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(54) Fall detector apparatus and computer software product for controlling such apparatus

(57) A fall detector apparatus 1 is disclosed. A housing 2 adapted to be worn by a user contains an impact detector 3 and an orientation detector 7. A processor 9 receives output signals from the impact detector 3 and orientation detector 7 and activates an alarm generator means 12 if an amount of a plurality of time intervals, following an impact to the impact detector 3, spent by the user in a horizontal orientation exceeds a threshold value.

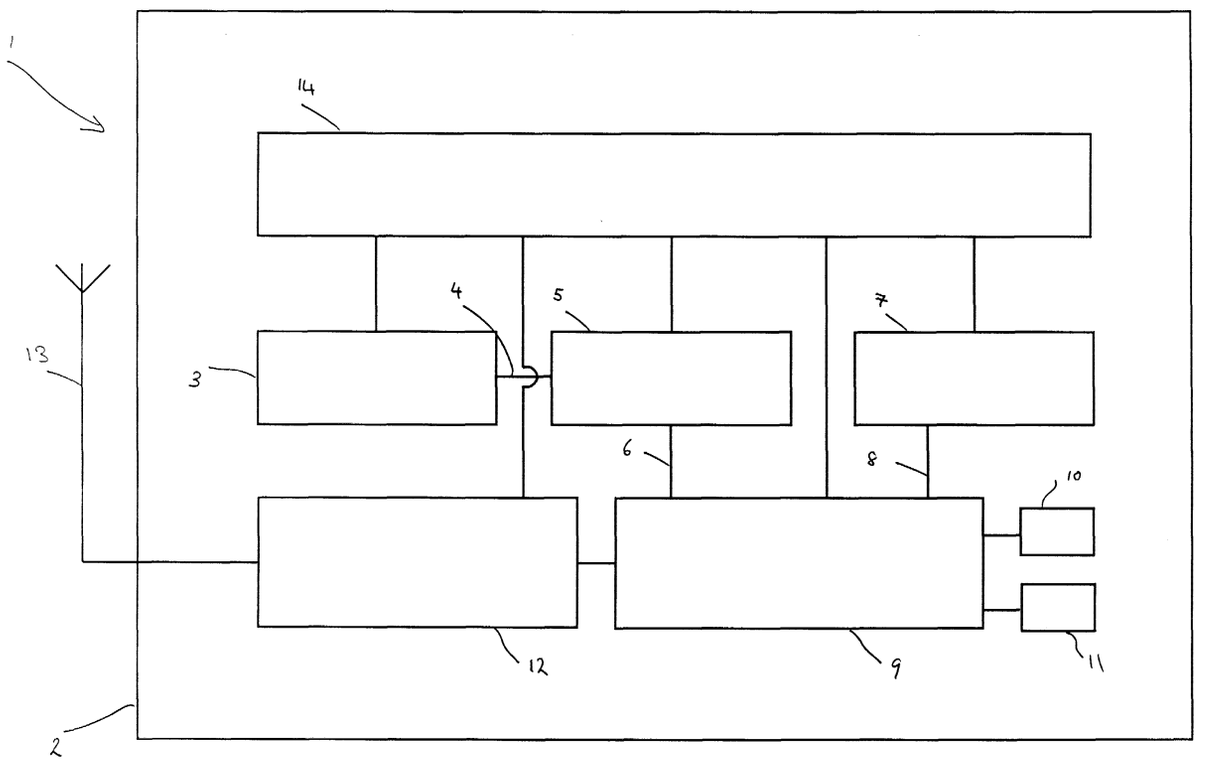

FIG. 1

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Description

[0001] The present invention relates to a fall detector apparatus and relates particularly, but not exclusively, to fall detector apparatus for use by infirm persons such as the elderly. The invention also relates to a method of detecting a fall by means of such apparatus, and a computer software product for controlling such apparatus.

