Monitor **10***w* can also be used in patient monitoring applications, such as in hospitals, so that patient health is monitored remotely and efficiently. By way of example, a monitor **10***w* may be attached to each critical care patient so that a facility (e.g., a hospital) can monitor each patient at a single monitoring location (i.e., at the location receiving signals **17**).

[**0205**] As an alternative heart rate monitor, device **10** of FIG. **1** has a detector in the form of a microphone. Processor **12** then processes microphone detector data to "listen" for breathing sounds to report breathing—or not breathing—as a health metric.

[0206] The invention also provides for efficiently integrating battery **18** with a monitor device. FIG. **3** illustrates one technique, wherein the monitor device (e.g., device **10**) includes a printed circuit board ("PCB") **40** that forms the back-plane forming the electrical interconnectivity with elements **42** (elements **42** can for example be any of items **12**, **14**, **16**, **20**, **22**, FIG. **1**). PCB **40** of FIG. **3** is a multi-layer board, as illustrated by layer line **44**. Between two layers **46***a*, **46***b*, PCB **40** is manufactured with two opposing terminals **48***a*, **48***b*. Terminals **48***a*, **48***b* can for example be copper tracks in PCB **40**, or copper with gold flash to facilitate good electrical connection. FIG. **3**A shows a top view of one terminal **48***a* with layer **46***a*, illustrating that terminal **48***a* is typically larger than other tracks **50** within PCB **40**. Accordingly, terminal **48***a* is large enough to form good electrical connection with a battery inserted between layers **46**, such as shown in FIG. **3**B. Specifically, FIG. **3**B shows PCB **40** separated between layers **46**, and a battery **52** inserted therebetween, to make powered connection to PCB **40** and its elements **42**. For purposes of clarity, only part of PCB **40** is shown in FIG. **3**B, and none of elements **42** are shown. Layers **46***a*, **46***b* may separated by prying layers **46** apart. Battery **52** can for example be a Li coin cell battery known in the art.

[0207] FIG. **3**C shows another PCB **40'** for use with a monitor device of the invention; except, in FIG. **3**C, terminals **48***a'*, **48***b'* are on opposing sides of PCB **40'**, as shown. PCB **40'** can be a single layer board, or multi-layer board. Batteries **52'** are coupled to PCB **40'** as shown in FIG. **3**D; and held to PCB **40'** by end clip **54**. FIG. **3**D illustrates clip **54** as a stand-alone element **54**-A; and alternatively as element **54**-B holding batteries **52'** in place to PCB **40'**. End clip **54** slides over PCB **40'** and batteries **52'** as illustrated by arrow **56**. End clip **54** is preferably conductive to complete the circuit to power PCB **40'** (at a contact point with PCB **40'**) and its elements **42** for use as monitor device.

[0208] Battery attachment to PCB **40"** can also be made as in FIG. **3**E, where battery (or batteries) **52"** is attached to one side of PCB **40"**. To make overall circuit connectivity, battery **52"** connects to terminal **48***a"*, and end clip **54'** makes connection with terminal **48***b"*, as shown. A contact point with PCB **40"** can be made to complete desired circuit functions. End clip **54** is thus preferably conductive to complete the circuit to power PCB **40"** and its elements **42** for use as a monitor device.

[0209] The battery integrations with PCBs of FIGS. **3**D and **3**E provide for simple and secure ways to mount batteries **52** within a package. Specifically, a housing **56** made to surround PCB **40** abuts end clip **54** and PCB **40**, as shown, to secure the monitor device for use in varied environments, and as a small package. Housing configurations are shown and described in greater detail below.

[0210] FIG. **3**F shows another PCB **60** for use with a monitor device of the invention. A battery **62** couples to PCB **60**, as shown, and a connecting element **64** completes the circuit between battery **62** and PCB **60** to power the monitor device. Preferably, element **64** is tensioned to help secure battery **62** to PCB **60**. FIG. **3**G shows PCB **60** and element **64** coupled together and without battery **62**. A terminal **66** (similar to terminals **48**) is also shown in FIG. **3**G to contact with one side of battery **62**.

[0211] FIG. **4** illustrates a preferred embodiment of the invention, not to scale, where packaging associated with a monitor device "powers" the device upon removal of the packaging. Specifically, in FIG. **4**, one monitor device **70**, with adhesive strips **72**, is shown with a protective wrapper **74** and non-stick strips **76**. One non-stick strip **76***a* has an extension **77** that electrically separates device **70** and a battery **78** so as to prevent electrical contact therebetween. Non-stick strip **76***a* is preferably thin, such as paper coated with non-stick material. Once strip **76***a* is removed by a user, connecting element **80** forces battery **78** to contact monitor device **70**, thereby powering the device. In this way, battery power is conserved until monitor device **70** is used operationally. Element **80** can for example take the form of element **64**, FIG. **3**G. FIG. **4**A shows monitor device **70** with wrapper **74** and non-stick strips **76** removed; as such, element **80** forces battery **78** to device **70** to make electrical contact therewith, powering device **70**. Those skilled in the art should appreciate that changes can be made within the above description without departing from the scope of the invention, including a monitor device with a single non-stick strip (instead of two) that has an extension to decouple the battery from device **70** until the strip is removed. Alternatively, the wrapper can couple with the extension to provide the same feature; so that when the wrapper is removed, the monitor device is powered.

[0212] FIG. **5** shows a monitor device **82** formed within a label **84**. Instead of adhesive strips, device **82** is disposed within label **84** for attachment, as above, to objects and persons. Label **84** has an adhesive **86** over one side, and preferably a non-stick strip **88** covering adhesive **86** until removed. For purposes of illustration, strip **88** is not shown in contact with adhesive **86**, though in fact adhesive **86** is sandwiched in contact between strip **88** and label **84**. Device **82** and label **84** provide an alternative to the monitor devices with adhesive strips described above, though with many of the advantages. FIG. **5**A shows a front view of device **82**, with adhesive **86** covering the one side of label **84**, and with strip **88** shown transparently in covering adhesive **86** until removed.

[0213] FIG. **6** shows a monolithic monitor device **90** constructed according to the invention. A rigid outer housing **92** surrounds PCB **94** and internal elements **96** (e.g., elements **10**-**22**, FIG. **1**), which provide functionality for device **90**. A magnetic element **98** couples with device **90** so that device **90** is easily attached to metal objects **100**. Accordingly, device **90** is easily attached to, or removed from, object **100**. Those skilled in the art should appreciate that alternative mechanical attachments are possible to couple device **90** to object **100**, including a mechanical pin or clip.

[0214] The MMDs of the invention operates to detect movement "metrics." These metrics include, for example, airtime, speed, power, impact, drop distance, jarring and spin; typically one MMD detects one movement metric, though more than one metric can be simultaneously detected by a given MMD, if desired (potentially employing multiple detectors). The MMD detector is chosen to provide signals from which the processor can interpret and determine the desired metric. For example, to detect airtime, the detector is typically one of an accelerometer or piezoelectric strip that detects vibration of an object to which the MMD is attached. Furthermore, the MMD of the invention preferably monitors the desired metric until the metric passes some threshold, at which time that metric is tagged with time and date information, and stored or transmitted off-board. If the

MMD operates within a single day, only time information is typically tagged to the metric.

[0215] By way of example, if the detector is an accelerometer and the MMD is designed to monitor "impact" (e.g., acceleration events that are less than about ½ second)—and yet impact data is not considered interesting unless the MMD experiences an impact exceeding 50 g's—the preferred MMD used to accomplish this task would continuously monitor impact and tag only those impact events that exceed 50 g's. The "event" in this example is thus a "50 g event." Such an MMD is for example useful when attached to furniture, or a package, in monitoring shipments for rough treatment. The MMD might for example record a 50 g event associated with furniture shipped on Oct. 1, 2000, from a manufacturer in California, and delivered on Oct. 10, 2000 to a store in Massachusetts. If an event stored in MMD memory indicates that on Oct. 5, 2000, at 2:30 pm, the furniture was clearly dropped, responsibility for any damages can be assessed to the party responsible for the furniture at that time. Accuracy of the time tag information can be days, hours, minutes and even seconds, depending on desired resolution and other practicalities.

[0216] Accordingly, data from such an MMD is preferably stored in internal memory (e.g., memory **20**, FIG. **1**) until the data are retrieved by receiver **24**. In the example above, the interrogation to read MMD data occurs at the end of travel of the MMD from point A to point B. Multiple events may in fact occur for an MMD during travel; and multiple events are usually stored. Alternatively, an MMD may communicate the event at the time of occurrence so long as a receiver **24** is nearby to capture the data. By way of example, if each FEDEX truck contained a receiver integrated with the truck, then any MMD contained with parcels in the truck can transmit events to the receiver at the occurrence of the event.

[0217] In another application, one or more monitor devices are attached to patients in a hospital, and one or more receivers are integrated with existing electronics at the hospital (e.g., with closed circuit television, phone systems, etc.). In operation, these devices are for example used to detect "events" that indicate useful information about the patients—information that should be known. If for example the monitor device has a Hall Effect detector that detects when the device is inverted, then a device attached to the collar bone (or clothing) of a patient would generate an "event" when the patient falls or lays down. An impact detector may also be used advantageously, to detect for example a 10 g event associated with a patient who may have fallen. Accordingly, monitor devices applied to patients in hospitals typically transmit event data at occurrence, so that in real time a receiver relays important medical information to appropriate personnel.

[0218] Movement devices of the invention can also transmit movement or other metrics at select intervals. If for example "impact" data is monitored by an MMD, then the MMD can transmit the maximum impact data for a selected interval—e.g., once per minute or once per five minutes, or other time interval. In this way, an MMD applied to a patient monitors movement; and any change in movement patterns are detected in the appropriate time interval and relayed to the receiver. An MMD may thus be used to inform a hospital when a patient is awake or asleep: when asleep, the MMD transmits very low impact events; when awake, the MMD transmits relatively high impact events (e.g., indicating that the patient is walking around).

[0219] FIG. **7** shows one monitor device **120** constructed according to the invention. Similar to device **10"** of FIG. **2** with regard to the adhesive bandage features of the device, device **120** has a detector in the form of a piezoelectric strip **122** disposed with the adhesive strip **124** (and, preferably, padding **121**). Strip **124** has adhesive **125** such as described above so that device **120** is easily attached to a human, e.g., to human arm **130**. In operation, as shown by schematic **130** of FIG. **7**A, bending of strip **124** also bends piezoelectric strip **122**, generating voltage spikes **123** detected by device processor **126**. Device **120** may thus operate to detect the heart pulse of a person: the tiny physical perturbation of piezoelectric strip **122** caused by arterial pressure changes is detected and processed by device **120** as movement metric **127**, which is then transmitted by port **129** to remote receiver(s) **132** as wireless data **133**. The pulse data **127**, over time, is usefully reconstructed for analytical purposes, e.g., as data **134** on display **136**, and may indicate stress or other patient condition that should be known immediately. By way of example, an "event" determined by device **120** based on movement metric **127** can be the absence or variation of a pulse, perhaps indicating that the patient died or went into cardiac arrest. It is clear that if arm **130** moves, the voltage signal generated by piezoelectric detector **122** may swamp any signal from the patient's pulse; however, since pulse data is detected at approximately 50 to 250 times per second, the underlying signal can be recovered, particularly after arm **130** ceases movement. Device **120** can include an A/D converter and/or voltage-limiting device **121** to facilitate measurement of voltage signals **123** from piezoelectric strip detector **122**. A battery **138** such as a Lithium coin cell can be used to power device **120**.

[0220] Device **120** may alternatively detect patient movement to provide real time detection of movement of a person or of part of that person. For example, such a device **120** may be used to monitor movement of an infant (instead of arm **150**) or other patient.

[0221] Note that the application of a monitor device **120** as described in FIG. **7** and FIG. **7**A can be expanded to detect respiratory behavior of a patient. FIG. **7**B shows a simplified schematic of one device **120'** with a longer piezoelectric strip detector **122'**. Detector **122'** circumferentially extends, at least part way, around the chest **150** of a patent; and movement of chest **150** during breathing generates voltage variations (e.g., similar to variations **133**, FIG. **7**) in response to physical perturbations of detector **122'**. Similar to pulse rate and pulse strength, therefore, device **120'** detects respiratory rate and/or strength. Pulse rate is determined by signal frequencies associated with movement metric **127**; and pulse strength is determined by magnitudes associated with movement metric **127**. Note that strip detector **122'** may be attached about chest **150** by one of several techniques, including by an adhesive strip (not shown) such as described above. A strap or elastic member **152** may be used to surround chest **150** to closely couple detector **122'** to chest **150**.

[0222] Devices such as device **120** or **120'** have additional application such as for infant monitoring. Attaching such a device to the chest (instead of arm **150**) of an infant to monitor respiration, pulse and/or movement provides a

remote monitoring tool and may prevent death by warning the infant's parents. A monitor device **10***w*, FIG. **2**E, may alternatively be used in such an application. Specifically, if for example a monitor device of the invention is attached to chest **150** of a child, processor **126** searches for "events" in the form of the absence of pulse, respiration and/or movement data. The device may thus track pulse or respiratory rate to synch up to the approximate frequency of the rate. When the device detects an absence in the repetitive signals of the pulse or respiratory rate, the device sends a warning message to an alarm for the parents. A system suitable for application with such an application is discussed in more detail in FIGS. **55** and **56**.

[**0223**] Data transmissions from a monitor device of the invention, to a receiver, typically occur in one of three forms: continuous transmissions, "event" transmissions, timed sequence transmissions, and interrogated transmissions. In continuous transmissions, a monitor device transmits detector signals (or possibly processed detector signals) in substantially real time from the monitor device to the receiver. Data reconstruction at the receiver, or at a computer arranged in network with, or in communication with, the receiver, then proceeds to analyze the data for desired characteristics. By way of example, by attaching multiple monitor devices to a person, all transmitting real-time data signals to the receiver, a reconstruction of that person's activity is determined.

[**0224**] Consider for example FIG. **8**. In FIG. **8**, a plurality of MMDs **150** are attached to person "a" and person "b". As shown, person A is engaged in karate training with person B. Data from MMDs **150**"stream" to a remote receiver, such as to the reconstruction computer and receiver **152** of FIG. **8**A. Each MMD **150** preferably has a unique identifier so that receiver **152** can decode data from any given MMD **150**. MMDs are placed on persons A, B at appropriate locations, e.g., on each foot and hand, head, knee, and chest; and receiver **152** associates data from each MMD **150** with the particular location. As data streams from MMD **150** to receiver **152**, data is reconstructed such as shown in plots **154** and **156**. Data plot **154** shows exemplary data from MMD **150***a* on the fist **160** of person A, and data plot **156** shows exemplary data from MMD **150***b* on the head **162** of person B. Each plot **154**, **156** are shown in FIG. **8**A as a function of time **164**. Other data plots for other sensors **150** (e.g., for illustrative sensors **2**, **3**, **4**) are not shown, for purposes of clarity.

[**0225**] Data plots **154**, **156** have obvious advantages realized by use of the MMDs of the invention. For example, plot **154** illustrates several fist "strikes"**166** generated by person A on person B, and data plot **156** illustrates corresponding blows **168** to the head of person B. Data **154**, **156** may for example be used in training, where person B learns to anticipate person A more effectively to soften or eliminate blows **168**.

[**0226**] Data plots **154**, **156** have further advantages for broadcast media; specifically, data **154**, **156** may be simultaneously relayed to the Internet or television **170** to display impact speed and intensity for blows given or received by persons A, B, and in real time, to enhance the pleasure and understanding of the viewing audience (i.e., viewers of television, and users of the Internet). Moreover, MMDs of the invention remove some or all of the subjectivity of impact events: a blow to an opponent is no longer qualitative but quantitative. By way of example, the magnitude of strikes **166** and blows **168** are preferably provided in the data streamed from MMDs **150**, indicating magnitude or force of the blow or strike. Data **154**, **156** thus represents real time movement metric data, such as acceleration associated with body parts of persons A, B. Data **154**, **156** may thereafter be analyzed, at receiver **152**, to determine "events", such as when data **154**, **156** indicates an impact exceeding 50 g's (or other appropriate or desired measure).

[**0227**] FIG. **8**B illustrates a representative display on television **157**, including appropriate event "data"**159** generated by an MMD system of the invention. Data **159** can for example derive from receiver **152**, which communicates the appropriate event data **159** to the broadcaster for TV **157**. Such event data **159** can include magnitude or power spectral density of acceleration data generated by MMDs **150**. Data **159** is preferably displayed in an easy to understand format, such as through bar graphs **161**, each impact detected by one or more MMDs **150** (in certain instances, combining one or more MMDs as data **159** can be useful). Bar graphs **161** preferably indicate magnitude of the impact shown by data **159** by peak bar graph element **161***a* on TV **157**.

[**0228**] Those skilled in the art should appreciate that any number of MMDs **150** may be used for applications such as shown in FIG. **8**. In boxing, for example, it may be appropriate to attach one MMD **150** per fist. One useful MMD in this application is for example monitor device **10** of FIGS. **2**, **2**D. That is, such a device is easily attached to the boxer's fist **158***a* or wrist **158***b* and, if desired, prior to applying gloves and wrapping **158***c*, as shown in FIG. **8**C. The device can alternatively be placed with wrapping **158***c*—making the device practically unnoticeable to the boxer. Preferably, MMD **10**''' of FIG. **8**C includes an accelerometer (as the MMD detector) oriented with a sensitivity axis **158***d* as shown; axis **158***d* being substantially aligned with the strike axis **158***e* of fist **158***a*. Data from the MMD wirelessly transmits through the gloves and wrapping to receiver **152**. Alternatives are also suitable, for example applying the MMDs to the boxer's wrapping or glove. An MMD can also be integrated within the boxing glove, if desired. In the event that the detector of the MMD is an accelerometer, then the sensitive axis of the accelerometer is preferably arranged along a strike axis of the boxer.

[**0229**] Data acquired from MMDs in sports like boxing and karate are also preferably collated and analyzed for statistical purposes. Data **154**, **156** can be analyzed for statistical detail such as: impacts per minute; average strike force per boxer; average punch power received to the head; average body blow power; and peak striking impact. Rotational information may also be derived with the appropriate detector, including typical wrist rotation at impact, a movement metric that may be determined with a spin sensor.

