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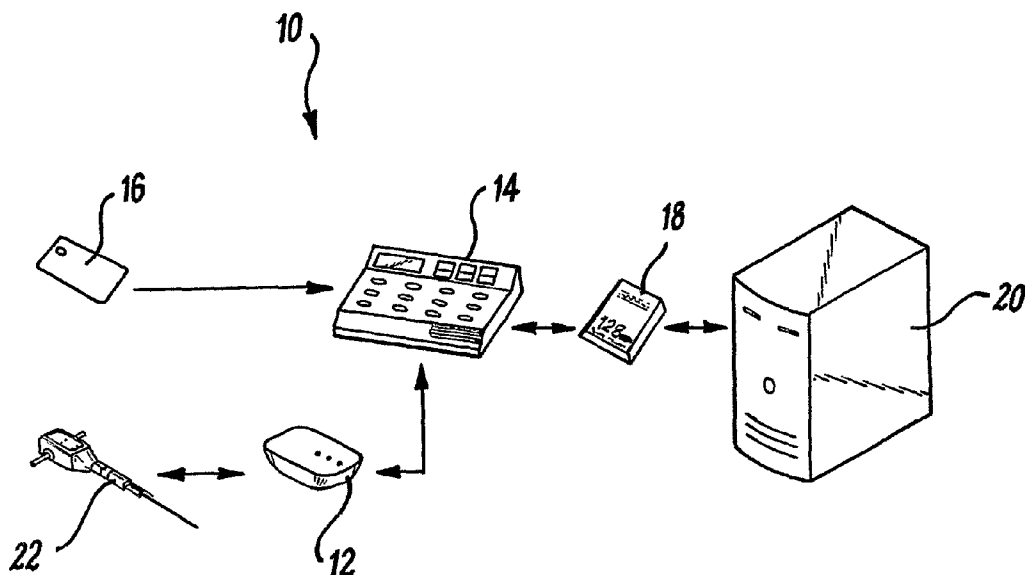
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(54) Title: MONITORING APPARATUS AND METHOD



(57) Abstract: The present invention relates to hand held tool monitoring apparatus (10). The hand held tool monitoring apparatus (10) comprises a mount, which in use of the hand held tool monitoring apparatus forms part of a hand held tool (22), and a monitoring component (12) configured to be releasably attached to the mount. The monitoring component (12) comprises an operative part of the hand held tool monitoring apparatus (10) and the hand held tool monitoring apparatus further comprises a vibration sensor and a timer. The vibration sensor is operable to sense vibration of the hand held tool (22) and to provide a vibration signal in response to sensed vibration when the monitoring component is attached to the mount. The timer is operative in dependence on the vibration signal to record a duration of vibration of the hand held tool (22).

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1 **Title: Monitoring Apparatus and Method**

2
3 Field of the invention

4
5 The present invention relates to a monitoring
6 apparatus and method and in particular a hand held tool
7 monitoring apparatus and method.

8
9 Background to the invention

10
11 Many hand held or hand guided tools transmit
12 vibration to the hands and arms of the operator. It is
13 known that such transmitted vibration, which is often
14 termed Hand Arm Vibration (HAV), can cause painful and
15 disabling diseases, such as white finger, following
16 regular long term exposure.

17 Apparatus for monitoring exposure to HAV inducing
18 tools is known. GB 2411472A describes a vibration
19 monitor that is worn by the operator. The vibration
20 monitor of GB 2411472A comprises a vibration sensor and
21 memory. The vibration sensor measures the magnitude and
22 frequency of vibration of a tool being used by the
23 operator, the magnitude and frequency of vibration being

1 stored in the memory along with a time and date stamp.
2 GB 2413189A describes a vibration monitor that is held by
3 an operator. The vibration monitor comprises a vibration
4 sensor and processing electronics. The vibration sensor
5 measures the vibration of a tool being used by the
6 operator and the processing electronics determines the
7 operator's cumulative exposure to the vibration and
8 provides an indication to the operator before exposure to
9 the vibration exceeds a safe level. GB 2299168A
10 describes a vibration monitor that is worn on the wrist
11 of an operator. The vibration monitor comprises a
12 vibration sensor and processing electronics. The
13 vibration sensor measures vibrations experienced by the
14 operator during use of a tool and the processing
15 electronics operates an alarm when an accumulated time
16 that the vibration level exceeds a predetermined
17 threshold exceeds a predetermined duration.