[0002] Alarm apparatus are known for use by elderly or infirm persons living alone or in sheltered accommodation. Such apparatus is designed to be manually operated in an emergency situation to summon assistance, for example by automatically initiating an alarm call to an external control centre. However, prior art apparatus of this type suffers from the drawback that if the user of the apparatus should fall and lose consciousness or otherwise become incapacitated, the user may be prevented from manually activating the apparatus to summon assistance.

[0003] An attempt to overcome this problem is disclosed in UK Patent Application No GB2323196, which relates to an automatic fall alarm designed to be worn on the clothing of a user, for example clipped to a belt, and which can automatically generate an alarm signal in response to an impact on the device if certain conditions are not met, such as the user re-setting the apparatus to indicate that there is no emergency. The device includes an impact detector such as an accelerometer, and an attitude monitor which can detect whether the user is horizontal after an impact and supply signals to a processor which executes an algorithm to decide whether to generate an alarm signal, based upon data about the number, frequency and severity of impact above a minimum threshold.

[0004] Although this prior art device goes some way to automatically generating alarm signals in response to a fall by a user, it suffers from the drawback that false alarms are frequently generated, i. e. alarm signals may be generated in response to non-emergency situations. For example, an alarm signal may inadvertently be generated in response to the user simply bending down to pick up an object. Furthermore, it is possible for an emergency situation following a fall by a user to fail to be detected by the apparatus because the user is not motionless on the ground.

[0005] Preferred embodiments of the present invention seek to overcome the above disadvantages of the prior art.

[0006] According to an aspect of the present invention, there is provided a fall detector apparatus comprising:

a housing adapted to be worn by a user;

impact detector means connected to the housing for generating a first signal in response to an impact thereto;

orientation detector means connected to the housing for producing a second signal indicative of whether the user is in a substantially horizontal or substantially vertical orientation;

processor means for receiving said first and second signals and generating a respective third signal indicating whether an amount of each of a plurality oftime intervals, following an impact to the impact detector means, spent by the user in a substantially horizontal orientation exceeds a respective threshold value and generating a fourth signal based on said third signals; and

alarm means for generating at least one alarm signal in response to at least one predetermined said fourth signal.

[0007] By observing an amount of each of a plurality of intervals following an impact which the user spends in a substantially horizontal orientation, this provides the advantage of improving the quality of automatic assessment carried out by the processor means regarding whether an alarm signal should be generated, thus minimising the incidence of false alarms.

[0008] In a preferred embodiment, said processor means includes prioritising means for allocating greater significance to a said third signal for a later said interval than for an earlier said interval

[0009] By attaching greater importance to third signals from later intervals than from earlier intervals, this provides the advantage that the apparatus takes greater note of the user remaining in a predominantly horizontal orientation for a significant period after an impact, or failing to recover sufficiently to stand up.

[0010] The processor means may include multiplier means for multiplying a plurality of said third signals by a respective coefficient and summing means for summing said multiplied third signals to provide said fourth signal.

[0011] The processor means in use preferably generates each said third signal of larger magnitude when said amount of the corresponding interval exceeds the respective threshold value than when it does not.

[0012] This provides the advantage offacilitating processing of signals by the device by increasing the magnitude of signals corresponding to the user being in a predominantly horizontal orientation.

[0013] The device may be adapted to enter a power saving mode if no alarm signal is generated.

[0014] The processor means may be adapted to generate said third signals only if said amount of an initial interval spent by the user in a substantially horizontal orientation exceeds a predetermined value.

[0015] The device may be adapted to enter a power saving mode if said amount of said initial interval does not exceed said predetermined value.

[0016] The impact detector means preferably gener-

ates a first signal dependent upon the acceleration applied thereto.

[0017] The impact detector means may comprise a plurality of accelerometers.

[0018] The apparatus preferably further comprises discriminator means for causing the processor means to generate said third signals only in response to impacts exceeding a predetermined magnitude.

[0019] This provides the advantage of minimising the extent to which false alarms are generated by minor impacts.

[0020] The orientation detector may comprise at least one electronic inclinometer

[0021] The apparatus may further comprise removal detector means for detecting removal of the housing from the user.