[**0230**] Other than continuous transmissions, such as illustrated in FIG. **8**, data from monitor devices of the invention also occur via one of "event" transmissions, timed sequence transmissions, and/or interrogated transmissions. FIG. **1** illustrates how interrogated transmissions preferably function: e.g., receiver **24** interrogates device **10** to obtain metrics. Event transmissions according to preferred embodiments are illustrated as a flow chart **170** of FIG. **9**. Timed

sequence transmissions according to preferred embodiments are also illustrated within flow chart **170** of FIG. **9**. In FIG. **9**, flow chart **170** begins in step **172** by powering the monitor device—either by inserting the battery, turning the device on, or removing a wrapper (or by similar mechanism) to power the device at the appropriate time. Once powered, the monitor device monitors detector signals, in step **174**, for metrics such as movement, temperature and/or g's. By way of example, to measure airtime or impact, the device processor monitors an accelerometer for the movement metric of acceleration. Step **176** assesses the metric for "events" such as airtime or "impact" (or, for example, for an event such as when temperature exceeds a certain threshold, or an event such as when humidity decreases below a certain threshold). Typically, though not required, all events are not reported, stored or transmitted. Rather, as shown in step **178**, events that meet or pass a preselected threshold are reported. By way of example, is an airtime event greater than ½ second—a magnitude deemed interesting by snowboarders? If so, such an event may be reported. If not, an airtime event of less than ½ second is not reported, and decision "no" from **178** is taken. If the event exceeds some threshold, decision tree "yes" from **178** sends the event data to the communications port (e.g., communications port **26**, FIG. **1**) in step **180**. The communications port then transmits the event to a receiver (e.g., receiver **24**, FIG. **1**) in step **182**. As an alternative, decision tree Yes_2 sends the event data to memory such that it is stored for later transmission, in step **184**. The Yes_2 decision tree is used for example when a receiver is not presently available (e.g., when no receiving device is available to listen to and capture data transmitted from the monitor device). Eventually, however, event data is transmitted off-board, in step **186**, such as when memory is full (a receiver should be available to capture the event data before memory becomes full) or when the monitor device is scheduled to transmit the data at a preselected time interval (i.e., a timed sequence transmission). For example, event data stored in memory may be transmitted off board every five minutes or every hour; data captured within that time interval is preferably stored in memory until transmission at steps **180** and **182**.

[0231] Note that timed sequence transmission of event data approaches "continuous" transmission of movement metric data for smaller and smaller timed sequence transmissions. For example, if data from the monitor device is communicated off-board each second (or less, such as each one tenth of a second), then that data becomes more and more similar to continuously transmitted data from the detector. Indeed, if sampling of the detector occurs at X Hz, and timed transmissions also occur at X Hz, then "continuous" or "timed sequence" data may be substantially identical. Timed sequence or event data, therefore, provides for the opportunity to process the detector signals, between transmissions, to derive useful events or to weed out noise or useless information.

[0232] FIG. **10** shows a sensor-dispensing canister **200** constructed according to the invention. Canister **200** is shown containing a plurality of sensor **202**. A lid **204** may be coupled with canister **200** to enclose sensors **202** within canister **200**, as desired. Each of sensors **202** can for example be a monitor device such as described above; however canister **200** can be used for other battery-powered sensors. Although canister **200** is shown with two-dozen sensors **202**, a larger or smaller number of sensors may be contained within its cavity **200***a*. As described in more detail below, canister **200** preferably contains one or both of (a) canister electronics and (b) a base assembly. Lid **204** preferably functions as a switch, to power the canister electronics when lid **204** is open, and to cause canister electronics to sleep when lid **204** is closed.

[0233] FIG. **10**A shows sensors **202** with base assembly **206**, and, for purposes of clarity, without the rest of canister **200**. Each of sensors **202** is shown with a monitor device **202***a* and an adhesive strip **202***b*; however, canister **200** may be used with other sensors (i.e., sensors that are not MMDs or EMDs) without departing from the scope of the invention. FIG. **10**B illustrates one sensor **202** in the preferred embodiment, and also illustrates a Mylar battery insulator strip **208** that keeps the sensor battery from touching its contact or terminal (not shown) within monitor device **202***a*. Strip **208** can for example serve as the "non-stick" strip or extension **77** discussed above in connection with FIG. **4**. Strip **208** preferably couples to base assembly **206** such as shown in FIG. **10**C. Accordingly, when a user removes a sensor **202** from canister **200**, strip **208** remains with base assembly **206**—and is no longer in contact with sensor **202**—and the monitor device's internal battery powers the device for use with its intended application, as shown in FIG. **10**D.

[0234] In one preferred embodiment of the invention, a canister **200'** (e.g., similar to canister **200** but with internal electronics) has its own battery **210**, micro-controller **212**, sensor time tag interface **214***a*, and real time clock **216** (collectively the "canister electronics"), as shown in FIG. **10**E. With such an embodiment, a sensor **202'** for use with canister **200'** has a mating time tab interface **214***b*. In addition to time tag interface **214***b*, sensor **202'** has a clock **218**, processor **220**, battery **222**, detector **224** and communications port **226**. In operation, sensor **202'** is generally not powered by battery **222** until removed from canister **200'**, as described above. Accordingly, real time clock information (e.g., the exact date and time) cannot be maintained within sensor **202'** while un-powered (i.e., so long as insulator strip **208'** prevents battery **222** from powering sensor **202'**) since clock **218** and other electronics require power to operate. However, in FIG. **10**E, the advantage provided by the canister electronics is that time tag information from real time clock **216** is imported to sensor **202'** through interfaces **214***a*, **214***b* after battery **222** powers device **202***a'* but before interfaces **214***a*, **214***b* disconnect so that sensor **202'** can be used operationally. As such, in the preferred embodiment shown in FIG. **10**F, interface **214***a* takes the form of flex cable **230** that remains attached between canister electronics and device **202***a'* until flex cable **230** extends to its full length, whereinafter sensor **202'** disconnects from cable **230**. Time tag relay **214***b* of device **202***a'*, FIG. **10**F, thus takes the form of a plug (not shown) to connect and alternatively disconnect with flex cable **230**. In FIG. **10**F, canister electronics (e.g., elements **210**, **212**, **216**) are disposed within base assembly **206'** and therefore flex cable **230** appears to extend only to base assembly **206'** when in fact cable **230** extends to canister electronics disposed therein. When a user removes sensor **202'** from canister **200'**, device **202***a'* is powered when strip **208'**, held with base assembly **206'** (or electronics therein) disconnects from sensor **202'**; and at that time clock **218** is enabled to track real time. Before flex cable **230** disconnects from sensor **202'**, time and/or data information is communicated between interfaces **214***a*, **214***b* to provide the "real" time to sensor **202'** as provided by clock

216. Once real time is provided to sensor **202'**, clock **218** maintains and tracks advancing time so that sensor **202'** can tag events with time and/or date information, as described herein.

[**0235**] One advantage of sensor canister **200'** is that once used, it may be reused by installing additional sensors within the cavity. In addition, one canister can carry multiple monitor devices, such as 100 MMDs that each respond to an event of "10 g's." In another example, another canister carries 200 MMDs that respond to an event of "100 g's." A canister of MMDs can be in any suitable number that meets a given application; typically however sensors within the canister of the invention are packaged together in groups of 50, 100, 150, 200, 250, 500 or 1000. A variety pack of MMDs can also be packaged within a canister, such as a canister containing ten 5 g MMDs, ten 10 g MMDs, ten 15 g MMDs, ten 20 g MMDs, ten 25 g MMDs, ten 30 g MMDs, ten 35 g MMDs, ten 40 g MMDs, ten 45 g MMDs, and ten 50 g MMDs. Another variety package can for example include groups of MMDs spaced at 10 g intervals. EMDs can also be packaged in variety configurations within canisters **200**, **200'**.

[**0236**] Canisters **200**, **200'** can also function to dispense one or a plurality of receivers. Specifically, each of elements **202** of FIG. **10** may alternatively be a receiver such as receiver **24** of FIG. **1**. In this way, a plurality of receivers may be dispensed and powered as described above. FIG. **10**G shows one receiver **231** constructed according to the invention. Receiver **231** has a communications port **232**, battery **233** and indicator **234**. Receiver **231** can further include processor **235**, memory **236** and clock **237**, as a matter of design choice and convenience such as to implement functionality described in connection with FIGS. **10**G, **10**H. Receiver **231** can for example be dispensed as one of a plurality of receivers—as an element **202**, **202'** dispensed from canisters **200**, **200'** above. In operation, battery **233** powers receiver **231** and receiver **231** receives inputs in the form of wireless communications (e.g., in accord with the teachings herein, wireless communications can include known transmission protocols such as radio-frequency communication, infrared communication and inductive magnetic communication) from a sensor such as an MMD. Communications port **232** serves to capture the wireless communications data such that indicator **234** re-communicates appropriate "event" data to a person or machine external to receiver **231**. Specifically, in one embodiment, receiver **231** operates to relay very simple information regarding event data from a movement device. If for example an MMD sends event data to receiver **231** that reported the MMD experienced an airtime event of five seconds, and it was important that this information was known immediately, then receiver **231** is programmed (e.g., through processor **235**) to indicate the occurrence of that five-second airtime event through indicator **234**. Such data may also be stored in memory **236**, if desired, until a person or machine requiring the data acquires it through indicator **234**. By way of another example, receiver **231** can take the form of a ski lift ticket **238** shown in FIG. **10**H. Lift ticket **238** is thus a receiver with an indicator **239** in the form of a LED. Lift ticket **238** is preferably made like other lift tickets, and may for example include bar code **240**, indicating that a person purchased the ticket for a particular day, and ticket connecting wire **241** to couple ticket **238** to clothing. Lift ticket **238** may beneficially be used with an MMD having a speed sensor detector; and that MMD reports (by wireless communication) speed "events" that exceed a certain threshold, e.g., 40 mph. Lift ticket receiver **238** captures that event data and reports it though indicator **239**. A person wearing lift ticket receiver **238** with a speed sensing MMD will thus be immediately known by the ski lift area that the person skis recklessly, as a lift operator can view the speeding violation indicator LED **239**. Alternatively, indicator **239** is itself a wireless relay that communicates with a third receiver such as a ski ticket reader currently used to review bar code **240**. Lift ticket receiver **238** can further include circuitry as in monitor device **10** of FIG. **1** so that it responds to wireless requests for appropriate "event data," such as speed violation data. As such, indicator **239** may take the form of a transmitter relaying requested event data to the third receiver, for example. Event data may be stored in memory **236** until requested by the third receiver interrogating lift ticket receiver **238**.

[**0237**] Preferably, canisters **200'** imparts a unique ID to the dispensed electronics—e.g., to each sensor or receiver taken from canister **200'**—for security reasons. More particularly, in addition to communicating a current date and time to the dispensed electronics, canister **200'** also preferably imparts a unique ID code which is used in subsequent interrogations of the dispensed electronics to obtain data therein. Therefore, data within a monitor device, for example, cannot be tampered with out the appropriate access code; and that code is only known by the party controlling canister **200'** and dispensing the electronics.

[**0238**] FIG. **10**G and FIG. **10**H illustrate certain advantages of the invention. First, receivers in the form of lift tickets **238** may be packaged and dispensed to power the lift ticket upon use. Lift tickets are dispensed by the thousands and are sometimes stored for months prior to use. Accordingly, battery power may be conserved until dispensed so that internal electronics function when used by a skier for the day. Further, tickets **238** monitor a user's performance behavior during the day to look for offending events: e.g., exceeding the ski resort speed limit of 35 mph; exceeding the jump limit of two seconds; or performing an overhead flip on the premises. Whatever the monitor device is set to measure and transmit as "events" may be visually displayed (e.g., a LED or LCD) at indicator **234** or re-transmitted to read the offending information. Receiver **231** may incorporate transponders as discussed above to facilitate the indicator functionality, i.e., to relay data as appropriate.

[**0239**] Batteries used in the above MMDs and devices like the lift ticket can benefit by using paper-like batteries such as set forth in U.S. Pat. No. 5,897,522, incorporated herein by reference. Such batteries provide flexibility in several of the monitor devices described herein. Powering such batteries when dispensing a sensor or receiver still provides advantages to conserve battery power until the sensor or receiver is used. A device battery **18** of FIG. **1** can for example be a paper-like battery or coin cell.

[**0240**] FIG. **10**I shows yet another sensor **231'** constructed according to the invention. Like receiver **231**, sensor **231'** preferably conforms to a shape of a license ticket, e.g., a ski lift ticket. However sensor **231'** does not couple to a separate monitor device; rather, sensor **231'** is a stand-alone device that serves to monitor and gauge speeding activity. Like other sensors of the invention, an "event" is generated and

communicated off-board (i.e., to a person or external electronics) when sensor **231'** exceeds a pre-assigned value. Typically, that value is a speed limit associated with the authority issuing sensor **231'** (e.g., a resort that issues a ski lift ticket). Sensor **231'** is preferably dispensed through one of the "power on" techniques described herein, such as by dispensing sensor **231'** from a canister **200**, **200'**. Typically, when sensor **231'** detects a speeding event, (a) data is communicated off-board (e.g., sensor **231'** generates a wireless signal of the speed violation), and/or (b) a visual indicator is generated to inform the authority (e.g., via a ski lift operator of the ski lift area) of the violation. In case (a), indicator **234'** may for example be a communications port such as port **16**, FIG. **1**; in the case (b), indicator **234'** may for example be an LED or other visual indicator that one can visually detect to learn of the speeding violation. Indicator **234'** of one embodiment is a simple LED that turns black (ON), or alternatively white (OFF), after the occurrence of a speeding event. A quick visual review of sensor **231'** thus informs the resort of the speeding violation.

[**0241**] Sensor **231'** also has a battery **233'** that is preferably powered when sensor **231'** is dispensed to a user (e.g., to a snowboarder at a resort). Optionally, position locator **243** is included with sensor **231'** to track earth location of sensor **23'**; processor **235'** thereafter determines speed based upon movement between locations over a time period (e.g., distance between a first location and a second location, divided by the time differential defined by arriving at the second location after leaving the first location, provides speed). Clock **237'** provides timing to sensor **231'**. Optionally, memory **236'** serves one of several functions as a matter of design choice. Data gathered by sensor **231'** may be stored in memory **236'**; such data may be communicated off-board during subsequent interrogations. As discussed above, data may also be communicated off-board at the occurrence of a speeding "event." As an alternative, indicator **234'** may be a transponder RFID tag to be read by a ticket card reader. In one embodiment, on slope transmitters irradiate sensor **231'** with a signal that reflects to determine Doppler speed; that speed is imparted to sensor memory **236'** and reported to the resort.

[**0242**] Preferably, sensor **231'** operates in "low power" mode. Position locater **243** in one preferred embodiment is a GPS receiver. GPS receiver and processor **243**, **235'** for example collectively operate to make timed measurements of earth location so as to coarsely measure speed. For example, by measuring earth location each five seconds, and by dividing the distance traveled in those five seconds by five seconds, a coarse measure of speed is determined. Other timed measurements could be made as a matter of design choice, e.g., ½, 1, 15, 20, 25, 30 or 60 seconds. By taking fewer measurements, and by reducing processing, battery power is conserved over the course of a day, as it is preferable that the ticket determines speeding violations for at least a full day, in Winter. Finely determining speed at about one-second intervals is useful in the preferred embodiment of the invention.

[**0243**] Memory **236'** may further define location information relative to one or more "zones" at a resort, such that speed may be assigned to each zone. In this manner, for example, a resort can specify that ski run "x" (of zone "a") has a speed limit of 35 mph, while ski run "y" (of zone "b") has a speed limit of 30 mph. Speeding violations within any of zones A or B are then communicated to the resort. The advantage of this feature of the invention is that certain slopes or mountain areas permit higher speeds, and yet other slopes (e.g., a tree skiing area) do not support higher speeds. The resort may for example specify speed limits according to terrain. GPS receiver **243** determines earth position—which processor **235'** determines is within a particular zone—and speed violations are then determined relative to the speed limit within the particular zone, providing a more flexible system for the ski resort.

[**0244**] Position locater **243** of another embodiment is an altimeter, preferably including a solid-state pressure sensor. Altimeter **243** of one embodiment provides gross position information such as the maximum and minimum altitude on a ski mountain. For a particular resort, maximum and minimum altitude approximately correspond to a distance of "z" meters, the distance needed to traverse between the minimum and maximum altitude. Processor **235'** then determines speed based upon dividing Z by the time between determining the minimum and maximum altitudes. Fractional speeds may also be determined. If for example a particular skier traverses between a maximum altitude and half-way between the minimum and maximum altitudes, then processor **235'** determines speed based upon dividing Z/2 by the time between determining (a) the maximum altitude and (b) the midpoint between the minimum and maximum altitudes.

[**0245**] As discussed above, one MMD of the invention includes an airtime sensor. FIG. **11** and FIG. **12** collectively illustrate the preferred embodiment for determining and detecting airtime in accord with the invention. An MMD configured to measure airtime preferably uses an accelerometer as the detector; and FIG. **11** depicts electrical and process steps **250** for processing acceleration signals to determine an "airtime" event. FIG. **12** illustrates state machine logic **280** used in reporting this airtime. By way of example, FIG. **12** shows that motion is preferably determined prior to determining airtime, as airtime is meaningful in certain applications (e.g., wakeboarding) when the vehicle (e.g., the wakeboard) is moving and non-stationary.

[**0246**] More particularly, FIG. **11** depicts discrete-time signal processing steps of an airtime detection algorithm. Acceleration data **252** derive from a detector in the form of an accelerometer. Two pseudo-power level signals **266***a*, **272***a* are produced from data **252** by differentiating (step **254**), rectifying (step **256**), and then filtering through respective low-pass filters at steps **266** or **272**. More particularly, a difference signal of data **252** is taken at step **254**. The difference signal for example operates to efficiently filter data **252**. The difference signal is next rectified, preferably, at step **256**. Optionally, a limit filter serves to limit rectified data at step **258**. Rectified, limited data may be resealed, if desired, at step **260**. The limiting and rescaling steps **258**, **260** help reduce quantization effects on the resolution of power signals **266***a*, **272***a*. Filtering at steps **266**, **272** incorporate different associated time constants, and feed binary hysteresis functions with different trigger levels, to produce "power" signals **266***a*, **272***a*.