18 The present inventor has appreciated that the above
19 described apparatus have disadvantages.

20 It is therefore an object of the present invention
21 to provide apparatus for measuring vibration of a hand
22 held tool.

23 It is a further object of the present invention to
24 provide apparatus for measuring a duration of vibration
25 of a hand held tool.

26 27 Statement of Invention

28
29 The present invention has been devised in the light
30 of the above noted appreciation and thus from a first
31 aspect there is provided hand held tool monitoring
32 apparatus comprising a mount, which in use of the hand
33 held tool monitoring apparatus forms part of a hand held

1 tool, and a monitoring component configured to be
2 releasably attached to the mount, the monitoring
3 component comprising an operative part of the hand held
4 tool monitoring apparatus, the hand held tool monitoring
5 apparatus further comprising a vibration sensor and a
6 timer, the vibration sensor being operable to sense
7 vibration of the hand held tool and provide a vibration
8 signal in response to sensed vibration when the
9 monitoring component is attached to the mount, and the
10 timer being operative in dependence on the vibration
11 signal to record a duration of vibration of the hand held
12 tool.

13 In use, the monitoring component is either attached
14 to the mount on the hand held tool or forms part of the
15 hand held tool and the hand held tool is operated.
16 Vibration produced by the hand held tool is sensed by the
17 vibration sensor and the timer is operative in dependence
18 thereon to record a duration of the vibration. When use
19 of the tool is complete, the monitoring component can be
20 removed from the mount. Thus, the monitoring component
21 can, for example, be used by an operator on another hand
22 held tool. The inventors have appreciated that measuring
23 vibrations directly on the tool, in contrast to GB
24 2411472A, GB 2413189A and GB 2299168A, can provide for
25 more accurate and reliable measurement of vibration
26 experienced by the operator. More specifically, the
27 accuracy and reliability of the apparatus of GB 2411472A,
28 GB 2413189A and GB 2299168A can depend on how the
29 apparatus is used. For example, if a tool is gripped
30 with a hand other than the hand or arm supporting the
31 known apparatus, the vibration level or duration may not
32 be measured properly. Furthermore, measurement of
33 vibration by the known apparatus is affected by where the

1 apparatus is worn or how the apparatus is held. As the
2 vibration sensor forms part of either the mount or the
3 monitoring component, which, in use, is attached to a
4 hand held tool to be monitored, the present invention
5 involves measurement of vibration directly on the hand
6 held tool and yet provides for removal of the monitoring
7 component from the tool. Thus, the monitoring component
8 can be used, for example, to provide a record of
9 vibration exposure for a particular operator.

10 More specifically, the monitoring component may be
11 configured to be carried by an operator.

12 More specifically, the monitoring component may be
13 of a size that permits the monitoring component to be
14 received in a pocket of an operator.

15 Alternatively or in addition, the monitoring
16 component may be configured for use by a particular
17 operator. For example, the monitoring component may
18 comprise a code, perhaps in electronic form, identifying
19 the monitoring component as being for use with the
20 particular operator.

21 Alternatively or in addition, the mount may be
22 configured to be attached to the hand held tool. For
23 example, the mount may be attached by means of bolts,
24 rivets or similar such means that provides for permanent
25 attachment of the mount to the tool.

26 Alternatively or in addition, the mount may form an
27 integral part of the hand held tool. For example, the
28 mount enclosure may be integrally formed with a casing of
29 the hand held tool.

30 More specifically, the hand held tool and the hand
31 held tool monitoring apparatus may be configured to
32 switch off the hand held tool when a predetermined
33 condition is satisfied.

1 More specifically, the hand held tool and the hand
2 held tool monitoring apparatus may be configured to
3 switch off the hand held tool by stopping supply of power
4 to operate the hand held tool.