[0022] The removal detector means is preferably connected to a clothing attachment clip.

[0023] According to another aspect of the present invention there is provided a method of operating a processor means in a fall detector apparatus to detect whether a user has fallen, the apparatus comprising:

a housing adapted to be worn by a user;

impact detector means connected to the housing for generating a first signal in response to an impact to said housing;

orientation detector means connected to the housing for producing a second signal indicative of whether the user is in a substantially horizontal or substantially vertical orientation;

processor means for receiving said first and second signals; and

alarm means actuable by said processor means for generating at least one alarm signal;

wherein the method comprises the steps of:

generating a respective third signal indicating whether an amount of each of a plurality of time intervals, following an impact to the impact detector means, spent by the user in a substantially horizontal orientation exceeds a respective threshold value;

generating a fourth signal based on said third signals; and

actuating said alarm means in response to at least one predetermined said fourth signal.

[0024] The method may further comprise the step of allocating greater significance to a said third signal for a later said interval than for an earlier said interval.

[0025] The method preferably further comprises the step of multiplying a plurality of said third signals by a respective coefficient and summing said multiplied third signals to provide said fourth signal.

[0026] The method preferably further comprises the step of generating each said third signal of larger magnitude when said amount of the corresponding interval exceeds the respective predetermined value than when it does not.

[0027] The method may further comprise the step of entering a power saving mode if no alarm signal is generated.

[0028] The method may further comprise the step of generating said third signals only if an amount of an initial interval spent by the user in a substantially horizontal orientation exceeds a predetermined value.

[0029] The method may further comprise the step of entering a power saving mode if said amount for said initial interval does not exceed said predetermined value.

[0030] The method preferably further comprises the step of generating said third signals only in response to impacts exceeding a predetermined magnitude.

[0031] According to a further aspect ofthe present invention, there is provided a computer programme element for operating a processor means of a fall detector apparatus to detect whether a user has fallen, the apparatus comprising:

a housing adapted to be worn by a user;

impact detector means connected to the housing for generating a first signal in response to an impact to said housing;

orientation detector means connected to the housing for producing a second signal indicative of whether the user is in a substantially horizontal or substantially vertical orientation; processor means for receiving said first and second signals; and

alarm means actuable by said processor means for generating at least one alarm signal;

wherein the computer programme element comprises;

computer programme code means to make the processor means (i) generate a respective third signal indicating whether an amount of each of a plurality of time intervals, following an impact to the impact detector means, spent by the user in a substantially horizontal orientation exceeds a respective threshold value; (ii) generate a fourth signal based on said third signals; and (iii) actuate said alarm means in response to at least one predetermined said fourth signal.

[0032] By providing a computer programme element for operating the processor means, this provides the advantage that apparatus can under certain circumstances be upgraded to take advantage of improvements in the operating algorithm of the apparatus. For example, upgrades to the operating software of the device could be provided on a carrier or downloaded from the Internet.

[0033] The computer programme element preferably further comprises computer programme code means for allocating greater significance to a said third signal for a later said interval than for an earlier said interval.

[0034] In a preferred embodiment, the code means in use multiplies each of a plurality of said third signals by a respective coefficient and sums said multiplied third signals to provide said fourth signal.

[0035] The computer programme element may further comprise computer programme code means to make the processor means generate each said third signal of larger magnitude when a said amount of the corresponding interval exceeds the respective predetermined value than when it does not.

[0036] The computer programme element may further comprise computer programme code means to make the apparatus enter a power saving mode if no alarm signal is generated.

[0037] The computer programme element may further comprise computer programme code means to make the processor means generate said third signals only if the said amount of an initial interval spent by the user in a substantially horizontal orientation exceeds a predetermined value.

[0038] The computer programme element may further comprise computer programme code means for causing the apparatus to enter a power saving mode if said amount for said initial interval does not exceed said predetermined value.