[**0247**] More particularly, data from step **260** is bifurcated along fast-signal path **262** and slow-signal path **264**, as shown. In path **262**, a low pass filter operation (here shown as a one pole, 20 Hz low pass filter) first occurs at step **266**

to produce power signal **266***a*. Two comparators compare power signal **266***a* to thresholds, at step **268**, to generate two signals **270** used to identify possible takeoffs and landings for an airtime event. In path **264**, a low pass filter operation (here shown as a one pole 2 Hz low pass filter) first occurs at step **272** to produce power signal **272***a*. Three comparators compare power signal **272***a* to thresholds, at step **274**, to generate three "confidence" signals **276** used to assess confidence of takeoffs and landings for an airtime event. Finally, a state machine **280**, described in more detail in FIG. **12**, evaluates signals **270**, **276** to generate airtime events **278**.

[**0248**] Those skilled in the art should appreciate that the airtime detection scheme of FIG. **11** also may be used for other detectors, such as those in the form of piezoelectric strips and microphones, without departing from the scope of the invention.

[**0249**] FIG. **12** schematically shows state machine logic **280** used to report and identify airtime events, in accord with the invention. State machine **280** includes several processes, including determining motion **282**, determining potential takeoffs **284** (e.g., of the type determined along path **262**, FIG. **11**), determining takeoff confirmations **286** (e.g., of the type determined along path **264**, FIG. **11**), determining potential landings **288** (e.g., of the type determined along path **262**, FIG. **11**), and determining landing confirmations **290** (e.g., of the type determined along path **264**, FIG. **11**). Logic flow between processes **282**, **284**, **286**, **288**, **290** occurs as illustrated and annotated according to the preferred embodiment of the invention.

[**0250**] In summary, the relative fast signal from fast-signal path **262**, FIG. **11**, isolates potential takeoffs and potential landings from data **252** with timing accuracy (defined by filter **266**) that meets airtime accuracy specifications, e.g., $\frac{1}{100}^{th}$ of a second. The drawback of detections along path **262** is that it may react to accelerometer signal fluctuations that do not represent real events, which may occur with a ski click in the middle of an airtime jump by a skier. This problem is solved by confirming potential takeoffs and landings with confirmation takeoffs and landings triggered by a slower signal, i.e., along path **264**. The slower signal **272***a* is thus used to confirm landings and takeoffs, but is not used for timing because it does not have sufficient time resolution.

[**0251**] An accelerometer signal described in FIG. **11** and FIG. **12** is preferably sensitive to the vertical axis (i.e., the axis perpendicular to the direction of motion, e.g., typically the direction of forward velocity, such as the direction down a hill for a snowboarder) to produce a raw acceleration signal (i.e., data **252**, FIG. **11**) for processing. Other accelerometer orientations can also be used effectively. The raw acceleration signal may for example be sampled at high frequencies (e.g., 4800 Hz) and then acted upon by the algorithm of FIG. **11**. With a stream of accelerometer data, the algorithm produces an output stream of time-tagged airtime events.

[**0252**] FIG. **13** graphically shows representative accelerometer data **300** captured by a device of the invention and covering an airtime event **302**. Event **302** occurs between takeoff **304** and landing **306**, both determined through the algorithm of FIG. **11**. Data representing power signals **266***a* and **272***a* are also shown. A ski click **310** illustrating the importance of signals **266***a*, **272***a* shows how the invention prevents identification of ski click **310** as a landing or second takeoff.

[**0253**] Data transmission from a sensor (e.g., an MMD) to a display unit (e.g., a receiver) is generally at least 99.9% reliable. In the case of one-way communication, a redundant transmission protocol is preferably used to cover for lost data transmissions. Communications are also preferably optimized so as to reduce battery consumption. One way to reduce battery consumption is to synchronize transmission with reception. The "transmission period" (the period between one transmission and the next), the size of the storage buffer in sensor memory, and the number of times data is repeated (defining a maximum age of an event) are adjustable to achieve battery consumption goals.

[**0254**] A state diagram for transmission protocols between one sensor and display unit, utilizing one-way transmission, is shown in FIG. **14** and FIG. **14**A. FIG. **14** and FIG. **14**A specifically show the operational state transitions for the sensor (chart **273**) and display unit (chart **274**) with respect to transmission protocols, in one embodiment of the invention. The numerical times provided in FIG. **14** are illustrative, without limitation, and may be adjusted to optimize performance. As those skilled in the art should appreciate, alternative protocols may be used in accord with the invention between sensors and receivers. With reference to FIG. **14** and FIG. **14**A, the display unit is generally in a low power mode unless receiving data, to conserve power in the display unit. To accomplish this, transmissions between the sensor and display unit are synchronized such that the display unit knows when the sensor can next transmit. When the sensor has no data to transmit, there preferably is no transmission; however, synchronization is still maintained by short transmissions. Synchronization need not be performed at each transmission period, but preferably at a suitably spaced multiple of the transmission period. The period between synchronization-only transmissions is then determined by the amount of clock drift between the display unit and the sensor unit. The sync-only transmission may include the power up sequence and the sync byte, such that the display unit maintains sync with sensor transmissions. The transmission period is preferably selectable by software for both the sensor and the display unit.

[**0255**] By way of example, one sensor unit is monitor device **10** of FIG. **1**, and one display unit is receiver **24** of FIG. **1**. When the sensor and receiver function as a pair, the sensor unit preferably has an identification (ID) number communicated to the display unit in transmission so that the display unit only decodes data from one particular sensor.

[**0256**] Preferably, the display unit determines the sync pattern for sensor transmissions by active listening until receipt of a synchronization or data transmission with the matching sensor ID. Once a valid transmission from the matching sensor is received, the display unit calculates the time of the next possible transmission and controls the display unit accordingly. When the sensor is an MMD used to determine airtime, and the sensor does not necessarily have a real time clock; data sent to the display unit includes airtime values with time information as to when the airtime occurred. As this sensor does not necessarily maintain a real time clock, the time information sent from the sensor is relative to the packet transmission time. Preferably, the

display unit, which has a real time clock, will convert the relative time into an absolute time such that airtime as an event is tagged with appropriate time and/or date information.

[0257] The amount of data communicated between the sensor and display unit varies. By way of example, for typical skier and snowboarder operation, an airtime event covering the 0-5 second range with a resolution of $1/100^{th}$ second is generally adequate. The coding of such airtime events can use nine data bits. Ten bits allow for measurement of up to approximately ten seconds, if desired. For an age, where the resolution of age is one second (i.e., a time stamp resolution) and the maximum age of a repeat transmission is fifteen seconds, four bits are used. Data transmission also typically has overhead, such as startup time, synchronization byte, sensor ID used to verify correct sensor reception, a product identifier to allow backwards compatibility in future receivers, a count of the number of data items in the packet, and, following the actual data, a checksum to gain confidence in the received data. This overhead is approximately six bytes in length. To reduce the effect of overhead, stored data in the sensor is preferably sent in one message. An airtime event for example can be stored in the sensor until transmitted with the desired redundancy, after which it is typically discarded. Thus, the number of airtime events included in a transmission depends upon the number of items still in the sensor's buffer (e.g., in memory **20**, FIG. **1**). When the buffer is empty, there is, generally, no data transmission.

[0258] A typical data transmission can for example include: <P/up> <Sync> <Sensor ID> <Product ID> <Count> [<Age> <Airtime>] <Checksum>. <P/up> is the power-up time for the transmitter. A character may be transmitted during power up to aid the transmitter startup, and help the receiver start to synchronize on the signal. The <Sync> character is sent so that the receiver can recognize the start of a new message. <Sensor ID> defines each sensor with a unique ID number such that the display unit can selectively use data from a matching sensor. <Product ID> defines each sensor with a product ID to allow for backward compatibility in future receivers. <Count> defines how many age/airtime values are included in a message. The <Age> field provides the age of an associated airtime value, which may be used by the display unit to identify when an airtime is retransmitted. <Airtime> is the actual airtime value. <Checksum> provides verification that the data was received correctly.

[0259] A sensor's buffer length should accommodate the maximum number of airtime jumps for the duration of retransmissions. By way of example, transmissions can be restricted so that no more than one jump every three seconds is recognized; and retransmissions should generally finish within a selected time interval (e.g., six seconds). Therefore, this exemplary sensor need only store two airtime events at any one time. The buffer length is preferably configurable, and can for example be set to hold four or more airtime events.

[0260] Transmission electronics within the sensor and display units may use a UART, meaning that data is defined in byte-sized quantities. As those skilled in the art understand, alternative transmission protocols can utilize bit level resolution to further reduce transmission length.

[0261] By way of example, consider an airtime event of 1.72 seconds, occurring 2.1 seconds before start of transmission. In accord with FIG. **14** and FIG. **14**A, the transmitted data would be as follows: <P/up> <Sync> <Sensor ID> <Product ID> <Count> [<Age> <Airtime>] <Checksum> <0xAA> <0xAD> <0x12><0x01>-;<0x01><0x02>0x158><0x21> Assuming that the age and airtime data are combined into two bytes, and that <P/up> is one byte in length, the entire packet is eight bytes in length. At a transmission speed of 1200 baud, a typical transmission speed between a sensor and receiver, the eight bytes takes 67 ms to transmit. Assuming sequential transmission periods of 500 ms, the transmission duty cycle is 13.4% for a single jump.

[0262] Those skilled in the art should appreciate that alternatives from the above-described protocols may be made without departing from the scope of the invention. In one alternative, pseudo random transmissions are used between a sensor and receiver. If for example two sensors are together, and transmitting, the transmissions may interfere with one another if both transmissions synchronously overlap. Therefore, in situations like this, a pseudo random transmission interval may be used, and preferably randomized by the unique sensor identification number <Sensor ID>. If both the display unit and the sensor follow the same sequence, they can remain in complete sync. Accordingly, a collision of one transmission (by two adjacent sensors) will likely not occur on the next transmission. In another alternative, it may also be beneficial for the receiver to define a bit pattern for the <Sync> byte that does not occur anywhere else in the transmitted data, such as used, for example, with the HDLC bit stuffing protocol. In another alternative, it may be beneficial to use an error correction protocol, instead of retransmissions, to reduce overall data throughput. In still another alternative, a more elaborate checksum is used to reduce the risk of processing invalid data.

[0263] In still another alternative, a "hamming Code" may be used in the transmission protocol. Hamming codes are typically used with continuous streams of data, such as for a CD player, or for the system described in connection with FIG. **8**; however they are not generally used with event or timed sequence transmissions described in connection with FIG. **14**. Nevertheless, Hamming codes may make the data paths more robust. The wireless receiver in the display unit may take a finite time in start-up before it can receive each message. Since a further goal of the transmission protocol is generally to reduce the overall number of transmissions from the sensor, it may be beneficial to add additional data to the transmission and send it fewer times rather than to retransmit data several times. For example, rather than sending all buffered airtime values with each transmission, two data items can be sent, together with a count of airtimes in the sensor buffer, and a sum of the airtimes. If the display unit misses one airtime (e.g., determined by the count value), it can use the sum value received and the summation of the airtimes it has previously received to determine the missing airtime. A similar scheme can be used for age values so as to determine the time of the missing airtime.

[0264] The display unit receiver is typically in the physical form of a watch, pager, cell phone or PDA; and, further, receivers also typically have corresponding functionality. By way of example, one receiver is a cell phone that additionally functions as a receiver to read and interpret data from an

MMD. Furthermore, a display unit is preferably capable of receiving and displaying more than one movement metric. As such, data packets described above preferably include the additional metric data, e.g., containing both impact and airtime event data. Display units of the invention preferably have versatile attachment options, such as to facilitate attachment to a wrist (e.g., via a watch or Velcro strap for over clothing), a neck (e.g., via a necklace), or body (e.g., by a strap or belt).

[0265] Sensors such as the monitor devices described above, and corresponding display unit receivers, preferably have certain characteristics, and such as to accommodate extreme temperature, vibration and shock environments. One representative sensor and receiver used to determine airtime in action sports can for example have the following non-limiting characteristics: sensor attaches to a flat surface (e.g., to snowboard, ski, wake-board); sensor stays attached during normal aggressive use; display unit attachable to outside of clothing or gear; waterproof; display unit battery life three months or more; sensor battery life one week or more of continuous use; on/off functionality by switch or automatic operation; characters displayed at data unit visible from a minimum of eighteen inches; minimum data comprehension time for data minimum of 0.5 second; last airtime data accessible with no physical interaction; one second maximum time delay for display of airtime data after jump; displayed data readable in sunlight; displayed data includes time and/or date information of airtime; user selection of accumulated airtime; display unit provides real time information; display unit operable with a maximum of two buttons; physical survivability for five foot drop onto concrete; scratch and stomp resistant; no sharp edges; minimum data precision $1/30^{th}$ second; minimum data accuracy $1/15^{th}$ second; minimum data resolution $1/100^{th}$ second; minimum data reliability $999/1000$ messages received; algorithm performance less than one percent false positive and less then two percent false negative indications per day; and temperature range minimum of −10 C-60 C.

[0266] Those skilled in the art should appreciate that the above description of communication protocols of "airtime" between sensor and receiver can be applied to monitor devices sensing other metrics, e.g., temperature, without departing from the scope of the invention.

[0267] By way of example, FIG. **15** shows functional blocks **320**, **322**, **324**, **326**, **328**, **330** of one sensor of the invention. The sensor's algorithm analyses signals from an internal detector and determines an event such as airtime. This event information is stored and made ready for transmission to the display unit. FIG. **16** shows functional blocks **332**, **334**, **336**, **338**, **340**, **342**, **344** of one display unit of the invention. Transmission protocols between functional blocks **326**, **332** ensure that data is received reliably. The internal detector of the sensor of FIG. **15** for example is an accelerometer oriented to measure acceleration in the Z direction (i.e., perpendicular to the X, Y plane of motion). Signals generated from the detector are sampled at a suitable frequency, at block **320**, and then processed by an event algorithm, at block **322**. The algorithm applies filters and control logic to determine event, e.g., the takeoff and landing times for airtime events. Event data such as airtime is passed to the data storage at block **324**. Data is stored to meet transmission protocol requirements; preferably, data is stored in a cyclic buffer, and once all data transmissions are performed, the data is discarded. Transmission can be performed by a UART, at block **326**, where data content is arranged to provide sufficient robustness. Power control at block **328** monitors signal activity level to determine if the sensor should be in operating mode, or in sleep mode. Sleep mode preserves the battery to obtain a greater operative life. While in sleep mode, the processor wakes periodically to check for activity. Timing and control at block **330** maintains timing and scheduling of software components.

[0268] With regard to FIG. **16**, receiver message handler at block **332** performs data reconstruction and duplication removal from transmission protocols. Resulting data items are sent to data management and storage at block **334**. Stored data ensures that the user can select desired information for display, at block **336**. The display driver preferably performs additional data processing, such as in displaying Total Lists (e.g., values representing cumulative of a metric), Best lists (e.g., values representing the best or highest or lowest metric), and Current Lists (e.g., values representing latest metric). These lists are filled automatically, but may be cleared or reset by the user. Buttons typically control the display unit, at block **338**. Button inputs by users are scanned for user input, with corresponding information passed to the user interface/menu control block **344**. The display driver of block **336** selects and formats data for display, and sends it to the receiver's display device (e.g., an LCD). This information may also include menu items to allow the user select, or perform functions on, stored data, or to select different operation modes. A real time clock of block **340** maintains the current time and date even when the display is inactive. The time and date is used to time stamp event data (e.g., an airtime event). Timing and control at block **342** maintains timing and scheduling of various software components. User interface at block **344** accepts input from the button interface, to select data items for display. A user preferably can scroll through menu items, or data lists, as desired.

[0269] FIG. **17** shows one housing suitable for use with a monitor device (e.g., an MMD) of the invention. The housing is shown with three pieces: a top element **362**, a bottom element **364**, and an o-ring **366**. As shown in FIG. **18**, elements **362**, **364** form a watertight seal with o-ring **366** to form an internal cavity that contains and protects sensor electronics **368** (e.g., detector **12**, processor **14**, communications port **16** of FIG. **1**) disposed within the cavity. Batteries **370** power sensor electronics **368**, such as described in connection with FIGS. **3**F, **3**G. In combination, the housing is preferably small, with volume dimensions less than about 35 mm×15 mm×15 mm. Generally, one dimension of the housing is longer than the other dimensions, as illustrated; though this is not required.

[0270] FIG. **19** shows an alternative housing **372** suitable for use with a sensor (e.g., an MMD) of the invention. Housing **372** is shown with three pieces: a top element **374**, a bottom element **376**, and an o-ring **378**. As above, elements **374**, **376** form a watertight seal with o-ring **378** to form an internal cavity that contains and protects sensor electronics disposed therein. FIG. **19** also shows housing **372** coupled to sensor bracket **380**. A mating screw **382** passes through housing **372**, as shown, and through sensor bracket **380** for attachment to a vehicle attachment bracket. FIG. **20** illustrates one vehicle attachment bracket **390**; FIG. **21** illustrates another vehicle attachment bracket **400**. Mat-

ing screw **382** preferably has a large head **382***a* so that human fingers can efficiently manipulate screw **382**, thereby attaching and detaching housing **372** from the vehicle attachment bracket, and, thereby, from the underlying vehicle. Screw **382** also preferably clamps together elements **374**, **376**, **378** at a single location to seal sensor electronics within housing **372**.

[**0271**] Bracket **390** of FIG. **20** attaches directly to vehicle **392**. Vehicle **392** is for example a sport vehicle such as a snowboard, ski, wakeboard, or skateboard. Vehicle **392** may also be part of a car or motorcycle. A surface **394** of vehicle **392** may be flat; and thus bracket **390** preferably has a corresponding flat surface so that bracket **390** is efficiently bonded, glued, screwed, or otherwise attached to surface **394**. Bracket **390** also has screw hole **396** into which mating screw **382** threads to, along direction **399**.

[**0272**] FIG. **21** shows one alternative vehicle attachment bracket **400**. Bracket **400** has an L-shape to facilitate attachment to bicycle frame **398**. Frame **398** is for example part of a bicycle or mountain biking sports vehicle. A seat **402** is shown for purposes of illustration. Bracket **400** has a screw hole **404** into which mating screw **382** threads to, along direction **406**. Sensor outline **408** illustrates how housing **372** may attach to bracket **400**.