5 Alternatively or in addition, the predetermined
6 condition may comprise at least one of: a vibration level
7 value being reached; and an incorrect licence being
8 provided for the hand held tool monitoring apparatus. In
9 the case of a vibration value being reached, the
10 predetermined condition may be satisfied when a vibration
11 level or recorded duration of vibration exceeds a
12 predetermined threshold, such as a threshold indicative
13 of a vibration dose level being exceeded. In the case of
14 an incorrect licence being provided, a user may have to
15 enter identification information to the monitoring
16 component identifying him as the user of the monitoring
17 component and, hence, of the hand held tool. The
18 provision of a check on the licence can reduce the
19 likelihood of an unauthorised person using the hand held
20 tool or the likelihood of a person whose vibration dosage
21 rate has been exceeded using the hand held tool.

22 Alternatively or in addition, the mount and
23 monitoring component may be configured to be detached
24 from each other by a single manual operation by a user.
25 For example, the monitoring component may be separated
26 from the mount by the user pulling the monitoring
27 component away from the mount or twisting the monitoring
28 component in relation to the mount.

29 Alternatively or in addition, the monitoring
30 component and the mount may comprise respective
31 cooperating magnetic components that in use provide for
32 releasable attachment of the monitoring component to the

1 mount. Thus, the monitoring component may be detached
2 rapidly from the mount by a user.

3 Alternatively or in addition, the monitoring
4 component and the mount may have respective surface
5 profiles configured to engage with each other to provide
6 for releasable attachment of the monitoring component to
7 the mount.

8 More specifically, the mount may define a recess
9 configured to receive at least a part of a body of the
10 monitoring component.

11 Alternatively or in addition, the monitoring
12 component may comprise a power switch that is configured
13 to switch on the monitoring component when the monitoring
14 component is attached to the mount.

15 More specifically, the power switch may comprise at
16 least one of: an electrically actuated switch; and a
17 mechanically actuated switch. The electrically actuated
18 switch may be magnetically actuated. For example,
19 electrically actuated switch may be a reed switch. The
20 mechanically actuated switch may be a push button switch.
21 Thus, where a push button switch is used, the monitoring
22 apparatus may be configured such that attaching the
23 monitoring component to the mount actuates the push
24 button switch.

25 Alternatively or in addition, the mount may comprise
26 hand held tool information for the hand held tool to
27 which the mount is attached.

28 More specifically, the mount may be configured to
29 convey the hand held tool information to the monitoring
30 component.

31 More specifically, the mount may comprise a
32 communications component operable to wirelessly convey

1 the hand held tool information to the monitoring
2 component.

3 More specifically, the communications component may
4 be passive. For example, the communications component
5 may be an RFID tag.

6 More specifically, the monitoring component may be
7 operable to actuate the passive communications component
8 and receive hand held tool information conveyed from the
9 mount.

10 Alternatively or in addition, the hand held tool
11 information may comprise hand held tool identification
12 information. Such identification information may, for
13 example, be a serial code for the hand held tool to which
14 the mount is attached.

15 Alternatively or in addition, the hand held tool
16 information may comprise hand held tool vibration
17 information.

18 More specifically, the hand held tool vibration
19 information may comprise a predetermined vibration dosage
20 rate. The vibration dosage rate may be a value of
21 vibration created by the hand held tool when in use over
22 a predetermined period of time. The vibration dosage
23 rate may be predetermined on the basis of a
24 manufacturer's specification or on the basis of
25 measurements made on the hand held tool, e.g. at the
26 location of the trigger handle on the hand held tool.

27 Alternatively or in addition, where the vibration
28 sensor is configured to be responsive to vibrations in
29 three mutually orthogonal axes the hand held tool
30 vibration information may comprise vibration axis
31 information regarding which measurement axis or
32 combination of axes is to be used for measurement or
33 detection of vibrations.

1 Alternatively or in addition, the monitoring
2 component may be configured to provide a vibration
3 exposure value in dependence upon the vibration dosage
4 rate conveyed from the mount and the duration of
5 vibration recorded by the timer.

6 More specifically, the monitoring component may be
7 configured to multiply the vibration dosage rate by the
8 duration of vibration recorded by the timer to provide a
9 vibration exposure value.

10 Alternatively or in addition, the vibration sensor
11 may comprise at least one vibration sensor, such as at
12 least one tri-axial accelerometer.

13 More specifically, the vibration sensor may comprise
14 a plurality of vibration sensors.

15 Alternatively or in addition, the monitoring
16 apparatus may be configured to be operative in dependence
17 upon at least one of a plurality of vibration signals.