[0039] The computer programme element preferably further comprises computer programme code means for causing said processor means to generate said third signals only in response to impacts exceeding a predetermined magnitude.

[0040] A preferred embodiment of the invention will now be described, by way of example only and not in any limitative sense, with reference to the accompanying drawings in which:-

Figure 1 is a block diagram of a fall detector apparatus embodying the present invention; and

Figure 2 is a flow diagram showing operation of a decision algorithm carried out by a processor of the apparatus of Figure 1.

[0041] Referring in detail to Figure 1, a fall detector apparatus 1 for detecting a fall by a user comprises a housing 2 to be attached to the clothing of a user, for example to a garment by means of a clip (not shown). An impact detector 3 detects changes in acceleration applied thereto, such as an accelerometer which will be familiar to persons skilled in the art, for example the EG&G IC Sensors Model 3022. The electrical output signal 4 from the accelerometer 3 is input to a discriminator 5 for generating an output signal 6 in response to impacts above a threshold magnitude.

[0042] An orientation detector 7, for example an electronic inclinometer, such as the Eurosensor "Cline" Model 100013-01, or other device which will be familiar to persons skilled in the art, generates an output signal 8 dependent upon the orientation of the housing 2 (i.e whether the housing is horizontal or vertical). The output signal 8 therefore depends upon whether the user wearing the apparatus 1 is standing vertically or lying horizontally.

[0043] The output signals 6 and 8 are fed to a processor 9, such as a microprocessor, which also receives outputs from a removal detector switch 10 which detects removal of the apparatus 1 from clothing of the user (for example by being connected to a clothing attachment clip) and from a re-set switch 11, the purpose of which will be described in greater detail below.

[0044] An output signal of the processor 9 is fed to an alarm generator means 12 which generates an alarm signal for feeding to an antenna 13 to transmit an alarm signal to a remote location. For example the alarm generator means 12 may cause an emergency call to a control centre to be dialled on the public telephone network The accelerometer 3, discriminator 5, orientation detector 7, processor 9 and alarm generator 12 are powered by means of a power supply 14.

[0045] Referring to Figure 2, in response to the discriminator 5 generating an output signal 6 indicating that the accelerometer 3 has detected an impact above a threshold value, the processor 9 operates at step S10 on the output signal 8 from orientation detector 7 to determine the percentage of time spent by the user in a horizontal orientation during an initial interval of x seconds. If this percentage is determined at step S12 to be less than a threshold value, the processor 9 determines that no emergency situation exists (for example because the user, having fallen over, has stood up again) and the apparatus passes into a power saving mode at step S14, in which only a limited number of the components of the apparatus 1 are supplied with power from power supply 14, in order to preserve the lifetime of the power supply 14.

[0046] If, on the other hand, the percentage is determined at step S12 to be greater than the threshold value, at step S16, the processor measures the percentage of time spent in a generally horizontal orientation in a further interval of x seconds. At step S18, it is determined whether that percentage is greater than or less than a threshold value, a variable P_n being set to 0 at step S20 if the percentage is less than the threshold value and set to 1 at step S22 if the percentage is greater than the threshold value. The process then passes to step S24,

after which the steps S16 to S24 are repeated n times. After the loop S16 to S24 has been repeated n times, the sum $\sum w_i P_i$ for i=0 to i=n is determined, the variable w_i representing a weighting factor which increases with increasing values of i, so that greater significance is allocated to the user being in a horizontal orientation in the later intervals. If the sum $\sum w_i P_i$ is determined at step S26 to be less than a predetermined threshold value, the processor 9 determines that no emergency situation exists, and the apparatus returns to the power saving mode at step S14. If, on the other hand, the sum exceeds the threshold value, a fall alarm is generated at step S28.

[0047] Referring again to Figure 1, a reset button (not shown) provided on the housing may be actuated by the user to actuate reset switch 11 to prevent an alarm signal being transmitted via antenna 13 if no emergency situation exists.

[0048] It will be appreciated by persons skilled in the art that the above embodiment has been described by way of example only, and not in any limitative sense, and that various alterations and modifications are possible without departure from the scope ofthe invention as defined by the appended claims.