[**0273**] Brackets **380**, **390**, **400** illustrate how sensors of the invention may beneficially attach to sporting vehicles of practically any shape, and with low profile once attached thereto. The brackets of the invention preferably conform to the desired vehicle and provide desired orientations for the sensor within its housing. By way of example, L-shaped bracket **400** may be used to effectively orient a sensor to bike **398**. If for example the sensor includes a two-axis accelerometer as the detector, with sensitive axes **410**, **412** arranged as shown, then vehicle vibration substantially perpendicular to ground (i.e., ground being the plane of movement for the vehicle, illustrated by vector A) may be detected in sensor orientations illustrated by attachment of housing **372** to attachments **390**, **400** of FIGS. **20** and **21**, respectively. In addition, such an arrangement provides for mounting the sensor to a vehicle with a low profile extending from the vehicle.

[**0274**] Vehicle attachment brackets (and sensor brackets) are preferably made with sturdy material, e.g., Aluminum, such that, once attached to a vehicle (e.g., vehicle **390** or **398**), the vibration characteristics of the underlying vehicle transmit through to the housing attached thereto; the sensor within the housing may then monitor movement signals (e.g., vibration of the vehicle, generally generated perpendicular to "a" in FIG. **20** and FIG. **21**) directly and with little signal loss or degradation.

[**0275**] FIG. **22** shows housing **374** from a lower perspective view, and specifically shows sensor bracket **380** configured with back connecting elements **376***a* of housing element **376**. FIG. **23** further illustrates bracket **380**. FIG. **24** further illustrates element **374**, including screw hole **374***a* for mating screw **382**, and in forming part of the cavity **374***b* for sensor electronics. FIG. **25** further illustrates element **376**, including screw aperture **376***b* for mating screw **382**. Elements **376**, **374** may optionally be joined together via attachment channels **377**, with screws or alignment pins.

[**0276**] FIG. **26** shows one housing **384** for a monitor device of the invention. Housing **384** is preferably made from mold urethane and includes a top portion **384***a* and bottom portion **384***b*. An o-ring (not shown) between portions **384***a*, **384***b* serves to keep electronics within housing **384** dry and free from environmental forces external to housing **384**. FIG. **27** shows the inside of top portion **384***a*; FIG. **28** shows the inside of bottom portion **384***b*; and FIG. **29** shows one monitor device **386**, constructed according to the invention, for operational placement within housing **384**. Portions **384***a*, **384***b* are clamped together by screw attachment channels **388**. In FIG. **29**, device **386** includes batteries **389***a*, **389***b* used to power a radio-frequency transmitter **390** and other electronics coupled with PCB **391**. Data from device **386** is communicated to remote receivers through antenna **392**. When transmitter **390** is a 433 MHz transmitter, for example, antenna **392** is preferably coil-shaped, as shown, running parallel to the short axis **393** of PCB **391** and about 4.5 mm above the non-battery edge **394** of PCB **391**. Coil antenna **392** is preferably about 15 mm long along length **392***a* and about 5.5 mm in diameter along width **392***b*; and coil antenna **392** is preferably made from about 20 turns **392***c* of enameled copper wire. Antenna **392** may be coupled to housing **384** via protrusions **385**. The o-ring between portions **384***a*, **384***b* may be placed on track **386**.

[**0277**] FIG. **30**, FIG. **31** and FIG. **32** collectively illustrate one mounting system for attaching monitor devices of the invention to objects with flat surfaces. FIG. **30** shows a plate **396** that is preferably injection molded using a tough metal replacement material such as the Verton™. Plate **396** is preferably permanently secured to the flat surface (e.g., to a ski or snowboard) with 3M VHB tape or other glue or screw. Skis, bicycles, and other vehicles use a corresponding shaped plate that accepts the same sensor. FIG. **31** shows plate **396** in perspective view with a monitor device **397** of the invention. FIG. **32** shows an end view illustrating how plate **396** couples with device **397**, and particularly with a lower portion **397***a* of device **397**.

[**0278**] FIG. **33** shows a top view of a long-life accelerometer sensor **420** constructed according to the invention. Sensor **420** can for example be an MMD. Accelerometer sensor **420** includes a PCB **422**, a processor **424** (preferably with internal memory **424***a*; memory **424***a* may be FLASH), a coin cell battery **426**, a plurality of g-quantifying moment arms **428***a-e*, and communications module **430**. PCB **422** has a matching plurality of contacts **432***a-e*, which sometimes connect in circuit with corresponding moment arms **428***a-e*. In one embodiment, module **430** is a transponder or RFID tag with internal FLASH memory **430***a*. The five moment arms **428***a-e* and contacts **432***a-e* are shown for illustrative purposes; fewer arm and contacts can be provided with accelerometer sensor, as few as one to four or more than five.

[**0279**] Battery **426** serves to power sensor **420**. PCB **422** and processor **424** serve to collect data from accelerometer(s) **428***a-e* when one or more contact with contacts **432***a-e*. Communications module **430** serves to transmit data from sensor **422** to a receiver, such as in communications ports **16**, **26**. Operation of accelerometer sensor **420** is described with discussion of FIG. **34**.

[**0280**] In illustrative example of operation of sensor **420**, moment arm **428***d* moves in direction **434***a* when force moves arm **428***d* in the other direction **434***b*. Once arm **428***d* moves far enough (corresponding to space **436**), then arm

428*d* contacts contact **432***d*. At that point, a circuit is completed between arm **428***d*, processor **424** and battery **426**, such as through track lines **438***a*, **438***b* connecting, respectively, contact **432***d* and arm **428***d* to other components with PCB **422**. A certain amount of force is required to move arm **428***d* to contact **432***d*; arm **428***d* is preferably constructed in such a way that that force is known. For example, arm **428***d* can be made to touch contact **432***d* in response to 10 g of force in direction **434***a*. Other arms **428***a-c*, **428***e* have different lengths (or at least different masses) so that they respond to different forces **434** to make contact with respective contacts **432**. In this way, the array of moment arms **428** quantize several g's for accelerometer **100**.

[**0281**] In the preferred embodiment, processor **424** includes A/D functionality and has a "sleep" mode, such as the "pic" 16F873 by MICROCHIP. Accordingly, accelerometer sensor **422** draws very little current during sleep mode and only wakes up to record contacts between arms **428** and contacts **432**. The corresponding battery life of accelerometer sensor **422** is then very long since the only "active" component is processor **424**—which is only active for very short period outside of sleep mode. Communications module is also active for just a period required to transmit data from sensor **420**.

[**0282**] Processor **424** thus stores data events for the plurality of moment arms **428**. By way of example, moment arms **428***a-e* can be made to complete the circuit with contacts **432** at 25 g (arm **428***e*), 20 g (arm **428***d*), 15 g (arm **428***c*), 10 g (arm **428***b*) and 5 g (arm **428***a*), and processor **424** stores results from the highest g measured by any one arm **428**. For example, if the accelerometer sensor experiences a force **434***b* of 20 g, then each of arms **428***e*, **428***d*, **428***c* and **428***b* touch respective contacts **432**; however only the largest result (20 g for arm **428***b*) needs to be recorded since the other arms (**428***e-c*) cannot measure above their respective g ratings. Longer length arms **428** generally measure less force due to their increased responsiveness to force. Those skilled in the art should appreciate that arms **428** can be made with different masses, and even with the same length, to provide the same function as shown in FIGS. **33** and **34**.

[**0283**] Data events from arms **428** may be recorded in memory **424***a* or **430***a*. If for example communications module **430** is a transponder or RFID tag, with internal FLASH memory **430***a*, then data is preferably stored in memory **430***a* when accelerometer sensor **420** wakes up; data is then off-loaded to a receiver interrogating transponder from memory **430***a*. Alternatively, processor **424** has memory **424***a* and event data is stored there. Module **430** might also be an RF transmitter that wirelessly transmits data off-board at predetermined intervals.

[**0284**] FIG. **35** shows a circuit **440** illustrating operation of accelerometer sensor **420**. Processor **424** is minimally powered by battery **426** through PCB **422**, and is generally in sleep mode until a signal is generated by one or more moment arms **428** with corresponding contacts **432**. Each arm and contact combination **428**, **432** serve to sense quantized g loads, as described above, and to initiate an "event" recording at processor **424**, the event being generated when the g loads are met. Processor **424** then stores or causes data transmission of the time tagged g load events similar to the monitor device and receiver of FIG. **1**.

[**0285**] FIG. **36** shows a runner speedometer system **450** constructed according to the invention. A sensor **452** is located with each running shoe **454**. For purpose of illustration, shoes **454**A, **454**B are shown at static locations "a" and "b", corresponding to sequential landing locations of shoes **454**. In reality, however, shoes **454** are not stationary while running, and typically they do not simultaneously land on ground **456** as they appear in FIG. **36**. Sensor **452**A is located with shoe **454**A; sensor **452**B is located with shoe **454**B. Sensors **452** may be within each shoe **454** or attached thereto. Sensors **452**A, **452**B cooperatively function as a proximity sensor configured to determine stride distance **461** between sensors **452**, while running. One or both of sensors **452** have an antenna **458** and internal transmitter (not shown). A sensor **452** can for example be a monitor device such as shown in FIG. **1**, where detector **12** is the proximity sensor and the transmitter is the communications port **16**. Receiver **462** is preferably in the form of a runner's watch with an antenna **466** and a communications port (e.g., port **26**, FIG. **1**) to receive signals from sensor(s) **452**. Receiver **462** also preferably includes a processor and driver to drive a display **468**. Receiver **462** can for example have elements **14**, **18**, **20**, **22**, **16** of device **10** of FIG. **1**. Receiver **462** preferably provides real time clock information in addition to other functions such as displaying speed and distance data described herein.

[**0286**] In the preferred embodiment, sensors **452** internally process proximity data to calculate velocity and/or distance as "event" data, and then wirelessly communicate the event data to receiver **462**. Alternatively, proximity data is relayed to receiver **462** without further calculation at sensors **452**. Calculations to determine distance or velocity performed by a runner using shoes **454** can be accomplished in sensor(s) **452** or in receiver **462**, or in combination between the two. Distance is determined by a maximum separation between sensors **452** for a stride; preferably, that maximum distance is scaled by a preselected value determined by empirical methods, since the maximum distance between sensors **452**A, **452**B determined while running is not generally equal to the actual separation **461** between successive foot landings (i.e., while running, only one of shoes **454** is on the ground at any one time typically, and so the maximum running separation is less than actual footprint separation **461**—the scaling value accounts for this difference and calibrates system **450**).

[**0287**] Velocity is then determined by the maximum stride distance (and preferably scaled to the preselected value) divided by the time associated with shoe **454** impacting ground **456**. An accelerometer may be included with sensor **452** to assist in determining impacts corresponding to striking ground **456**, and hence the time between adjacent impacts for shoe positions A and B. Events may be queued and transmitted in bursts to receiver **462**; however events are typically communicated at each occurrence. Events are preferably time tagged, as described above, to provide additional timing detail at receiver **462**.

[**0288**] FIG. **37** shows an alternative runner speedometer system **480** constructed according to the invention. A sensor **482** is located with one running shoe **484**. For purpose of illustration, shoe **484** is shown at two distinct but separate static locations "a" and "b", corresponding to successive landing locations of shoe **484**. In reality, shoe **484** is not stationary while running, and also does not simultaneously

land at two separate locations A, B on ground **486** as it appears in FIG. **37**. Shoe **484** can correspond to the left or right foot of a runner using system **480**. Sensor **482** is located with shoe **484**; it may be within shoe **484** or attached thereto. Sensor **482** has an accelerometer oriented along axis **490**, direction **490** being generally oriented towards the runner's direction of motion **491**. Sensor **482** has an antenna **488** and internal transmitter (not shown). Sensor **482** can for example be a monitor device such as shown in FIG. **1**, where detector **12** is the accelerometer oriented with sensitivity along direction **490**, and the transmitter is the communications port **16**. Sensor **482** transmits travel or acceleration data to receiver **492**. Receiver **492** is preferably in the form of a runner's watch with an antenna **496** and a communications port (e.g., port **26**, FIG. **1**) to receive signals from sensor **482**. Receiver **492** also preferably includes a processor and driver to drive a display **498**. Receiver **492** can for example have elements **14**, **18**, **20**, **22**, **16** of device **10** of FIG. **1**. Receiver **492** preferably provides real time clock information in addition to other functions such as displaying speed and distance data described herein.

[**0289**] In one embodiment, sensor **482** transmits continuous acceleration data to receiver **492**; and receiver **492** calculates velocity and/or distance based upon the data, as described in more detail below. Sensor **492** thus operates much like an MMD **150** described in FIG. **8**, and receiver **492** processes real time feeds of acceleration data to determine speed and/or distance. In the preferred embodiment, however, sensor **482** internally processes acceleration data from its accelerometer(s) to calculate velocity and/or distance as "event" data; it then wirelessly communicates the event data to receiver **492** as wireless data **493**. Events are preferably queued and transmitted in bursts to receiver **492**; however events are typically communicated at each occurrence (i.e., after each set of successive steps from A to B). Events are preferably time tagged, as described above, to provide additional timing detail at receiver **492**.

[**0290**] Generally, sensor **482** calculates a velocity and/or distance event after sensing two "impacts." Impacts **500** are shown in FIG. **38**. Each impact is detected by the sensor's accelerometer; when shoe **484** strikes ground **486** during running, a shock is transmitted through shoe **484** and sensor **482**; and sensor **482** detects that impact **500**. An additional accelerometer in sensor **482**, oriented with sensitivity perpendicular to motion direction **491**, may also be included to assist in detecting the impact; however even one accelerometer oriented along motion direction **490** receives jarring motion typically sufficient to determine impact **500**.

[**0291**] Alternatively, sensor **482** calculates velocity and/or distance between successive low motion regions **502**. Regions **502** correspond to when shoe is relatively stationary (at least along direction **491**) after landing on ground **486** and prior to launching into the air.

[**0292**] Once impact **500** or low motion region **502** is determined within sensor **482**, sensor **482** integrates acceleration data generated by its internal accelerometer until the next impact or low motion region to determine velocity; a double integration of the acceleration data may also be processed to determine distance. Preferably, data from the sensor accelerometer is processed through a low pass filter. Preferably, that filter is an analog filter with a pole of about 50 Hz (those skilled in the art should appreciate that other filters can be used). However, generally only velocity is calculated within sensor **482**; and distance is calculated in receiver **492** based on the velocity information and time T between impacts **500** (or low motion regions **502**) of sensor **482**. Preferably, velocity is only calculated over the time interval T_i between each impact **500**. Velocity may alternatively be calculated over an interval that is shorter than T, such that runner velocity is scaled to velocity over the lesser interval. The shorter interval is useful in that acceleration data is sometimes more consistent over the shorter interval, and thus much more appropriate as a scalable gauge for velocity. Given the short time of T, very little drift of accelerometer data occurs, and velocity may be determined sufficiently. T_i is typically less than about one second, and is typically about ½ second or less.

[**0293**] Briefly, the processor within sensor **482** samples accelerometer data within each "t" period, or portion of the T period, and integrates that data to determine velocity. The initial velocity starting from each impact **500** (or low motion region **502**) is approximately zero. If A_i represents one sample of accelerometer data, and the sampling rate of the processor is 200 Hz (i.e., preferably a rate higher than the low pass filter), then $A_i/200$ represents the velocity for one sample period (1/200 second) of the processor. Data **504** illustrates data A_i over time t. Since T (in seconds)*200 samples=x samples are taken for each period T, then the sum of all of the $A_i/200$ for each of the x samples, divided by the number x, determines average velocity over period T. For integrations over a period that is less than T, fewer samples (less than x) are used to calculate velocity.

[**0294**] Sensor **482** calculates and transmits its velocity data to receiver **492**. Velocity data V_1 corresponds to period T_1, velocity data V_2 corresponds to period T_2, and so on. Generally, because of processing time, sensor **482** in this example transmits V_1 in period T_2, transmits V_2 during period T_3, and so on. Receiver **492** averages V_i, over time, and communicates the average to the runner in useful units, e.g., 10 mph or 15 kmph.

[**0295**] Note that if only one accelerometer is provided with each shoe **484**, then calibration of velocity V_i may be made for sensor **452** by calibration against a known reference, e.g., by running after a car or running on a treadmill. More particularly, since the accelerometer is oriented in various ways during a period T, other than along direction **491**, then errors are induced due to the acceleration of gravity and other forces. However, since V_i is reported sequentially to receiver **492**, a correction factor may be applied to these velocities prior to display on display **498**. By way of example, if one runner substantially maintains his shoes **484** level, such that accelerometers in sensors **492** maintain a constant orientation along direction **491** during period T, then the reported V_i reasonably approximates actual velocity over that period. However if the runner points his shoes with toe towards ground **486**, during period T, then only a component of the detected acceleration vector is oriented along direction **491**. However, by calibrating system **480** against a known reference, a substantially true velocity for each period T may be obtained. Moreover, shoe sensor **482** can have a different adjustment factor applied for different gaits (e.g., jogging or running, as shoe orientations during period T may vary for different gaits).

[**0296**] Generally, a calibration for velocity is made at least once for each shoe using the invention, to account for

variations in electronic components and other effects. Calibration also adjusts for the gait of the runner in orienting the accelerometer relative to ground **486**. Preferably, like several of the MMDs described herein, a battery powers sensor **482**; and that battery can be replaced once depleted. Implanting the MMD within shoe **484** is beneficial in that a fixed orientation, relative to direction **491**, is made at each landing.