18 More specifically, the monitoring apparatus may be
19 configured to be operative in dependence upon a selected
20 one of the plurality of vibration signals. For example,
21 the plurality of vibration signals may differ from each
22 other as regards a particular characteristic, such as
23 range of detectable acceleration, sensitivity, noise,
24 range of vibration frequency or axis of vibration.

25 In a form, the vibration sensor may be configured to
26 be responsive to a plurality of ranges of detectable
27 acceleration and to provide a vibration signal for each
28 range. Thus, the monitoring apparatus may be configured
29 to select a vibration signal of greatest amplitude from
30 the plurality of vibration signals. For example, where
31 the vibration sensor comprises three accelerometers with
32 a first accelerometer tuned to be responsive to a low
33 level of maximum acceleration, a second accelerometer

1 tuned to be responsive to a medium level of maximum
2 acceleration and a third accelerometer tuned to be
3 responsive to a high level of maximum acceleration, the
4 vibration signal of greatest amplitude can be selected.

5 In another form, the vibration sensor may be
6 configured to be responsive to vibrations in three
7 mutually orthogonal axes and to provide a vibration
8 signal for each axis.

9 More specifically, the monitoring apparatus may be
10 configured to select one of the three vibration signals.

11 More specifically, the monitoring apparatus may be
12 operative to select a vibration signal on the basis of a
13 comparison amongst the three vibration signals, e.g. to
14 select a vibration signal of highest value representative
15 of a strongest vibration.

16 Alternatively or in addition, a root mean square
17 (RMS) value of a vibration signal may be taken. Where
18 there is more than one vibration sensor a root mean
19 square value of a vibration signal from each vibration
20 sensor may be taken.

21 Alternatively or in addition, the monitoring
22 apparatus may be configured to operate the timer in
23 dependence upon the selected one of the vibration
24 signals.

25 Alternatively or in addition, the monitoring
26 component may be configured to provide for accumulated
27 storage of data, such as vibration exposure values. Thus
28 an exposure value can be accumulated over an extended
29 period of time, e.g. over a whole day when the tool is
30 used several times during the day.

31 Alternatively or in addition, the hand held tool
32 vibration information may comprise a predetermined
33 vibration threshold value. The vibration threshold value

1 may be representative of a minimum level of vibration
2 exhibited when the hand held tool is operating and ready
3 for use. The vibration threshold value can be employed
4 to distinguish between vibration levels when the hand
5 held tool is operating and ready for use and vibration
6 levels when the tool is in stand-by but not operating and
7 ready for use. For example non-electrically or non-
8 pneumatically powered tools, such as combustion engine
9 driven tools, have a lower but significant level of
10 vibration when they are connected to a source of power
11 and switched on and in stand-by (i.e. when the internal
12 combustion engine is running) than when they are
13 operating and ready for use (e.g. when the blades of a
14 hedge cutter are operating). Likewise, certain
15 electrically or pneumatically powered tools may be
16 intended to operate and be ready for use for only a
17 proportion of the time that they are switched on. Thus,
18 such electrically or pneumatically powered tools, e.g. an
19 angle grinder, may have a vibration threshold value
20 representative of a minimum level of vibration reached
21 when the tool is operating and ready for use (e.g. when
22 the disc of the angle grinder is rotating).

23 Thus, the monitoring component may be configured to
24 operate the timer in dependence upon the vibration
25 threshold value. More specifically, the monitoring
26 component may be operative to compare the vibration
27 signal provided by the vibration sensor with the
28 vibration threshold value and to operate the timer in
29 dependence upon the comparison. Thus, if the vibration
30 signal is greater than the vibration threshold value the
31 timer may be started. Also, if the vibration signal
32 falls below the vibration threshold value the timer may
33 be stopped.

1 More specifically, where the vibration sensor is
2 configured to be responsive to vibrations in three
3 mutually orthogonal axes and to provide a vibration
4 signal for each axis and the hand held tool vibration
5 information comprises vibration axis information, the
6 monitoring component may be operative to select a
7 vibration signal or a combination of vibration signals on
8 the basis of the vibration axis information.