Claims

1. A fall detector apparatus comprising:

a housing adapted to be worn by a user;

impact detector means connected to the housing for generating a first signal in response to an impact thereto;

orientation detector means connected to the housing for producing a second signal indicative of whether the user is in a substantially horizontal or substantially vertical orientation;

processor means for receiving said first and second signals and generating a respective third signal indicating whether an amount of each of a plurality of time intervals, following an impact to the impact detector means, spent by the user in a substantially horizontal orientation exceeds a respective threshold value and generating a fourth signal based on said third signals; and

alarm means for generating at least one alarm signal in response to at least one predetermined said fourth signal.

2. An apparatus according to claim 1, wherein said processor means includes prioritising means for allocating greater significance to a said third signal for a later said interval than for an earlier said interval.

3. An apparatus according to claim 2, wherein said processor means includes multiplier means for multiplying a plurality of said third signals by a respective coefficient and summing means for summing said multiplied third signals to provide said fourth signal.

4. An apparatus according to any one of the preceding claims, wherein said processor means in use generates each said third signal of larger magnitude when said amount of the corresponding interval exceeds the respective threshold value than when it does not.

5. An apparatus according to any one of the preceding claims. wherein said apparatus is adapted to enter a power saving mode if no alarm signal is generated.

6. An apparatus according to any one of the preceding claims, wherein said processor means is adapted to generate said third signals only if said amount of an initial interval spent by the user in a substantially horizontal orientation exceeds a predetermined value.

7. An apparatus according to claim 6, wherein said device is adapted to enter a power saving mode if said amount of said initial interval does not exceed said predetermined value.

8. An apparatus according to any one of the preceding claims, wherein said impact detector means generates a first signal dependent upon the acceleration applied thereto.

9. An apparatus according to claim 8, wherein the impact detector means comprises a plurality of accelerometers.

10. An apparatus according to any one of the preceding claims, further comprising discriminator means for causing the processor means to generate said third signals only in response to impacts exceeding a predetermined magnitude.

11. An apparatus according to any one of the preceding claims, wherein the orientation detector comprises at least one electronic inclinometer.

12. An apparatus according to any one of the preceding claims, further comprising removal detector means for detecting removal of the housing from the user.

13. An apparatus according to claim 12, wherein the re-

moval detector means is connected to a clothing attachment clip.

14. A method of operating a processor means in a fall detector apparatus to detect whether a user has fallen, the apparatus comprising:

a housing adapted to be worn by a user;

impact detector means connected to the housing for generating a first signal in response to an impact to said housing;

orientation detector means connected to the housing for producing a second signal indicative of whether the user is in a substantially horizontal or substantially vertical orientation;

processor means for receiving said first and second signals; and

alarm means actuable by said processor means for generating at least one alarm signal;

wherein the method comprises the steps of:

generating a respective third signal indicating whether an amount of each of a plurality of time intervals, following an impact to the impact detector means, spent by the user in a substantially horizontal orientation exceeds a respective threshold value;

generating a fourth signal based on said third signals; and

actuating said alarm means in response to at least one predetermined said fourth signal.

15. A method according to claim 14, further comprising the step of allocating greater significance to a said third signal for a later said interval than for an earlier said interval.

16. A method according to claim 15, wherein said step of allocating greater significance comprises multiplying a plurality of said third signals by a respective coefficient and summing said multiplied third signals to provide said fourth signal.

17. A method according to any one of claims 14 to 16, further comprising the step of generating each said third signal of larger magnitude when said amount of the corresponding interval exceeds the respective predetermined value than when it does not.

18. A method according to any one of claims 14 to 17, further comprising the step of entering a power saving mode if no alarm signal is generated.

19. A method according to any one of claims 14 to 18, further comprises the step of generating said third signals only in response to impacts exceeding a predetermined magnitude.