[**0297**] To alleviate the problems associated with acceleration errors, one preferred sensor **482'** for a shoe **484'** is shown in FIG. **39**. Sensor **482'** is shown in a side cross sectional view (not to scale); and motion direction **491'** of the runner is shown in relation to accelerometer orientation axes **506***a*, **506***b* and ground **486'**. Shoe **484'** is shown flat on ground **486'** and generally having a sole orientation **487** also at angle θ relative to accelerometer axis **506***a*. Sensor **482'** has at least a two-axis accelerometer **510** (or, alternatively, a three axis accelerometer, with the third axis oriented in direction **506***c*) as the sensor detector, with one axis **506***a* oriented at angle θ relative to ground **486'** (and hence relative to shoe sole **487** on ground **486'**). Angle θ is chosen, preferably, such that accelerometer axis **506***a* maximally orients along axis **491'** while the runner runs. Specifically, since during a period T the toe of shoe **484'** tips towards ground **486'** while running, then angle θ approximately orients that accelerometer such that its sensitive axis **506***a* is parallel with axis **491'** for at least part of period T_i. Angle θ can be approximately forty-five degrees. Other angles are also suitable; for example an angle θ of zero degrees is described in connection with FIG. **37**, and other angles up to about seventy-five degrees may also function sufficiently. Axis **506***b* is preferably oriented with sensitivity perpendicular to orientation **506***a*. Data from accelerometer **510** is communicated to low pass filter **511** and then to processor **512** where it is sampled as data $A_{i,\,a,\,b,\,c}$ (a, b, c representing the two or three separate axes **506***a-c* of sensitivity for accelerometer **510**). Data $A_{i,\,a,\,b,\,c}$ is then used to (a) determine impacts **500** (and/or low motion regions **502**), as above, and (b) determine V_i based upon $A_{i,\,a,\,b,\,c}$ for any given period T_i (or for any part of a period T). Errors in V_i are corrected by processing the several components $A_{i,\,a,\,b,\,c}$ of the acceleration data. If for example data $A_{i,\,a}$ is "zero" for part of period T, then either the shoe is at constant velocity, or stopped; or if $A_{i,\,a}$ is "one" then it is substantially oriented with the toe greatly tipped towards ground **486'**, such that that accelerometer reads the acceleration due to gravity only. Data $A_{i,\,b}$ may be used to determine which physical case it is, and to augment the whole A_i data stream in determining V_i.

[**0298**] Once processor **512** determines V_i for period T_i, then communications port **514** transmits V_i to the user's watch receiver (e.g., receiver **492**, FIG. **37**) as wireless data **515**. The watch receiver calculates a useful runner speed, e.g., 15 km/hour, and displays that to the user. Battery **516** powers sensor **482'**.

[**0299**] Note that the systems of FIG. **36**, **37**, **39** provide other benefits associated with upward or downward movement and work functions. Such upward or downward movement, when determined, defines a change of potential energy that may be reported as work or caloric burn. For example, accelerometer **510** can include multiple axes, such that angle θ may be determined. By knowing vertical climb, even over short distances, a work function is created. An inclinometer or angle measurement may also be integrated into such systems, and work functions may also be determined on a hill. Certain MMDs of the invention include for example speed detectors (e.g., accelerometers or Doppler radar devices) to determine speed. By using the hill angle for the upward or downward movement, with speed, another work function is created associated with the climb or descent. Such a work function can add to caloric consumption calculations in fitness or biking applications. Such inventions are also useful in determining whether the climb occurred on a hill or on stairs, also assisting the work function calculation.

[**0300**] There are several advantages of the invention of FIGS. **36-39**. The prior art such as shown in U.S. Pat. No. 6,052,654, incorporated by reference, describes a calculating pedometer; but the system does not automatically calculate speed and distance as the invention does. Another patent, U.S. Pat. No. 5,955,667, also incorporated herein by reference, requires the use of a tilt sensor or other mechanism that determines the angular orientation of accelerometers relative to a datum plane. The invention does not require tilt sensors or the continual determination of the angle of the accelerometers relative to a fresh datum plane.

[**0301**] FIG. **40** shows one runner speedometer system **520** constructed according to the invention. System **520** includes a GPS monitor device **522**, accelerometer-based monitor device **524**, and wrist instrument **526**. Device **522** is similar to device **10** of FIG. **1** except detector **12** is a GPS chipset receiving and decoding GPS signals. Device **522** has a processor (e.g., processor **12**, FIG. **1**) that communicates with the chipset detector to determine speed and/or distance. Speed and/or distance can be accurately determined without knowing absolute location, as in the GPS sensors of the prior art. Speed and/or distance information is then wirelessly communicated, via its communications port, to wrist instrument **526** as wireless data **531**. Instrument **526** is preferably a digital watch with functionality such as receiver **24**, FIG. **1**. Preferably, device **522** clips into clothing pocket of the runner's shirt **530**. As described above, system **520** includes one or two accelerometer-based devices **524** in runner shoes **532**. Device(s) **524** in shoe(s) **532** augment GPS device **522** to improve speed and/or distance accuracy of system **520**; however either device **522**, **524** may be used without the other. Together, however, system **520** preferably provides approximately 99% or better accuracy (for speed and/or distance) under non-obscured sky conditions. Wrist instrument **526** collates data from GPS device **522** and accelerometer device(s) **524** to provide overall speed and distance traveled information, as well as desired timing and fitness data metrics.

[**0302**] System **520** thus preferably has at least one MMD **524** attached to, or within, runner shoe **532**; MMD **524** of the preferred embodiment includes at least one accelerometer arranged to detect forward acceleration of runner **525**. A processor within MMD **524** processes the forward acceleration to determine runner speed. Additional accelerometers in MMD **524** may be used, as described herein, to assist in determining speed with improved accuracy. In the preferred embodiment, MMD **524** wirelessly transmits speed as wireless data **527** to wrist instrument **526**, where speed is displayed for runner **525**. System **520** providing speed from a single MMD **524** can provide speed accuracy of about 97%. To improve accuracy, a second MMD **524** (not shown)

is attached to, or placed within, a second shoe **532**; the second MMD **524** also determining runner speed. Speed information from a second shoe **532***b* is thus combined with speed information from shoe **532***a* to provide improved speed accuracy to runner **525**; for example, the two speeds from shoes **532***a*, **532***b* are averaged. System **520** providing speed from a pair of MMDs **524** can provide speed accuracy of better than 97%.

[**0303**] System **520** works as a runner speedometer with MMD **524** (or multiple MMDs **524**, one in each shoe **532**). However, to improve accuracy of speed delivered to runner **525**, a GPS chip device **522** is attached to clothing **530** of runner **525**. Device **522** may for example be placed within a pocket of clothing **530**, the pocket being in the shoulder region so that device **522** has a good view of the sky. Device **522** processes successive GPS signals to determine a speed based upon successive positions. System **520** utilizing device **522** thus provides enhanced speed to runner **525** when using device **522**. Speed from device **522** is communicated to wrist instrument **526** where it is displayed for runner **525**. Preferably, instrument **526** uses speed from device **522** when speed data is consistent and approximately similar to speed data from MMD **524**. Instrument **526** alternatively combines speed data from device **522** and device **524** to provide a composite speed. If device **522** is obscured, so GPS signals are not available, then system **520** provides speed to runner **525** solely from MMD **524** (or multiple MMDs **524**, one in each shoe). As an alternative, device **522** can be integrated within a pocket in a hat worn by runner **525**, such that device **522** again has an unobscured view of the sky.

[**0304**] FIG. **41** shows a computerized bicycle system **540** constructed according to the invention. In use, system **540** determines caloric burn or "work" energy expended, among other functions described herein. System **540** includes fore/aft tilt sensor **542** and speed sensor **544**; sensors **542**, **544** determine then wirelessly transmit bicycle tilt information and speed information, respectively, and as wireless data **545**, to receiver and display **546**. A processor (not shown) in receiver and display **546** combines data from sensors **542**, **544** to determine elevation change, and, hence, work energy (e.g., change of potential energy); receiver and display **546** then displays work energy to a user of bicycle system **540**. Work energy may be converted to caloric bun, in one embodiment of the invention. Sensor **542** may include a small gyroscope or an electrolytic type tilt device, known in the art, as the detector for measuring bicycle tilt. Speed sensor **544** is readily known in the art; however the combination of speed sensor **544** with other sensors of FIG. **41** provides new and useful data accord with the invention.

[**0305**] System **540** can additionally include crank torque measurement sensor **548**. Sensor **548** preferably includes a strain gauge connected with bicycle crank **550** to measure force applied to pedals **552** and wheels **554**. Preferably, a sensor **548** is applied to each pedal so that system **540** determines the full effort applied by the cyclist on any terrain. Sensor(s) **548** accumulate, process and transmit tension data to receiver and display **546**. System **540** can additionally include tension measurement sensor **556** used to measure tension of chain **558**. Sensor **556** similarly accumulates, processes and transmits tension data to receiver and display **546**. Device **546** preferably includes processing and memory elements (e.g., similar to receiver **231**, FIG. **10**G) to accumulate and process data from one or more of sensors **542**, **544**, **548**, **556** in the desired way for a user of system **540**.

[**0306**] As alternatives to system **540**, without departing from the scope of the invention, those skilled in the art should appreciate that (1) sensor **542** may be combined with either of sensor **544** or receiver **546**; (2) sensors **542** and **544** may communicate through electrical wiring instead of through wireless communications; (3) a GPS sensor providing earth location and altitude may instead provide the data of sensors **542**, **544** for system **540**; and (4) receiver and display **546** may instead be a watch mounted to a user's wrist. Preferably, system **540** includes memory, e.g., within receiver and display **546**, that stores gradient information associated with a certain ride on terrain, and then provides a "trail difficulty" assessment for the stored data. Maximum and minimum gradients are also preferably stored and annotated in memory for later review by a user of system **540**.

[**0307**] FIG. **42** shows a system **600** constructed according to the invention. System **600** is particularly useful for application to spectator sports like NASCAR. System **600** in one application thus includes an array of data capture devices **602** coupled to racecars **604**. A data capture device **602** may for example be a monitor device as described herein, with one or a plurality of detectors to monitor movement metrics. As described below, data capture devices **602** preferably have wireless transmitters connected with antennas to transmit wireless data **606** to listening receivers **608**. Receivers **608** can take the form of a computer relay **608***a* and/or a crowd data device **608***b*, each of which is described below. In the preferred embodiment, data capture devices **602** communicate wireless data **606** to computer relay **608***a*; and computer relay **608***a* relays select wireless data **610** to a plurality of crowd data devices **608***b*. However, data capture devices **602** can directly relay wireless data **606** to crowd data devices **608***b*, if desired, and as a matter of design choice. Crowd data devices **608***b* are provided to spectators **612** during a sporting event, such as a NASCAR race of racecars **604** on racetrack **605**. Devices **608***b* may be rented, sold or otherwise provided to spectators **612**, such as in connection with ticketing to access racetrack **605**, and to sit in spectator stands **616**. Data devices **608***b* may also be modified personal data devices or cell phones enabled to interpret wireless data **606** and/or **610** for display of relevant information to its owner-spectator. Access to data **606**, **610** in this manner is preferably accomplished contractually such that the cell phones or data devices have encoded information necessary to decode wireless data **606** and/or **610**.

[**0308**] Wireless data **606** can for example be at 2.4 GHz since data capture device **602** may be sufficiently powered from racecars **604**. Wireless data **610** can for example be unlicensed frequencies such as 433 MHz or 900-928 MHz, so that each crowd data device **608***b* may be powered by small batteries such as described herein in connection with receivers for monitor devices. Wireless data **610** can further derive from cellular networks, if desired, to communicate directly with a crowd data device. Wireless link **606** and **610** can encompass two way communications, if desired, such as through wireless transceivers.

[**0309**] Computer relay **608***a* may further provide data directly to a display scoreboard **614** so that spectators **612**

may view scoreboard **614** for information derived by system **600**. Scoreboard **614** may for example be near to spectator stand **616**.

[**0310**] FIG. **43** shows one data capture device **602'** constructed according to the invention. Device **602'** may be attached to car **604'** or integrated with car **604'**. For purposes of illustration, car **604'** is only partially shown, with wheels **605** and body **607**. Preferably, device **602'** is integrated with existing car electronics **618**. For example, car electronics **618** typically include a speedometer and tachometer, and other gauges for fuel and overheating. Device **602'** thus preferably integrates and communicates with car electronics **618**, as illustrated by overlapping dotted lines between items **602'** and **618**. Device **602'** also communicates desired metric information to spectators **612** (either directly or through computer relay **608***a*). Device **602'** thus includes a wireless transmitter **620** and antenna **622** to generate wireless data **606'**.

[**0311**] Data relayed to spectators **612** can be of varied format. Device **602'** can for example be an MMD with a detector providing acceleration information. Acceleration data in the form of "g's" and impact is one preferred data communicated to spectators **612** through wireless data **606'**. Car **604'** may in addition have accelerometers as part of car electronics; and device **602'** preferably communicates on-board acceleration data as wireless data **606'**. Device **602'** and car electronics **618** can for example include a speedometer, accelerometer, tachometer, gas gauge, spin sensor, temperature gauge, and driver heart rate sensor. An on-board computer can further provide position information about car **604'** position within the current race (e.g., 4^{th} out of fifteen racecars). Accordingly, device **602'** collects data from these sensors and electronic sources and communicates one or more of the following information as wireless data **606'**: racecar speed, engine revolutions per minute, engine temperature, driver heart rate, gas level, impact, g's, race track position, and spin information. As described in connection with the monitor devices above, data **606'** may be continually transmitted or transmitted at timed sequence intervals, e.g., every minute. Data **606'** may also be transmitted when an event occurs, e.g., when a major impact is reported by a device **602'** (e.g., in the form of an MMD) such as when car **604'** experiences a crash. A spin sensor also preferably quantifies rollover rate, acceleration and total rotations (e.g., four flips of the car is 1440 degrees).

[**0312**] FIG. **44** shows one crowd data device **608***b'* constructed according to the invention. Device **608***b'* in one embodiment is a cell phone constructed and adapted to interpret information from wireless data **606'** (or data **610**). Device **608***b'* can also be a receiver such as receiver **24** of FIG. **1**. Device **608***b'* preferably includes a display **621** to display metrics acquired from information within wireless data **606'** (and/or data **610**). Communications port **623** and antenna **624** capture data **606'** and/or **610**. An internal processor decodes and drives display **621**. On-Off button **628** turns device **608***b'* on and off. Car selector button **630** provides for selecting which car **604'** to review data from. Data mode button **632** provides for selecting which data to view from selected car **604'**.

[**0313**] Data captured by device **608***b'* may be from one car or from multiple cars **604**. Car selection button **630** can be pressed to capture all data **606'** from all cars, or only certain data from one car, or variants thereof. In one embodiment, the update rate transferred as wireless data **606'** from any car **604'** to any crowd data device is about one second; and so each device generally acquires data from one car at any one time and "immediately" (i.e., within about one second) acquires data from another car if selected by button **630**. Alternatively, all data **606'** from all cars **604** are communicated and captured to each device **608***b'*. This alternative mode however uses more data bandwidth to devices **608***b'*.

[**0314**] Accordingly, users of crowd data device **608***b'* may view performance and data metrics from any car of choice during a race. Currently, spectators only have a vague feel for what is actually happening to a car at a race between multiple cars **604**. With the invention, a spectator can monitor her car of choice and review data personally desired. One spectator might for example be interested in the driver heart rate of one car; one other spectator might for example be interested in the speed of the lead car; yet another spectator might for example be interested in the temperature of the top four cars; most spectators are concerned about which car is the lead car. In accord with the invention, each spectator may acquire personal desired data in near real time and display it on individual crowd data devices in accord with the invention. Data captured from system **600** can further be relayed to the Internet or to broadcast media through computer relay **608***a*, if desired, so that performance metrics may be obtained at remote locations and, again, in near real time.

[**0315**] The invention also provides for displaying certain data at display scoreboard **614**. Computer relay **608***a* may in addition connect to race officials with computers that quantify or collate car order and other details like car speed. Such data can be relayed to individuals through crowd data devices **608***b* or through scoreboard **614**, or both.

[**0316**] System **600** may be applied to many competitive sports. For example, when the data capture device is like an MMD, system **600** can be applied to sports like hockey, basketball, football, soccer, volleyball and rodeos. An MMD in the form of an adhesive bandage, described above, is particularly useful. Such an MMD can for example be applied with football body armor or padding, as illustrated in FIG. **45**. FIG. **45** shows a football player's padding **650** with an MMD **652**. MMD **652** can be applied external to padding **650**, though it is preferably constructed internally to padding **650**. MMD **652** operates like a data capture device **602** of system **600** (FIG. **42**). MMD **652** can for example capture and relay impact information to spectators of a football game, where each of the players wears body armor or padding such as padding **650**, to provide performance metrics for all players and to individual spectators. Impacts from blows between players may then be obtained for any player for relay to any spectator or user of the Internet according to the teachings of the invention. Device **652** can alternatively include other detectors, e.g., heart-rate detectors, to monitor fitness and tiredness levels of athletes in real time; preferably, in this aspect, MMD **652** attaches directly to the skin of the player.

[**0317**] Likewise, an MMD of the invention is effectively used in rodeo, as shown in FIG. **46**. Preferably one MMD **654** attaches to the saddle **656** of the animal **658** ridden in the rodeo (or to the horn of a bull, or to a rope attached to the animal), and one MMD **660** attaches to the rider **662** on

animal **658**. Each MMD generates a signal, similar to signals **154**, **156** of FIG. **8**A. As such, data from each MMD **654**, **660** can be compared to the other to assess how well rider **662** rides in saddle **656**. This comparison may be beneficially used in judging, removing subjectivity from the sport. For example, by attaching MMD **660** with the pant-belt **662**A of rider **662**, if signals from MMDs **654**, **660** collate appropriately, then rider **662** is efficiently riding animal **658**. Of course, one MMD **654** or **660** can also be used beneficially to report metrics such as impact to the audience.

[**0318**] FIG. **47** shows a representative television or video monitor display **678** of a bull **670** and bull rider **672**, as well as a plurality of MMDs **674**A-D attached thereto to monitor certain aspects of bull and rider activity, in accord with the invention. Display **678** also includes a graphic **676** providing data from one or more of MMDs **674** so that a view of display **678** can review movement metric content associated bull and/or rider activity. In exemplary operation, MMD **674**A is attached to back rope **680** so as to monitor, for example, rump bounce impacts and frequency; MMD **674**B is attached to rider rope **682** so as to monitor, for example, loosening of the grip of rider **672** onto bull **670**; MMD **674**C is attached to bull horn **684** so as to monitor, for example, bull head bounce and frequency; and MMD **674**D is attached to rider **672** so as to monitor, for example, rider bounce and frequency, and impact upon being thrown from bull **670**. A sensor (not shown) may also attach to the rider's foot or boot, if desired. MMDs **674** can for example be coupled to a reconstruction computer and receiver **152** of FIG. **8**A, so as to process multiple MMDs **674** and to report meaningful data to a television, scoreboard and/or the Internet. Data collected from MMDs **674** in one embodiment are collated and stored in a database so as to characterize bull strength and throwing efficiency over time. For example, by looking at magnitude and frequency of acceleration data from MMD **674**C over time for a particular bull provides detail as to how the bull behaves over time. Professional bull riding media can then better gauge which bulls to use for which riders and events.