9 Alternatively or in addition, where the vibration
10 sensor is configured to be responsive to vibrations in
11 three mutually orthogonal axes and to provide a vibration
12 signal for each axis, the monitoring component may be
13 operative to select a vibration signal or a combination
14 of vibration signals based on a comparison amongst the
15 three vibration signals and to use the selected vibration
16 signal or signals in the comparison with the vibration
17 threshold value.

18 More specifically, the monitoring component may be
19 operative to select a vibration signal or a combination
20 of vibration signals that is representative of a
21 strongest vibration.

22 The hand tool monitoring apparatus may further
23 comprise an indicator configured to indicate at least one
24 vibration value in dependence on the vibration signal.

25 More specifically, the at least one indicated
26 vibration value may comprise at least one vibration
27 exposure value.

28 More specifically, the at least one vibration
29 exposure value may comprise a remaining exposure value
30 for the current day of use of the monitoring apparatus by
31 a user. There may be a safe daily vibration exposure
32 limit for a user. Thus, the remaining exposure value can

1 provide a useful indication of how much further work can
2 be done by the user before his exposure limit is reached.

3 Alternatively or in addition, the at least one
4 vibration exposure value may comprise a user's
5 accumulated exposure value over a plurality of uses.
6 Thus, for example, where a user attaches the monitoring
7 apparatus to a particular tool and makes use of the
8 monitoring apparatus in the morning, then detaches the
9 monitoring apparatus for a period of time before re-
10 attaching the monitoring apparatus to the particular tool
11 for re-use in the afternoon, the accumulated exposure
12 value corresponds to the sum of exposure values during
13 the morning and afternoon uses of the monitoring
14 apparatus.

15 Alternatively or in addition, the at least one
16 vibration exposure value may comprise a user's last
17 exposure value during use of the monitoring apparatus
18 with a most recently used tool. Thus, for example, where
19 the monitoring apparatus is used with several tools in
20 turn the last exposure value corresponds to the exposure
21 value measured during use with the most recently used
22 tool.

23 Alternatively or in addition, the indicator may
24 comprise a plurality of digits operative to display the
25 at least one vibration exposure value.

26 More specifically, where the at least one vibration
27 exposure value comprises a remaining exposure value for
28 the current day of use, an accumulated exposure value,
29 and a last exposure value, the indicator may be operative
30 to display at least two of these exposure values
31 simultaneously.

1 Alternatively, the indicator may be operative to
2 display at least two of the exposure values on an
3 alternating basis.

4 Alternatively or in addition, the indicator may be
5 operative to display the remaining exposure value
6 alternatively with either the accumulated exposure value
7 or the last exposure value.

8 More specifically, the monitoring apparatus may be
9 operative to select the accumulated exposure value for
10 display when the monitoring apparatus is attached to a
11 tool.

12 Alternatively, the monitoring apparatus may be
13 operative to select the last exposure value for display
14 when the monitoring apparatus is detached from a tool.

15 Alternatively or in addition, the indicator may be
16 configured to indicate a plurality of categories of
17 vibration value.

18 More specifically, the indicator may comprise a
19 plurality of visual indicators, each visual indicator
20 being operative to indicate one of the plurality of
21 categories of vibration value, e.g. corresponding to a
22 vibration level being below a warning level value, a
23 vibration level being above the warning level value and a
24 vibration level being above a exposure limit value.

25 More specifically, the visual indicators may be
26 operative to display different colours, e.g. green, amber
27 and red.

28 In a first form the monitoring component may
29 comprise the vibration sensor and the timer.

30 In a second form the mount may comprise the
31 vibration sensor and the monitoring component may
32 comprise the timer. The monitoring component may

1 comprise a microprocessor. Thus, the timer may be
2 comprised as part of the microprocessor.

3 In a third form the mount may comprise the vibration
4 sensor and the timer. More specifically, the monitoring
5 component may comprise a data storage memory.

6 More specifically, the monitoring component may be
7 configured to periodically store a vibration based on the
8 vibration signal in the data storage memory. Thus, a
9 record of vibration levels during use can be made. For
10 example, the monitoring component may be constituted as
11 an active RFID card.