20. A method of operating a processor means in a fall detector apparatus to detect whether a user has fallen, the apparatus comprising:

a housing adapted to be worn by a user;

impact detector means connected to the housing for generating a first signal in response to an impact to said housing;

orientation detector means connected to the housing for producing a second signal indicative of whether the user is in a substantially horizontal or substantially vertical orientation;

processor means for receiving said first and second signals; and

alarm means actuable by said processor means for generating at least one alarm signal;

the method substantially as hereinbefore described with reference to the accompanying drawings.

21. A computer programme element for operating a processor means of a fall detector apparatus to detect whether a user has fallen, the apparatus comprising:

a housing adapted to be worn by a user;

impact detector means connected to the housing for generating a first signal in response to an impact to said housing;

orientation detector means connected to the housing for producing a second signal indicative of whether the user is in a substantially horizontal or substantially vertical orientation; processor means for receiving said first and second signals; and

alarm means actuable by said processor means for generating at least one alarm signal;

wherein the computer programme element comprises;

computer programme code means to make the processor means (i) generate a respective third

signal indicating whether an amount of each of a plurality of time intervals, following an impact to the impact detector means, spent by the user in a substantially horizontal orientation exceeds a respective threshold value; (ii) generate a fourth signal based on said third signals; and (iii) actuate said alarm means in response to at least one predetermined said fourth signal.

22. A computer programme element according to claim 21, further comprising computer programme code means for allocating greater significance to a said third signal for a later said interval than for an earlier said interval.

23. A computer programme element according to claim 22, wherein the code means in use multiplies a plurality of said third signals by a respective coefficient and sums said multiplied third signals to provide said fourth signal.

24. A computer programme element according to any one of claims 21 to 23, further comprising computer programme code means to make the processor means generate each said third signal of larger magnitude when a said amount of the corresponding interval exceeds the respective predetermined value than when it does not.

25. A computer programme element according to any one of claims 21 to 24, further comprising computer programme code means to make the apparatus enter a power saving mode if no alarm signal is generated.

26. A computer programme element according to any one of claims 21 to 25, further comprising computer programme code means to make the processor means generate said third signals only if the said amount of an initial interval spent by the user in a substantially horizontal orientation exceeds a predetermined value.

27. A computer programme element according to claim 26, further comprising computer programme code means for causing said processor means to generate said third signals only in response to impacts exceeding a predetermined magnitude.