[**0319**] Those skilled in the art should also appreciate that MMDs **674** can include different detectors providing data desired by sports media. For example, if the MMD contains a linear accelerometer, linear motion forces are reported; if the MMD contains a rotational accelerometer, rotational forces are reported. These MMDs may be placed on various parts of bull **670** or rider **672**, such as on the body and head. Data from MMDs may be relayed to television, scoreboards and/or the Internet. Data collated on the Internet preferably includes bull and rider performance summaries.

[**0320**] FIG. **48** shows one EMD or MMD **684** constructed according to the invention. EMD or MMD **684** has specific advantages as a "wearable" sensor, similar to MMD **10**", FIG. **2**. EMD or MMD **684** utilizes "flex strip"**688** (known in the art) to mount mini-PCBs **686** (devices **686** can also be silicon chips) directly thereto. As a whole, EMD or MMD **684** can "wrap" about objects and persons to fulfill the variety of needs disclosed herein. By way of example, EMD or MMD **684** is useful for comfortable attachment to the rodeo rider **662**, FIG. **46**, such as to monitor and report "impact" events. Another such EMD or MMD **684** may be attached to a bull or rider to monitor and report heartbeat. In one embodiment, a Kapton flex circuit **688** connects battery **690** to the PCBs **686**, and PCBs **686** to one other, so as to flexibly conform to the shape of the underlying object or body. In one option, EMD or MMD **684** is all housed high-density foam or similar flexible housing **694**; this can maximize the EMD or MMD's protection and allow it to be worn close to the object of body. For example, such an EMD or MMD **684** may be worn on the torso of a person, where accurate g-levels seen by the body can be measured. In one embodiment, battery **690** is a plastic Lithium-ion power cell that has a malleable plastic case with any variety of form factor. Other batteries may also be used, in accord with the invention.

[**0321**] The invention of one preferred embodiment employs data taken from monitor devices such as described above and applies that data to video games, arcade games, computer games and the like (collectively a "game") to "personalize" the game to real ability and persons. For example, when a monitor device is used to capture airtime (and e.g., heart rate) of a snowboarder, that data is downloaded to a database for a game and used to "limit" how a game competitor plays the game. In this way, a snowboard game player can compete against world-class athletes, and others, with some level of realism provided by the real data used in the game.

[**0322**] More particularly, one missing link in the prior art between video games and reality is that one a person can be great at a video game and relatively poor at a corresponding real sport (e.g., if the game is a snowboard game, the player may not be a good snowboarder; if the game is a car race, the person may not be a good race car driver; and so on). With performance metrics captured as described herein, the data is applied such that an entirely new option is provided with games. As known in the art, games take the form of PLAYSTATION, SEGA, GAMEBOY, etc.

[**0323**] In operation the invention of the preferred embodiment works as follows. Individuals use a monitor device to measure one or more performance metrics in real life. Data from the monitor devices are then downloaded into a game (or computer running the game) for direct use by the game. Data used in the game may be averaged or it may be the best score for a particular player. By way of example, when the performance metric is "airtime", the option applied to the game allows the game player (typically a teenager) to measure a certain number of airtimes, in real life, and download them into the game so that the air the game player 'catches' during the game corresponds to his real airtime (e.g., best airtime, average airtime, etc.). Data used in games can be collated and interpreted in many ways, such as an individual's best seven airtimes of a day or a personal all time record for an airtime jump.

[**0324**] The effect of the invention applied to games is that game users are somewhat restricted in what they can do. In a ski game, for example, a kid that does not have the natural athletic ability to do flips will not, if the option is selected, be permitted to perform flips in a game. Competitions within games then become far more real. If a kid catches only one second of airtime, on average, then it is unlikely that he can catch three seconds of airtime like Olympic athletes; accordingly, when the gaming option is selected, those kids will not be permitted within the game to throw airtime (and corresponding tricks that require like airtimes) of three seconds or higher, for example. The game restricts them to doing tricks that could actually be completed in their normal airtime.

[0325] There would of course still be elements making the game unrealistic, and fun. The invention applied to games does however add a measure of realism to the games. For example, limiting a game to airtime may restrict movements to certain types, e.g., one flip instead of two. This is one example of how the invention applied to games makes the game much more real. Another gaming option is to permit the gaming user to expand their current real performance by some percentage. For example, a gaming user can instruct the game to permit 100% performance boost to his real data in competitions in the game. In this way, the gaming user knows how far off his real performance is from gaming performance. If for example it takes a 120% performance boost to beat a well-known Olympic athlete, then she knows (at least in some quasi-quantitative measure) how much harder she will need to work (i.e., 20%) to compete with the Olympic athlete.

[0326] Similar limitations to the games may be done with other metrics discussed herein, including drop distance, speed and impact, heart rate and other metrics. For example, by acquiring "impact" data through an MMD of the invention, it is known how much impact a particular athlete achieves during a jump or during a particular activity. By way of example, by collecting impact data from a boxer or karate athlete, it is roughly known the magnitude of impacts that that person endures. Such limitations are applied to games, in accord with other embodiments of the invention. Accordingly, a video game competitor may be limited to actions that he or she can actually withstand in real life. Spin rates too can limit the game in similar ways.

[0327] In the preferred embodiment of the invention, data from monitor devices applied to persons are downloaded as performance metrics into games. These metrics become parameters that are adhered to by the player if the gaming option is selected within the game. The ability to play the game, and the moving of the correct buttons, joystick or whatever, is thus linked to the real sport. By way of example, PLAYSTATION has a 'world championship' for the games. In accord with the invention, game players may now compete with their ability tied to competitions within the game, making it much more realistic on the slopes, vert ramp or other game obstacle.

[0328] In accord with one embodiment, systems like system **600** are also effectively applied to "venues" like skateparks. The data capture devices (preferably in the form of MMDs) are applied to individual users of the venue, e.g., skateboarders. Data acquired from the users are transmitted to a computer relay that in turn connects directly to game providers or Internet gaming sources. The venues are thus linked to games. Resorts with venues such as terrain parks are thus incentivized to make their venue part of the gaming world, where kids play in their park in synthesized video, and then actually use the venue to acquire data for use with the game. By tying competitors together from real venues to gaming, a real venue and a game venue become much more alike. Stigmas associated with playing games may also be reduced because gaming is then tied to reality and kids can participate in meaningful ways, both at the venue and within the game. Kids can then compete based upon real ability at both the game and in real life.

[0329] FIG. **49** shows one network gaming system **700** constructed according to the invention. System **700** operates to collect data from one or more monitor devices **702**, such as through an Internet connection **703** with multiple home users of devices **702**. A server **704** collates performance data and relays parameters to games. By way of example, server **704** relays these parameters to a computer game **705** through Internet connection **706**. Game **705** includes a real personal data module **708** that stores parameters from server **704**. Users of computer game **705** may select an option to invoke the parameters of module **708**, thereby limiting the game as described above.

[0330] As an alternative, users of devices **702** may directly download game parameters to computer game **705**, as through a local data link **710**. Users may also type game parameters directly into module **708**. In either case, computer game **705** has real limiting functions to gaming actions via the invention. Preferably server **704** controls the download of data to computer game **705** so that data is controlled and collated in a master database for other uses and competitions.

[0331] System **700** can further network with an arcade game **720** in a similar manner, such as through Internet connection **718**. Real performance data is again stored in real personal data module **722** in game **720** (or at the computer controlling game **720**) so that users have restrictions upon play. User ID codes facilitate storing and accessing data to a particular person. In this way, users of arcade games can access and limit their games to real data associated with their skill. Competitions between players at arcade games, each with their own real personal data in play, increase the competitiveness and fairness of game playing.

[0332] FIG. **50** illustrates a simplified flow chart of game operation such as described above. A start of a game maneuver starts at step **730**. A start may be initiated by a joy stick action, or button action, for example. Prior to performing the action, the game compares the desired game maneuver with real personal data, at step **732**. At step **734**, a comparison is made to determine whether the requested maneuver is within preselected limits (e.g., within a certain percentage from real personal data) related to the real personal data. If the answer is yes, then the game performs the maneuver, at step **736**. If the answer is no, then the game modifies, restricts or stops the maneuver, at step **738**.

[0333] FIG. **51** shows one speed detection system **800** constructed according to the invention. System **800** includes a ticket reader **802** for each ski lift **804**. For example, reader **802-1** covers ski lift **804-1** to read tickets of persons riding ski lift **804-1**; reader **802-2** covers lift **804-2** to read tickets of persons riding lift **804-2**. Lift **804-1** carries persons (e.g., skiers and snowboarders) between locations "a" and "b"; lift **804-2** carries persons from locations "c" to "d". These persons travel (e.g., by ski or snowboard) from location B to A by approximate distance B-A, from location B to C by approximate distance B-C, from location D to A by approximate distance D-A, and from location D to C by approximate distance D-C.

[0334] Approximate distances B-A, B-C, D-A, D-C are stored in remote computer **806**. Specifically, computer **806** has memory **808** to store distances B-A, B-C, D-A, D-C. Computer **806** and readers **804** preferably communicate by wireless data **810-1**, **810-2**; thus computer **806** preferably has antenna **812**, and associated receiver and transmitter

814, to facilitate communications **810**. Computer **806** further has a processor **816** to process data and to facilitate control of computer **806**.

[**0335**] A representative reader **802'** is shown in FIG. **52**. Reader **802'** has an antenna **820** and transmitter/receiver **822** to facilitate communications **810'** with computer **806**. Among other functions, reader **802'** reads ski lift tickets such as ticket **826** of a person riding lifts **804** via a scan beam **807**. Ticket **826** usually includes a bar code **828** read by reader **802'**.

[**0336**] In operation, a ticket **826** is read each time for persons riding lifts **804**. A time is associated with when the ticket is read and logged into computer **806**. When that ticket **826** again is read, e.g., either at lift **804-1** or **804-2**, a second reading time is logged into computer **806**. Processor **816** of computer **806** then determines speed based upon (a) the two reading times, (b) the approximate lift time for the appropriate lift **804**, and (c) the distance traveled (i.e., one of distances B-A, B-C, D-A, D-C). For example, suppose a person enters lift **804-1** at 9 am exactly and enters lift **804-2** at 9:14 am. Suppose lift **804-1** takes ten minutes, on average, to move a rider from A to B. Accordingly, this person traveled distance B-C in four minutes. If distance B-C is two miles, then that person traversed distance B-C with a speed of 30 mph. If the resort where system **800** is installed sets a maximum speed of 25 mph for the mountain **801**, then that person exceeded the speed and may be expelled from the resort. Note further that the resort may specify speed zones, corresponding to each of the paths B-A, B-C, D-A, D-C. If for example path B-A has a wide path, then a speed may be set at 30 mph. A person successively repeating lift **804-1** may thus be checked for speeds exceeding 30 mph. If on the other hand path D-A has a lot of trees, then a speed of 20 mph may be set; and a rider who rides lift **804-2** and arrives at lift **804-1** can be checked for violations along route D-A.

[**0337**] When a ski lift **804** stops, then additional time is added to that person's journey. A feedback data mechanism tracking lift movement can augment data in computer **806** to adjust skier speed calculations on dynamic basis.

[**0338**] Note that system **800** serves to replace or augment sensor **231'** of FIG. **10**I. Since sensor **231'** independently determines speed, then reader **802** may for example read sensor **231'** to see whether speeds were exceeded for one or more zones. Sensor **231'** may instead have a visual indicator which is triggered when a person exceeds a speed limit in any of zones for B-A, B-C, D-A, D; and a human operator sees the indicator when there is a violation.

[**0339**] As shown in FIG. **53**, one monitor device **840** of the invention incorporates a GPS receiver chip **842** to locate device **840**. Device **840** is preferably integrated with an adhesive strip such as discussed in FIG. **2**. Device **840** also preferably "powers on" when opened and dispensed, such as shown in FIGS. **4** and **10**. In operation, device **840** is generally applied to persons or objects to assess, locate and log "events". By way of example, by attaching device **840** to a new computer shipped to a retailer, an impact event may be recorded and stored in memory **846** by an accelerometer detector **844**, as described above, and a location associated with the impact event is also stored, as provided by GPS chip **842**. As such, for example, the exact amount of damage received by the computer, as well as the exact location of where the damage occurred, is stored in memory **846**. As described herein, other detectors **844** may be used to generate "events" (e.g., a spin event, or an airtime event, temperature, humidity, flip-over events, etc.) in conjunction with GPS chip **842**. Data in memory **846** is relayed to a receiver **850** having data access codes of device **840**. Alternatively, data is communicated to receiver **850** by wireless and timed-sequence transmissions. Communications ports **852**, **854** facilitate data transfers **860** between device **840** and receiver **850**. Transfers **860** may be one way, or two-way, as a matter of design choice. A clock **862** may be incorporated into device **840** to provide timing and/or real-time clock information used to time tag data events from one or both of detector **844** and GPS chip **842**. As above, a battery **864** serves to power device **840**. A processor **848** serves to manage and control device **840** to achieve its functionality.

[**0340**] FIG. **54** shows a system **866** suitable for use with a device **840**, or with other MMDs or EMDs disclosed herein. System **866** has particular advantages in the shipping industry, wherein a device **865** (e.g., device **840**, or one or more EMDs or MMDs) attaches to a package **867** (or to the goods **868** within package **867**) so that system **866** can monitor data associated with shipment of goods and package **868**, **867**. Multiple devices **865** may be attached to package **867** or goods **868** as needed or required to obtain the data of interest. Certain data determined by device **865**, during shipment, include, for example, impact data or g's, temperature, data indicating being inverted, humidity and other metrics. In sum, one or more of these data are wirelessly communicated, as wireless data **863**, to an interrogation device reader **869** to assess the data corresponding to shipment conditions and/or abuse of package **867** and/or goods **868**. Data **863** preferably includes "time tag" data indicating when a certain "event" occurred, e.g., when goods **868** experienced a 10 g event. Preferably, data from reader **869** is further relayed to a remote database **871** so that system **866** may be operated with other similar systems **866** so as to monitor a large amount of packages and goods shipments at different locations. Damaged goods can for example be evaluated by any reader **869** and recorded into a common database **871** by the controlling company.

[**0341**] The invention of FIG. **54** thus has certain advantages. Companies that ship expensive equipment **868** have an incentive to prove to the receiver that any damage incurred was not the result of faulty packaging **867** or unsatisfactory production and assembly. Also, shipment insurers want to know when and where damage occurs, so that premiums may be adjusted appropriately or so that evidence may be offered to encourage the offending party to improve handling procedures.

[**0342**] The monitor devices of the invention have further application in medicine and patient health. One monitor device **870** of the invention is shown in FIG. **55**. Specifically, device **870** attaches to a baby's body **872** (e.g., to a baby's chest, throat, leg, arm, buttocks or back) to monitor movement such as respiratory rate, pulse rate, or body accelerations. Device **870** of the preferred embodiment synchronizes to repetitive movements (e.g., pulse rate or respiratory rate) and generates an "event" in the absence of the repetitive movements. Device **870** can for example be device **10***w*, FIG. **2**E, facilitating easy placement on the infant by the adhesive strip (which is also beneficially sterilized) to measure heart rate as an event. Device **870** can

alternatively be a monitor device using a microphone to detect "breathing" as a health metric for the infant. Regardless of the metric, the event reported by device **870** is preferably communicated immediately as wireless signals **874** to a remote monitor **876**, with an antenna **878** to receive signals **874**. Monitor **876** is preferably portable so as to be carried with the infant's parents. Monitor **876** generates an audible or visual alarm when an event is received from signals **874**. Device **870** seeks to address the very realistic concern of parents relative to Sudden Infant Death Syndrome, or other illnesses. Device **870** preferably relays a warning event data to alarm monitor **876** within seconds of detecting trouble with the infant. For example, if device **870** detects the absence of heart rate or breathing, the alarm at monitor **876** is made in near real time.

[**0343**] Like other monitor devices herein, device **870** has a detector **870***a* to detect the desired metric. For purposes of illustration, other elements such as the device's communications port and processor are not shown, though reference may be made to FIG. **1** to construct device **870**. In one embodiment, detector **870***a* is a piezoelectric element that generates a voltage signal at every pulse or breath of baby **872**, such as shown and described in FIG. **7**-**7**B. Detector **870***a* may alternatively be an accelerometer arranged to sense accelerations of the infant's chest (or other body portion); and thus chest (or other body portion) accelerations are used to determine the repetitive signal (or simply movement or absence of movement). Preferably, the sensitive axis of the accelerometer is perpendicular to baby body **872**. For example, such an accelerometer can be used to sense accelerations of the baby's chest, rising and falling. In still another embodiment, detector **870***a* is a force-sensing resistor or electro-resistive element generating signals responsive to force or weight applied to device **870**. Such a device is useful to sense when baby body **872** rolls onto device **870**. Yet another detector **870***a* is a Hall Effect detector; that detector within device **870** detects when baby body **872** inverts, that is when the baby rolls over. A roll over event is one particular event of interest by parents; and in this embodiment, a warning signal **874** is generated at each roll over. Detector **870***a* can alternatively be a microphone; and the device's processor processes the sound data to detect recurring audible data indicative of breathing sounds.

[**0344**] Preferably, device **870** is integrated with an adhesive strip **880**; and device **870** and strip **880** form an adhesive bandage monitor device such as described above in connection with FIGS. **2**-**2**D, **8**C. Device **870** and strip **880** are also preferably packaged so as to "power on" when dispensed or used. A wrapper such as described in FIGS. **4**-**4**A may be used; or preferably device **870** and wrapper **880** dispense from a canister **200**, **200'** such as described above in FIGS. **10**-**10**F. In this way, device **870** is conveniently dispensed and applied to baby body **872**, and without contamination and germs.

[**0345**] Those skilled in the art should appreciate that device **870** may also attach to the infant in a variety of places depending on the parent's desire. Device **870** may for example attach to the back or bottom of the infant, and generate an event for every time the infant rolls over.