12 The hand tool monitoring apparatus may further
13 comprise a user identification component configured to
14 identify one of a plurality of possible users. This can
15 be advantageous, for example, where the hand tool
16 monitoring apparatus is used in a place of employment and
17 is liable to use by any one of a number of employees.

18 More specifically, the user identification component
19 may comprise a specific user component (e.g. a magnetic
20 strip identification card) comprising information for a
21 specific user (e.g. the specific user's payroll number)
22 and configured to be carried by the specific user; and a
23 separate, specific user configurable component associated
24 with the vibration sensor and to which information for
25 the specific user can be conveyed. In use, a user can
26 carry the specific user component and use it to convey
27 information specific to him to the user configurable
28 component. This allows the hand tool monitoring
29 apparatus to be used by several users. More
30 specifically, use of the tool by different users can be
31 distinguished and a vibration exposure for each user can
32 be determined.

1 The hand tool monitoring apparatus may further
2 comprise a base component configured for use at a central
3 location spaced apart from a location of use of the
4 vibration sensor on a hand held tool.

5 More specifically, the base component and the
6 vibration sensor may be configured for transmission of a
7 transmission signal between the base component and the
8 vibration sensor.

9 More specifically, the base component and the
10 vibration sensor may be configured for transmission of
11 the transmission signal by at least one of a wired
12 coupling and an inductive coupling.

13 Alternatively or in addition, the transmission
14 signal may comprise at least one of a power signal, e.g.
15 for recharging a battery in the vibration sensor, and a
16 data signal. Thus, in a preferred form a battery of the
17 vibration sensor may be re-charged by way of an inductive
18 coupling between the base component and the vibration
19 sensor.

20 Alternatively or in addition, the base component may
21 be configured to provide for at least one of: storage of
22 the vibration sensor when not in use; re-charging of a
23 battery power supply associated with the vibration
24 sensor; storage of data recorded in use of the vibration
25 sensor on a hand held tool; and configuring of a
26 vibration sensor for use by a specific user by means of
27 specific user information.

28 More specifically, the base component may be
29 configured for use with a plurality of vibration sensors.

30 Alternatively or in addition, the operative part of
31 the hand held tool monitoring apparatus may comprise at
32 least one of: the vibration sensor, the timer and data
33 storage memory.

1 Alternatively or in addition, the monitoring
2 apparatus may further comprise communications apparatus
3 comprising first and second Radio Frequency
4 Identification (RFID) transceivers, the first and second
5 RFID transceivers being configured to wirelessly transmit
6 data between the first and second RFID transceivers, the
7 first RFID transceiver forming part of the base component
8 and the second RFID transceiver forming part of the
9 monitoring component.

10 More specifically, the first and second RFID
11 transceivers may be configured for operation at at least
12 one of: 125 kHz and 13.56 MHz.

13 Alternatively or in addition, one of the first and
14 the second RFID transceivers may be configured by having
15 its emanated RF field turned off. Thus, of the two RFID
16 transceivers only one may have its emanated field turned
17 on, namely the RFID transceiver that is transmitting
18 data.

19 More specifically, where the RFID transceivers are
20 operable at 125 kHz, the emanated field may be turned off
21 by writing an appropriate command to the RFID
22 transceiver.

23 Alternatively, where the RFID transceivers are
24 operable at 13.56 MHz, the emanated field may be turned
25 off by writing a series of '1's to the RFID transceiver
26 after a control word containing option bits is written to
27 the RFID transceiver.

28 Alternatively or in addition, the first and second
29 RFID transceivers may be configured for handshaking
30 between them before transmission of data from one to the
31 other.

32 More specifically, the base component may comprise
33 an RFID transponder and the second RFID transceiver may

1 be configured to receive data from the RFID transponder.
2 When the second RFID transceiver receives data from the
3 RFID transponder, the second RFID transceiver may be
4 configured to wait for the first RFID transceiver to
5 transmit data.

6 Alternatively or in addition, the first and second
7 RFID transceivers may be configured for duplex
8 transmission of data between them.

9 Alternatively or in addition, the hand held tool
10 monitoring apparatus may further comprise an isolator
11 operative to change the vibration signal to take account
12 of a change in a vibration characteristic between the
13 hand held tool and the operator. Thus, the isolator may,
14 for example, be used to take account of the vibration
15 reducing effects of an isolated handle on the hand held
16 tool.