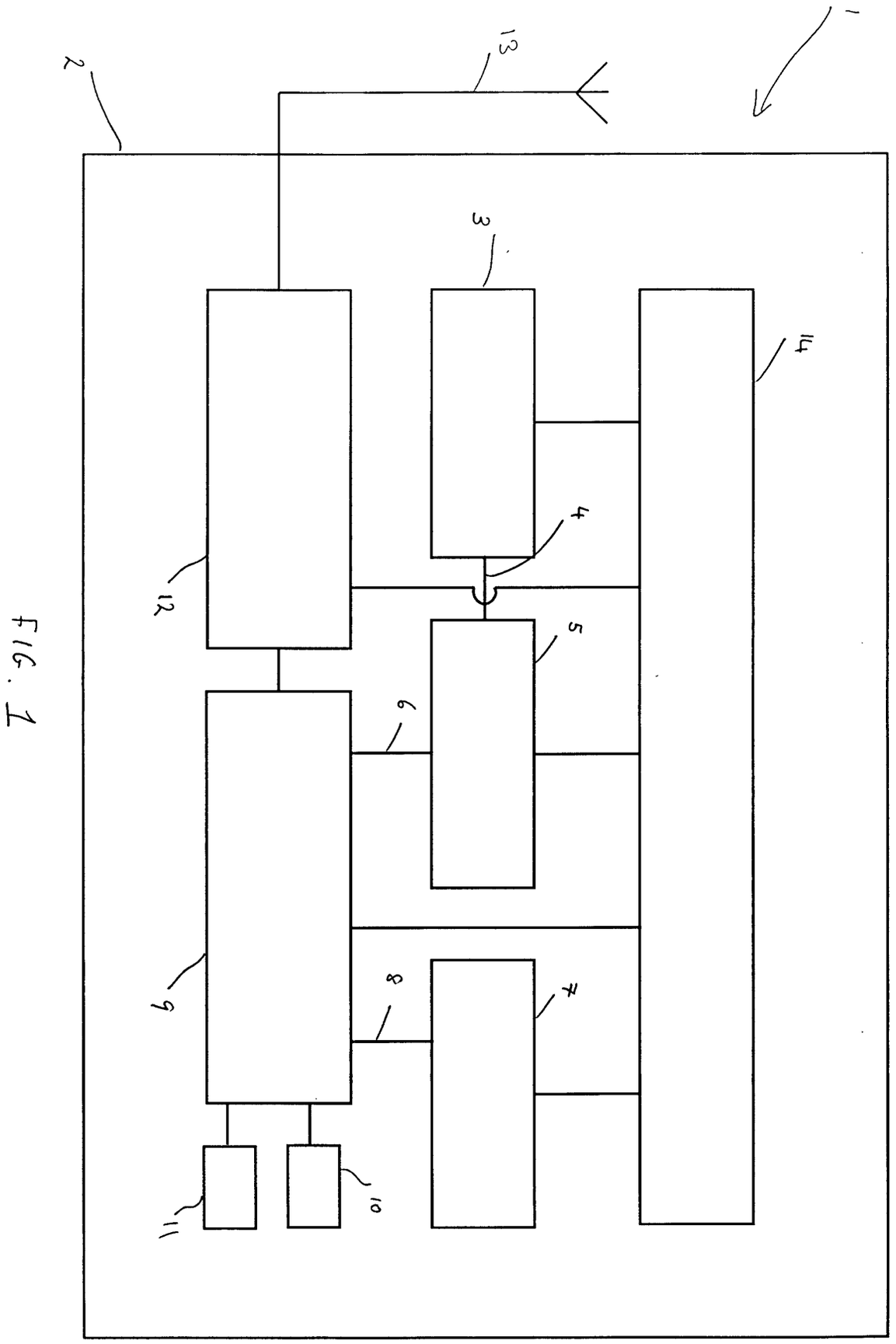

FIG. 1

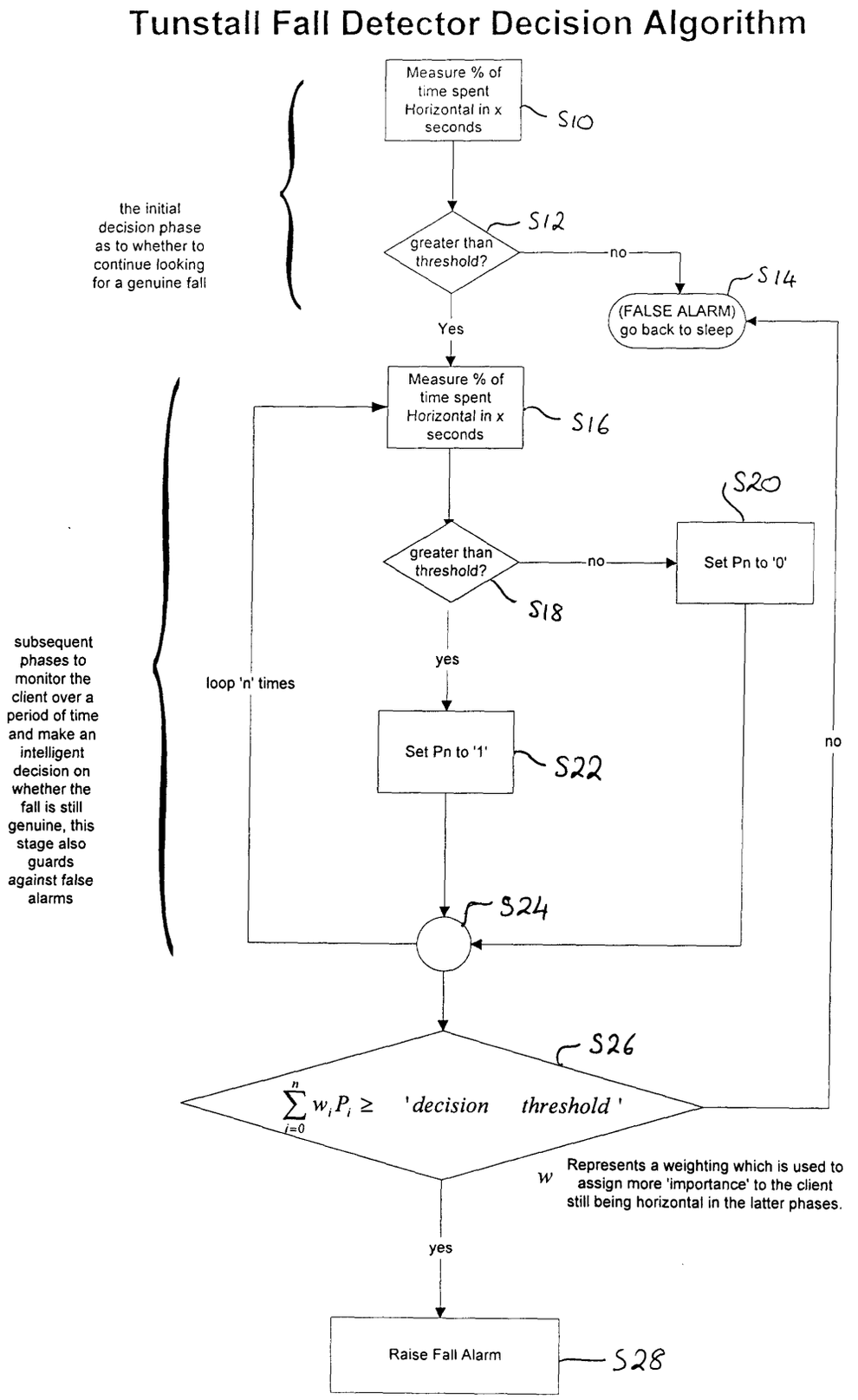
Tunstall Fall Detector Decision Algorithm
Measure % of time spent Horizontal in x seconds
S10
the initial decision phase as to whether to continue looking for a genuine fall
greater than threshold?
S12
no
S14
(FALSE ALARM) go back to sleep
Yes
Measure % of time spent Horizontal in x seconds
S16
S20
greater than threshold?
no
Set Pn to '0'
S18
subsequent phases to monitor the client over a period of time and make an intelligent decision on whether the fall is still genuine, this stage also guards against false alarms
yes
loop 'n' times
Set Pn to '1'
S22
no
S24
S26
$\sum_{i=0}^{n} w_i P_i \geq$ 'decision threshold'
w
Represents a weighting which is used to assign more 'importance' to the client still being horizontal in the latter phases.
yes
Raise Fall Alarm
S28

FIG. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 30 1297

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	EP 0 877 346 A (SUISSE ELECTRONIQUE MICROTECH) 11 November 1998 (1998-11-11)	1-3,6, 12, 14-17, 20-24,26	G08B21/00
Y	* column 1, line 48 - column 2, line 2 * * column 2, line 36 - line 54 * * column 3, line 17 - line 27 * * column 3, line 46 - line 53 * * column 4, line 15 - line 24 * * column 4, line 35 - line 40 * * column 4, line 45 - line 49 * * claim 1 * * claims 2,3 *	13,25	

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Y	An automated translation of the document is available at the website of the IPDL, Japanese Patent Office See also WPI Abstract. * paragraphs [0008],[0020]-[0022],[0024] * * figures 5,6 *	13,25	
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	* page 2, line 12 - line 28 * * page 3, line 3 - line 20 * * page 3, line 25 - line 29 *		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 April 2001	De la Cruz Valera, D

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 01 30 1297

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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27-04-2001

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82