[**0346**] FIG. **56** shows a flowchart of steps associated with applying and using one monitor device according to the invention. At start **884**, the device is unwrapped and/or dispensed from a container. The device is then applied to a baby's body, preferably as an adhesive bandage package, in step **886**. Once applied, the device synchronizes to baby body movement (such as repetitive movements associated with pulse or respiratory rate), breathing sounds or heart rate, in step **888**. The device then searches for "events" in the form of the absence of repetitive signals, indicating for example the danger of an absence of pulse, heart rate or respiration, in step **890**. In step **892**, the monitor device generates a wireless signal as a warning; that signal is received at a remote receiver at step **894**. Once received, remote receiver generates an audible alarm (e.g., a buzzer sounds) or visible alarm (e.g., an LED is lit), in step **896**. Preferably, steps **890**-**896** occur in less than one or several seconds (e.g., less than five or ten or fifteen seconds). Once the alarm occurs, a parent checks the infant (step **898**) to determine whether the alarm is real and, if needed, to administer aid. If for some reason the alarm was incorrect, the remote receiver is reset (step **898**) and the monitor device continues to assess distressing situations to generate events.

[**0347**] As an alternative, the detector of the monitor device (FIG. **55**) is a temperature (or alternatively a humidity) detector, and the alarm monitor merely tracks infant temperature for worried parents; such a device is useful for sick infants in particular. The temperature sensor can be coupled with other detectors (e.g., heart rate) to provide multiple functions, if desired.

[**0348**] The MMDs and EMDs of the invention thus have several other advantages. They may be used discretely and safely as medical diagnostic and monitoring detectors. With appropriate detectors, EMDs of the invention can for example provide for portable, wireless pulse oxymeters or blood glucose monitors. With the appropriate detectors in MMDs, rehabilitation clinicians would be able to quantitatively monitor metrics such as limb movement and balance. EMDs equipped with certain detectors may find use as real time, remote and inexpensive pH monitors and blood gas monitors.

[**0349**] One MMD **900** of the invention and useful in medical applications is shown in FIG. **57**. MMD **900** is similar to device **10** of FIG. **1**, but in addition (or alternatively) has a detector **902** that senses weight. Detector **902** for example is a force sensing resistor or electro-resistive device. Preferably, MMD **900** is applied to one or more locations at the bottom of a human foot **906** via attachment with adhesive strips **908**. Those skilled in the art should appreciate that MMD **900** can alternatively be located at other locations on the human body. On the occurrence of an "event", MMD **900** generates wireless signals **910** for receipt at a remote receiver **912**, here shown in the form of a watch with antenna **914**. Watch **912** is generally worn by the person having foot **906**.

[**0350**] MMD **900** is preferably in the form of an MMD **10***z* of FIGS. **2**B-**2**C, though with a weight sensing detector. In operation, MMD **900** is first calibrated: all the weight of person with foot **906** is applied to MMD **900** so that detector **902** is calibrated to that entire weight. Alternatively, a separate weight simply calibrates MMD **900**. Thereafter, MMD **900** generates "events" corresponding to fractions of the entire weight that the person with foot **906** applies to MMD **900**. For example, one MMD **900** generates wireless data **910** each time MMD **900** experiences at least one-

fourth the entire weight; that data **910** is converted and displayed on receiver **912**, as shown. In this way, when a cast is applied to a person, MMD **900** may be applied under foot, so that the person may obey doctor's orders to put no more than ¼ weight on foot **906**, for example. As an alternative, MMD **900** is already calibrated to certain weights, e.g., 200 lbs, 180 lbs, etc. A precalibrated MMD **900** may then be applied to 200 lbs persons to generate events as needed. For example, an MMD **900** is used effectively to generate an event, to inform the person, that ½ or ¾ of the person's entire weight is on one foot.

[**0351**] A weight sensing MMD may also take the form of MMD **920**, FIG. **58**. Here, MMD **920** has an array of detectors **922**. Detectors **922** may be force sensing resistors or other weight sensitive elements. Detectors **922** collectively and electrically couple to processor **924**. Other elements (not shown) connect with processor **924**, e.g., a communications port and battery, such as monitor device **10** of FIG. **1**. In operation, MMD **920** senses weight applied to foot **930** while walking or standing. Over time, MMD **920** ascertains the actual weight of the person of foot **930**. Once weight is determined, MMD **920** relays weight information to a remote receiver, e.g., watch **940** with antenna **940***a*, via wireless signals **942**. Receiver **940** displays pertinent data, e.g., what fractional weight is applied onto foot **930**.

[**0352**] In this way, a person may track his or her weight at any time. MMD **920** and receiver **940** may also communicate two-way, so that watch **940** queries MMD **920** for weight data, thereby conserving battery power. Those skilled in the art should appreciate that MMD and receiver **920**, **940** may be configured differently and still be within the scope of the invention. In one embodiment, MMD **920** is integrated with a shoe pad insert to fit into any shoe. Alternatively, MMD **920** is integrated directly into a shoe, as shown in FIG. **59**. Detector **922** may also have fewer or more detectors depending upon design placement of detectors relative to foot **930**; that is, a single detector can be used to measure weight if arranged to accurately detect all or part of a person's weight. In such a configuration, MMD **920** may take the form of an adhesive bandage monitor device with a single detector and applied to the sole of a foot, as shown in FIG. **57**. Preferably, weight is calibrated prior to use (e.g., when shoe is lifted off the ground) so that weight is determined relatively. In another embodiment, selectively positioning elements **922** to high impact areas of foot **930** (e.g., at the ball and heel of foot **930**), the invention monitors impact and improper walking or running events so as to provide corrective feedback to users or doctors.

[**0353**] FIG. **59** shows a shoe-based weight sensing system **950** constructed according to the invention. System **950** has one or more weight sensing detectors **952** coupled to a processing section **954** (and, as a matter of design choice, other components such as shown in device **10** of FIG. **1**)—all arranged with a shoe **956** (or within an insert for shoe **956**). In operation, shoe **956** generates wireless signals **958** for a remote receiver (e.g., watch **940**, FIG. **58**) to inform the person wearing shoe **956** of his or her weight or weight loss. By integrating a transceiver and antenna **959** with processing section **954**, the remote receiver interrogates shoe **956** for weight information. In this way, health conscious persons can wear shoe **956** and learn of their weight at any desired time. Such a shoe **956** is for example useful in determining weight loss. By way of example, a runner may use shoe **956** to determine weight loss in ounces, informing the runner that he or she should drink replacement water. Accordingly, in the preferred embodiment, a runner first calibrates his or her weight prior to a race; then system **950** reports weight loss relative to the calibrated weight. Those skilled in the art should appreciate that alternatives from the foregoing may be achieved without departing from the scope of the invention.

[**0354**] FIG. **60** shows one force-sensing resistor **960** suitable for use with the systems and/or MMD of FIGS. **57**-**59**. Resistor **960** includes resistive material **962** and interdigitated contacts **964**A, **964**B; material **962** forms an electrical path between contact **964**A and contact **964**B. In operation, a force applied to resistor **960** increases the conductivity in the path between contacts **964**A, **964**B. By measuring resistance or conductance between contacts **964**A, **964**B, the applied force onto resistor **960** is known. Typically, resistor **960** is calibrated so that a particular resistance translates into and applied force; as such, a processor such as processor **954** or **924** may be used to monitor and report force at any given time. In one embodiment, force is reported to users in pounds, providing a typically used weight designation for such users.

[**0355**] Preferably, resistor **960** includes flexible polymers as active spring agents as the sensing element for loading conditions. Such polymers provide load-sensing resistors with enhanced performance and with preferable mechanical characteristics.

[**0356**] FIG. **61** shows another weight sensing device **970** constructed according to the invention. Device **970** is formed of a shoe **972** and includes a fluid cavity **974** that displaces and pressurizes with applied force—a force such as provided by a user wearing shoe **972**. A pressure sensor **976**A coupled with cavity **974**, through a small conduit **975**, measures pressure. A processor (e.g., processor **954**, **924** above) coupled with sensor **976**A monitors pressure signals and converts the signals to weight. As above, preferably device **970** is calibrated such that a particular pressure corresponds to a particular weight. Preferably, and for increased accuracy, cavity **974** does not completely displace away from any portion of cavity **974** when a user applies weight to cavity **974** while wearing shoe **972**.

[**0357**] As an alternative to a single cavity **974**, cavity **974** can also be made up of separate fluid cells, as exemplified by sections **974**A, **974**B, **974**C, and **974**D, and multiple sensors **976**A, **976**B. In this embodiment, cavity membrane walls **978** separate sections **974**A, **974**B, **974**C, **974**D; optionally two or more of sections **974**A, **974**B, **974**C, **974**D have an individual pressure sensor monitoring pressure of the particular section, such as sensor **976**A for section **974**D and sensor **976**B for section **974**C. This embodiment is particularly useful in providing highly accurate weight sensing for a user of shoe **972**. Each fluid cell **974**A-D may for example have differing pressurization characteristics to manage the overall weight application of a human foot. For example, cells **974**B, **974**C may be formed with higher pressure cavities as they are, respectively, under the ball or heel of the foot and likely have to accommodate higher pressures (i.e., higher applied weight to those sections). In either event, a processor connected to the several pressure sensors **976**A, **976**B beneficially determines weight as a combination of different pressures of the different fluid cells.

Alternatively, a single pressure sensor **976**A may be used to sequentially measure pressure from various fluid cells **974**A-D; and the processor (not shown) then determines weight based upon the several measurements.

[**0358**] Those skilled in the art should appreciate that the number of cells **974**A-D, and the number of sensors **976**A, **976**B, are a matter of design choice and do-not depart from the scope of the invention; more or fewer cells **974** or sensors **976** may be used without departing from the scope of the invention. Those skilled in the art should also appreciate that a shoe insert can alternatively house cavity **974** (and/or sections **974**A, **974**B); for example, shoe **972** can for example be a shoe insert instead of a shoe—constructed and arranged such that a user applies weight on cavity **974** in use.

[**0359**] A weight-sensing device of the invention, for example as set forth in FIG. **61** may benefit from additional information such as temperature, as fluid pressure characteristics vary with temperature. Accordingly, in one embodiment of the invention, an additional detector is integrated with the processor to monitor temperature. As such, a device **970** for example can include one or more pressure detector **976** and a temperature detector (not shown), both of which input data to the processor for processing to determine weight applied to cavity **974** (or sections **974**A-D).

[**0360**] FIG. **62** shows an alternative arrangement of fluid sections **974'** (e.g., shown as fluid sections **976'**, **1000**, **1004**) integrated with a shoe insert **972'**. Preferably, sections **974'** are integrated within insert **972'**, though FIG. **62** shows sections **974'** external to insert **972'** for purposes of illustration. In operation, a user stepping on insert **972'** pressurizes the various sections **974'**—and a processor (not shown) determines weight based upon pressure data from pressure sensors **976'** connected with the various sections **974'**. Higher pressure areas **1000** and lower pressure areas **1002** are then preferably measured by separate pressure sensors **976'**. One or more pressure conduits **1004** may be used to couple like-pressure areas so that a single sensor **976'** monitors a single like-sensor area.

[**0361**] The invention thus has several advantages in regard to weight loss, monitoring and human fitness. In accord with the above invention, a user of a weight monitoring system or device disclosed herein can review his or her weight at nearly any time. Runners using such a system and device to know their hydration loss; chiropodists may wish to monitor weight distribution over a patient's feet; and athletic trainers may wish to analyze weight distribution and forces. The invention of these figures assists in these areas. In making these measurements, force-sensing resistors may be used; but strain gauge pressure sensors in the shoe may also be used. Preferably, in such embodiments, the bottom surface of the foot is covered by sensors, as weight is not often evenly distributed. Accordingly, a single sensor may not encompass a preferred arrangement, and therefore multiple sensors are preferred in the sole of the shoe (or in a shoe insert), with the results of all sensors summed or combined to a single "weight" answer. In one embodiment, only a portion of the foot need to be covered, covering a certain percentage of the overall weight; and that percentage is scaled to a user's full weight. Weight and compression forces monitored in a shoe or shoe insert, in accord with the invention, can further assist in gauging caloric and/or physical effort.

[**0362**] FIG. **63** shows a professional wrestling rink system **1100** constructed according to the invention. System **1100** has a rink **1102** within which professional wrestlers compete (often times theatrically). Adjacent rink **1102** are tables **1104** and chairs **1106**, sometimes used in conjunction with rink **1102** (e.g., items **1104** and **1106** are sometimes used to smash over a wrestler as part of a performance). A plurality of sensors (e.g., MMDs or EMDs) **1108** are placed (attached, stuck to, etc.) throughout rink, table and/or chairs **1102**, **1104**, **1106**. For example, in one preferred embodiment a plurality of MMD sensors **1108** are placed under rink canvas **1110**, such as at positions marked "x", so as to report "impact" of wrestlers in rink **1102**. MMD sensors **1108** may also be placed on one or more of the corner posts **1112** or ropes **1114**—used to form rink **1102**. Sensors **1108** are shown illustratively in a few positions about items **1102**, **1104**, **1106**, **1110**, **1112**, **1114** for purposes of illustration—when in reality such sensors **1108** would be difficult to see, or would be hidden from view (for example, sensors **1108** are preferably under canvas **1110**).

[**0363**] Data from sensors **1108** typically include information such as impact, as described above. Events associated with "impact" are communicated wirelessly to a receiving computer **1120** as wireless data **1122**. Data **1122** for example includes digital data representing impact data received at any of sensors **1108** when wrestlers hit canvas **1110**, move ropes **1114**, or hit post **1112**. Receiving computer **1120** preferably has an antenna **1124** and communications port **1126** to receive data **1122**. Computer **1120** typically re-processes and then retransmits data **1122** to a media site **1129**, such as television, scoreboard or the Internet, so that viewers may see data **1122** associated with wrestling at rink **1102**. Since wrestling in and about rink **1102** is often based on choreographed action, computer **1120** preferably includes a data manipulation section **1130** which post processes data **1122** in predetermined ways. For example, section **1130** may apply an exponential or quadratic function to data **1122** so that, in effect, and by way of example, a 25 g impact on canvas **1110** is reported as a 25 g impact, but a 50 g impact on canvas **1110** is reported as a 1000 g impact.

[**0364**] Section **1130** may also manipulate data for a particular player. For example, FIG. **64** shows a representative television display **1131** that includes data from system **1100**. FIG. **53** also shows representative wrestlers **1132** in rink **1102**. In a preferred embodiment, one or more sensors **1108** are also placed on wrestlers **1132**, such as shown, to monitor events such as impact received directly on wrestlers **1132**. In one embodiment, sensors **1108** of FIG. **64** are of the form of an adhesive bandage MMD, described above. In another embodiment, sensors **1108** are integrated into the waistband of the wrestler; this has advantages as being close to the wrestler's center of gravity and is thus more representative of total impact received by a particular wrestler.

[**0365**] Data from computer **1120** is thus reported to a media destination **129** such as television so that it may be displayed to audience members. FIG. **64** shows one exemplary data display **1134** overlaid with the actual wrestling performance—for television display **1131**—and showing impact data in "qualitative" bar scales. Display **1134** may include qualitative wording such as shown. Display **1134** also preferably includes an advertiser overlay **1136** promot-

ing a certain brand; typically that advertiser pays for some or all of the content provided for by system **1100** and shown in display **1134**.

[**0366**] Thus, FIGS. **63** and **64** demonstrate benefits in which the TV viewer desires to see information such as a display of forces acting on wrestlers in real- or near real-time; the data being presented in graphical or numeric form and with a range of possible analyses performed on the forces such as latest, largest average and total. These forces typically act in at least two planes i.e. from the side and from the front or back, though the invention may also take account of forces in all three planes. Typically, the forces of interest are those acting on the main mass (torso) of the wrestler, while flailing feet and arms are not generally as important as body slams. The system of the invention thus resolves forces on individuals and can detect the force of collision between two wrestlers.

[**0367**] In the preferred embodiment, at least one sensor **1108** attached to ropes **1114** preferably takes the form of a long thin sensor (e.g., 0.5"×3") with a short piece wire (e.g., 3") protruding from one end to function as the antenna. This sensor's electronics utilizes a small low power accelerometer as the sensing detector, and incorporates a simple gain block, a small micro controller such as Microchips' PIC12LC672, and a small low power transmitter such as RFMs' RX6000 or RF Solutions' TX1. These electronics mount on flex circuit (e.g., as shown in FIG. **48**) to allow for the excessive bending forces likely to be encountered. The power source is preferably a single small (thinnest available) lithium cell.

[**0368**] In the preferred embodiment, at least one sensor **1108** attached to posts **1112** incorporates a gas pressure sensor as the detector; such a sensor is incorporated into the cushions protecting the corner posts **1112** and thus registers an increase reading as the wrestlers collide with the posts Alternatively, such a sensor may be incorporated directly into a cushion attached to post **1112**; preferably such a cushion is airtight. FIG. **61** shows one fluid-based pressure sensor that may be configured to such an application as the cushion with post; gas may for example replace the fluid or gel of FIG. **61**. In an alternative configuration, sensors **1108** integrated with the posts **1112** may include strain gauges as the detector. Mounted directly to the posts **1112**, these sensors indicate the forces acting on the post as the wrestlers impact the posts **1112**. In another alternative, a post sensor may include vibration or accelerometer detector so that the sensor **1108** determines impact forces.

[**0369**] In one embodiment, at least one of the sensors attached to ropes **1114** include extension detectors (or LVDT devices) at the points where the ropes are mounted. Sensors **1108** with strain gauges may also be used. Sensors attached to ropes **1114** preferably detect "rope deflection" as a reported metric.

[**0370**] In one embodiment, sensors **1108** in the floor incorporate piezoelectric cables mounted as an interlocking grid attached to the underside of the floor. For example, such cables connect the "x" locations of FIG. **63**. In such a configuration, only one sensor **1108** may be needed to monitor floor impact as all cables act as a single "detector" for an MMD sensor **1108**. Floor or canvas sensors **1108** may also incorporate strain gages attached in an array on the underside or around the perimeter at points where the floor **1110** is suspended. Vibration sensors and accelerometers may alternatively be used as the detector in any floor-monitoring sensor **1108**.

[**0371**] FIG. **65** shows one surfing application for an MMD **1140** of the invention. MMD **1140** of one preferred embodiment includes an accelerometer detector (e.g., as in MMD **10** above) and MMD **1140** determines "g's" for big bottom turns. On-board signal processing for example preferably determines the location of a big bottom turn and records an "event" associated with the number of G's in the turn. G's may also be reported for other locations. One difficulty with such measurements is that there may be many larger G forces surfboard **1146** from flips, kicks and other actions; however the invention solves this difficulty by filtering out such actions. In one embodiment, the processor within MMD **1140** monitors the low frequency component of the accelerometer detector to determine the difference in the peaks and troughs of sinusoidal movement, so that MMD **1140** reports wave size and height over time.

[**0372**] One MMD **1140** may also gauge the power of a wave landing on top of the surfer **1142**. Such an MMD **1140** preferably includes a pressure detector to determine pressure within water **1144** when a wave lands on surfboard **1146** and on surfer **1142**. A "maximum pressure" event is then reported by MMD **1140**.

[**0373**] Another MMD **1140** includes an inclinometer or other angle determination detector to determine and report angle of the surfboard **1146**; for example a maximum angle is reported for a given run or day.

[**0374**] Data from any particular metric (e.g., g's in a turn, angle of surfboard, pressure under water) provided by MMD **1140** is preferably reported wirelessly to a watch worn by surfer **1142**; however such data may also be displayed on a display integrated with surfboard **1146** or directly with sensor **1140**, such as shown with an airtime sensor in U.S. Pat. No. 5,960,380, incorporated herein by reference. In the form of a wristwatch, one MMD of the invention includes a pressure sensor housed in the watch; the MMD watch then reports the maximum pressure events without need of a separate MMD **1140** mounted to surfboard **1146** (or integrated therein).

[**0375**] In one preferred embodiment, MMD **1140** includes a speed detector (such as a Doppler module or accelerometers as discussed herein or in U.S. Pat. No. 5,960,380) so that surfer speed is reported to surfer **1142**. Preferably, in this embodiment, distance traveled is also reported; by way of example the receiver of data from MMD **1140** (e.g., a digital watch) converts speed to distance by multiplying speed by a time duration traveled over that speed. FIG. **66** shows MMD **1140'** including a Doppler module that radiates energy **1150**, as shown, to determine whether the rider of surfboard **1146'** is within the "green Room"—i.e., within a wave **1152**. Preferably, such an MMD **1140'** also includes a speed sensor which indicates that board **1146'** is in motion so that the time duration of riding within the Green Room is determined accurately.

[**0376**] FIG. **67** shows a personal network system **1300** constructed according to the invention. System **1300** keeps track of personal items, such as cell phone **1302**, car keys **1304**, wallet or purse **1306**, personal data assistant **1308**, digital watch **1309**, and/or personal computer **1310**. Addi-

tional, fewer or different personal items can be tracked in system **1300**, at the selection of a user of system **1300**. For example, a user can set up system **1300** to keep track of cell phone **1302** and keys **1304** only. Briefly, each personal item of FIG. **67** includes a network transceiver: cell phone **1302** has transceiver **1302***a*, car keys **1304** has transceiver **1304***a*, wallet or purse **1306** has transceiver **1306***a*, data assistant **1308** has transceiver **1308***a*, watch **1309** has a transceiver **1309***a*, and computer **1310** has transceiver **1310***a*. Each transceiver **1302***a*, **1304***a*, **1306***a*, **1308***a*, **1309***a*, **1310***a* communicates with every other transceiver substantially all the time via a wireless link **1320**. Those skilled in the art appreciate that each transceiver **1302***a*, **1304***a*, **1306***a*, **1308***a*, **1309***a*, **1310***a* include an antenna to receive and communicate data on link **1320**. In the preferred embodiment, each transceiver **1302***a*, **1304***a*, **1306***a*, **1308***a*, **1309***a*, **1310***a* only maintains communications with any other transceiver over a selected distance, e.g., 100 feet, herein identified as the Network Distance. For example, cell phone transceiver **1302***a* maintains communications with every other transceiver **1304***a*, **1306***a*, **1308***a*, **1309***a*, **1310***a* so long as cell phone **1302** is within the Network Distance of every other device **1304**, **1306**, **1308**, **1309**, **1310**. However, for example, once cell phone **1302** is separated by keys **1304** by more than the Network Distance, then cell phone **1302** ceases communications with keys **1304** but maintains communications with other items **1306**, **1308**, **1309**, **1310** (assuming items **1306**, **1308**, **1309**, **1310** are within the Network Distance from cell phone **1302**).

[**0377**] In one preferred embodiment, each transceiver **1302***a*, **1304***a*, **1306***a*, **1308***a*, **1309***a*, **1310***a* includes a Bluetooth microchip and transceiver known in the art. Bluetooth transceivers only maintain a communication link (at a frequency of about 2.4 GHz in the ISM band) over a short range, e.g., 50 feet, and are not generally suitable for longer communication distances.

[**0378**] Optionally, one or more of transceivers **1302***a*, **1304***a*, **1306***a*, **1308***a*, **1309***a*, **1310***a* are instead transponders; and at least one of items **1302***a*, **1304***a*, **1306***a*, **1308***a*, **1309***a*, **1310***a* provide excitation energy to the transponders to "reflect" data along link **1320** to provide the functionality described herein. Those skilled in the art should appreciate that items **1302***a*, **1304***a*, **1306***a*, **1308***a*, **1309***a*, **1310***a* may incorporate other technology, such as transmitters, to facilitate like functionality. That is, not every item **1302**, **1304**, **1306**, **1308**, **1309**, **1310** needs to transmit and receive data on link **1320**. For example, wallet **1306** can include a transmitter instead of a transceiver to provide data about itself on link **1320**; and other items **1302**, **1304**, **1308**, **1309**, **1310** can use wallet data to know whether it is in the network or not (even though wallet **1306** does not know whether other items **1302**, **1304**, **1308**, **1309**, **1310** are in the network). Transponders can provide like functionality for certain items **1302**, **1304**, **1306**, **1308**, **1309**, **1310** as a matter of design choice.

[**0379**] Wireless link **1320** includes information about time and items in the network; preferably the information also includes location information. For example, data **1320** informs each item **1302-1310** that every other item is still within the network, and, thus, that one or more items have not moved to beyond the Network Distance. If one item—e.g., keys **1304**—leaves the network so that item **1304** no longer communicates on link **1320**, every other item **1302**, **1306**, **1308**, **1310** knows that item **1304** is no longer linked and data is stored on every other item **1302**, **1306**, **1308**, **1310** indicating a time when item **1304** left the network. Preferably, the stored data in every other item also includes where the network was when keys **1304** disappeared.

[**0380**] In the simplest embodiment, each of items **1302-1310** includes a corresponding indicator **1302***b*-**1310***b*; each of indicators **1302***b*-**1310***b* can for example be a LED, LCD, buzzer or vibrator. When any of items **1301-1310** are "lost" from the network—e.g., one item moves beyond the Network Distance—then the indicator in one or more of the other items tells the user of system **1300** that an item has "left". That person can then expend effort to location the lost item. By way of example, each of indicators **1302***b*-**1310***b* may provide a beep, sound or vibration to provide the user with knowledge of a lost item **1302-1310**.

[**0381**] In a more complex embodiment, data stored on any item **1302-1310** indicating the loss of any item within network **1300** is a "cookie" of information detailing when and where an item left the network. In this way, a user of system **1300** can locate and find the lost item by reviewing cookies in any other item. By way of example, consider a network **1300** made from keys **1304**, wallet **1306**, digital watch **1309** and cell phone **1302**—items commonly carried by a male business person. In the preferred embodiment, this person would designate items **1302**, **1304**, **1306**, **1309** as being "in network" (such as described below in connection with FIG. **68**)—and system **1300** thereafter monitors items **1302**, **1304**, **1306**, **1309** so that the person can keep track of items **1302**, **1304**, **1306**, **1309**. If for example this person leaves his cell phone **1302** in a restaurant, then items **1304**, **1306**, **1309** know this occurred and inform him of the time, and preferably the location, of when cell phone **1302** was lost. Thus for example, watch **1309** can light an LED (as indicator **1309***b*) that an item is lost; item **1304** can indicate (through a LCD indicator **1304***b*) that cell phone **1302** was lost in cell area corresponding to downtown Boston at 15:15 pm. Specifically, in one embodiment, cell phone **1302** provides "location" information of at least a cell area; and cell phone **1302** provides "time" information by its real time clock (those skilled in the art appreciate that keys **1304**, digital watch **1309** or any other item can also include a real time clock as a matter of design choice). Accordingly, link **1320** has location and time information updated to each item **1304**, **1306**, **1309**. In leaving his cell phone at the restaurant, keys **1304**, wallet **1306**. watch **1309** receive "cookie" deposited in internal memory indicating when and where cell phone **1302** left the network of items **1302**, **1304**, **1306**, **1309**. Accordingly, the person reviews data in either of items **1304**, **1306**, **1309** to learn of where he left his cell phone. Note that if he then lost item **1304**, he may also learn something of when item **1304** left the smaller network of items **1304**, **1306**, **1309** depending upon time and location data available. Those skilled in the art appreciate that cell phone technology enables more precise location information of where a cell phone is; and preferably this information will be provided to network system **1300** so that more precise location information is available to all network items. GPS receiver chips may also be incorporated into any of items **1302-1310** to provide the location information as described herein in connection with system **1300**.

[**0382**] Users of system **1300**"program" which items are in the network preferably through a personal computer inter-

face, shown in FIG. **68**. In FIG. **68**, a personal computer **1312** connects with a transceiver controller **1314** to program a network transceiver **1316***a* (representative of any transceiver **1302***a*, **1304***a*, **1306***a*, **1308***a*, **1309***a*, **1310***a*, for example). Controller **1314** preferably includes a transceiver that wirelessly communications with transceiver **1316***a* via a data control link **1321**. Computer **1312** provides security and ID information so that items networked in system **1300** are secure relative to other users with other networks. By way of example, computer **1312** may provide an password key that is only known and used by items of network **1300**; so that other items of other networks does not communicate on link **1320**.

[**0383**] Note that a "wallet" or "purse" do not generally have electronics associated therewith, to provide the functionality described above. Therefore, in the preferred embodiment, a transceiver **1306***a* is "attached" to a wallet or purse to provide the underlying electronics. By way of example, such a transceiver takes the form of a credit card inserted into the wallet or purse. FIG. **69** illustrates one non-electronic item **1340**, e.g., a wallet **1306**, attached to a transceiver **1340***a* suitable for construction as an attachment like a smart card. Transceiver **1340***a* can for example include a Bluetooth microchip **1324***a* or alternatively a transmitter or transponder **1324***b*. A GPS receiver **1322** can alternatively be included with transceiver **1340***a*. An antenna **1326**, if needed, provides for communication along link **1320**, FIG. **67**. An LCD or LED data interface provides data and/or warnings to users reviewing item **1340** (and specifically transceiver **1340***a*). A user interface **1340***c* permits access to and/or modification of data or functionality of transceiver **1340***a*. A real time clock **1330** preferably provides time data for time stamping "lost" item information onto network link **1320**, so that a user would know when item **1340** (or other items) were lost. In the preferred embodiment, a cookie memory stores "events" associated with lost items—e.g., a cell phone was lost at GPS coordinates X,Y at noon, providing obvious benefit in finding the lost item.

[**0384**] FIG. **70** and FIG. **71** show an electronic drink coaster **1400** constructed according to the invention. Internal electronics **1402** sense the weight of a drink **1404** on coaster **1400** to automatically inform a restaurant or bar, via wireless signals **1406** to a restaurant or bar receiver **1408**, that the customer needs a drink or refill. In one embodiment, a customer can also place an order from coaster **1400**. Liquid (e.g., beer) **1410** may be used to calibrate electronics **1402** so that electronics **1402** knows when glass **1412** is full or empty, to report the information as data **1406**.

[**0385**] FIG. **71** shows a top plan view of coaster **1400**, including customer order or calibration buttons **1410***a*, **1410***b*. Electronics **1402**, typically internal to coaster **1400**, include a weight detector **1420**, communications port **1422**, processor **1424**, and antenna **1426**; electronics **1402** are similar in design to many of the MMDs or EMDs described herein. Weight detector **1420** detects weight on coaster **1400**; and processor **1422** decides how to use the weight information in a meaningful way. By way of example, processor **1422** knows the approximate weight of glass **1412** onto weight detector **1420**, and once glass **1412** is filled with beer it also knows when glass **1412** is empty—creating one reporting event to bar receiver **1408**, if desired. Users of coaster **1400** can also select inputs to coaster electronics **1402** so as to place orders, wirelessly, to restaurant receiver **1408**. For example, a user of coaster **1400** can order "another beer" by pressing button **1410***a*. Other order functions can of course be included with coaster **1400**, including an LED **1430** that provides the status of orders, sent to coaster **1400** via receiver **1408**.

[**0386**] FIG. **72** shows a package management system **1500**, and sensor **1502**, of the invention. Sensor **1502** (e.g., an MMD or EMD described herein) may be integrated directly with a shipping label **1504** for attachment to a box or envelope to ship products, goods or other material. Sensor **1502** includes an integrated circuit **1502**A, a communications port **1502**B and a battery **1502**C to communicate data (e.g., impact, temperature, humidity) experienced by label **1504** to external devices. By way of example, a remote receiver **1508** may be used to interrogate or read data from sensor **1502**. In the preferred embodiment, sensor **1502** also includes a unique package identifier (e.g., like a bar code) so as to identify label **1504** and the goods associated therewith. A receiver **1508** linked to a transportation channel of label **1504** (e.g., a transportation channel traveled by a shipping truck **1510**) may then communicate with sensor **1502**, e.g., via wireless link **1505**, to determine whether label **1504** is in the correct channel. Accordingly, sensor **1502** helps track label **1504** and may further prevent theft of packages linked to label **1504** since the wireless system may automatically determine inappropriate location of label **1504**. A remote wireless relay tower **1512** may communicate with receiver **1508** so as to manage and track label **1504** movement and location during shipment. The invention may augment or even replace manual scanning of labels for shipping packages; the invention may also prevent theft of packages by automatically identifying inappropriate packages in shipment channels.

[**0387**] In the preferred embodiment, a dispenser **1514** may contain several labels similar to label **1504**; dispenser preferably issues label **1504** in a manner similar to canister **200**, FIG. **10**, so as to "power on" label **1504** with an internal time stamp. A location code and/or time code are thus preferably communicated from dispenser **1514** to sensor **1502** when label **1504** issues **1516** from dispenser **1514**.

[**0388**] FIG. **73** shows a product integrity tracking system **1600** of the invention. One or more sensors **1602** (e.g., each of the sensors being an MMD or EMD) attach to a customer product **1604**. Preferably, sensors **1602**"stick" to product **1604** similar to MMDs or EMDs discussed herein. Product **1604** may be any product of value, including, for example, medical devices, computers, furniture and pharmaceuticals (in the case of pharmaceuticals, sensors **1604** may for example attach to packaging containing the pharmaceuticals, or be arranged adjacent to product **1604**, such as indicated by sensor **1602**A). Typically, product **1604** initiates shipment along a shipping channel at the customer facility **1610** (e.g., a plant or laboratory). The company of facility **1610** may for example independently attach sensors **1602** to product **1604**. A shipping channel may for example include a separate shipping company such as FED EX with a truck **1612**. At the conclusion of travel, product **1604** reaches its destination **1614** (e.g., a place controlled by the customer of the company of facility **1610**). At destination **1614**, sensors **1604** are read through wireless link **1619** by an interrogating device **1620** so as to see how product **1604** fared during travel. The shipping company may have persons **1622** to take the reading or this may occur automati-

cally at destination **1614**. Data acquired from sensor **1602** may for example include impact (or "acceleration information") and temperature, each preferably with a time stamp help track event occurrences (e.g., an acceleration event greater than 10 g's at 9:10 AM, Monday). Multiple sensors **1602** provide for detecting event occurrences at different locations on product **1604**. This is particularly useful for complex medical devices that may have a relatively sturdy base and a fragile robotic arm, each with different performance specifications (e.g., each with a maximum load allowance); sensors **1602** may thus each attach to separate area of product **1604** so that product integrity information **1619** may be determined for multiple locations. Data from device **1620** may communicate automatically, via link **1621**, and back to facility **1610** through network **1630** (e.g., the Internet) and through a firewall **1632** so as to communicate product integrity information, in near real-time, to the company of product **1604**. In this way, this company may better manage its brand integrity of product **1604** during shipment. If a damaging event occurred to product **1604**, during shipment, that company will learn about it and may ship a replacement product (or move to refurbish product **1604**).

What is claimed is:

1. A movement monitor device, comprising:

a detector for generating a signal in response to movement of the device;

a real time clock;

a processor for processing the signal to generate one or more movement events and for time-tagging the movement events with time information from the clock; and

a first communications port and a receiver, wherein the first communications port wirelessly communicates events, tagged with the time information, to the receiver and wherein the first communications port communicates the events to the receiver substantially continuously, the receiver having a second communications port for receiving the events and for reconstructing the substantially continuous events to generate media signals suitable for display with broadcast media.

2. A device of claim 2, wherein the receiver communicates the media signals to one of Television or the Internet.

3. A movement monitor device, comprising:

a detector for generating a signal in response to movement of the device;

a real time clock;

a processor for processing the signal to generate one or more movement events and for time-tagging the movement events with time information from the clock;

a first communications port for communicating events, tagged with the time information, to a receiver remote from the device; and a receiver selected from the group of MP3 players, electronic PDAs, digital watches, cell phones and pagers, for receiving the events and relaying the events to a user.

4. A device of claim 3, further comprising headphones connected with the receiver for synthesizing the events as voice data to the user.

5. A movement monitor device, comprising:

a detector comprising an accelerometer for generating an acceleration signal in response to movement of the device;

a real time clock;

a processor for processing the acceleration signal to detect and generate one or more impact events and for time-tagging the impact events with time information from the clock; and

a first communications port for communicating events, tagged with the time information, to a receiver remote from the device.

6. A movement monitor device, comprising:

a detector comprising an accelerometer for generating an acceleration signal in response to movement of the device;

a real time clock;

a processor for processing the acceleration signal to detect and generate one or more power events and for time-tagging the power events with time information from the clock; and

a first communications port for communicating events, tagged with the time information, to a receiver remote from the device.

7. A movement monitor device, comprising:

a detector comprising an accelerometer for generating an acceleration signal in response to movement of the device;

a real time clock;

a processor for processing the acceleration signal to detect and generate one or more jarring events and for time-tagging the jarring events with time information from the clock; and

a first communications port for communicating events, tagged with the time information, to a receiver remote from the device.

* * * * *