17 More specifically, the isolator may comprise at
18 least one filter. More specifically, the filter may
19 comprise at least one of: an electronic filter; and a
20 mechanical filter (e.g. rubber provided underneath the
21 vibration sensor). An electronic filter may, for
22 example, be provided for each axis of vibration. Where
23 the filter is an electronic filter, filter coefficients
24 may be predetermined and stored, for example, in the
25 mount.

26 Alternatively or in addition, the hand held tool
27 monitoring apparatus may be operative to store the
28 vibration signal. Thus, the vibration signal may be used
29 to, for example, provide an indication of incorrect use
30 of a tool as indicated by an abnormally high level of
31 vibration. Alternatively the vibration signal may be
32 used, for example, to provide an indication (e.g. in
33 terms of an abnormally high level of vibration or a

1 particular frequency characteristic) of a fault with the
2 tool or a need to have the tool serviced. The vibration
3 signal may also be used to provide a check of a vibration
4 exposure determined on the basis of operation of the
5 timer.

6 Alternatively or in addition, the hand held tool
7 monitoring apparatus may be configured to store data
8 (e.g. recorded durations of vibration) that is at least
9 one of: time stamped and date stamped. Thus, a record
10 may be established of vibration dosage over a period of
11 time.

12 The term hand held tool as used herein is to be
13 construed as covering hand guided tools and indeed any
14 kind of tool or machine that during use is in contact
15 with an operator's hand or other part of his body.

16 Further embodiments of the above aspect may comprise
17 one or more features of the following aspects.

18 According to a second aspect of the present
19 invention there is provided a hand held tool monitoring
20 method using monitoring apparatus comprising a mount and
21 a monitoring component, the method comprising the steps
22 of: attaching the monitoring component, which comprises
23 an operative part of the hand held tool monitoring
24 apparatus, to the mount, the mount, in use, forming part
25 of the hand held tool, the monitoring component and mount
26 being configured for releasable attachment of the
27 monitoring component to the mount; operating a vibration
28 sensor of the hand held tool monitoring apparatus to
29 sense a vibration of the hand held tool and to provide a
30 vibration signal in dependence upon the sensed vibration;
31 operating a timer of the hand held tool monitoring
32 apparatus in dependence upon the vibration signal to

1 record a duration of vibration of the hand held tool; and
2 removing the monitoring component from the mount.

3 More specifically, the step of attaching the mount
4 to the hand held tool may comprise attaching the mount at
5 a location on the hand held tool spaced apart from a
6 location where an operator engages the hand held tool
7 when the tool is in use.

8 More specifically, the step of attaching the mount
9 to the hand held tool may comprises attaching the mount
10 at a location on the hand held tool that is as close as
11 is practical to a location where an operator engages the
12 hand held tool when the tool is in use.

13 Embodiments of the second aspect of the present
14 invention may comprise one or more features of the first
15 aspect of the present invention.

16 According to a third aspect of the present invention
17 there is provided a hand held tool comprising hand held
18 tool monitoring apparatus according to the first aspect
19 of the present invention.

20 Embodiments of the third aspect of the present
21 invention may comprise one or more features of the first
22 aspect of the present invention.

23 According to a fourth aspect of the present
24 invention, there is provided a hand held tool monitoring
25 apparatus comprising a vibration sensor and a timer, the
26 vibration sensor in use forming part of a hand held tool
27 and being operable to sense vibration of the hand held
28 tool and provide a vibration signal in response to sensed
29 vibration, the timer being operative in dependence on the
30 vibration signal to record information corresponding to a
31 duration of vibration of the hand held tool, the hand
32 held tool monitoring apparatus being operative to store
33 information corresponding to the vibration signal.

1 More specifically, the hand held tool monitoring
2 apparatus may further comprise a data store.

3 More specifically, the data store may be operative
4 to store information corresponding to the vibration
5 signal and a duration recorded by the timer.

6 Alternatively or in addition, the vibration sensor
7 may form part of a mount.

8 More specifically, the mount may be configured to be
9 attached to the hand held tool.

10 Alternatively or in addition, the mount may form an
11 integral part of the hand held tool.

12 Further embodiments of the fourth aspect of the
13 present invention may comprise one or more features of
14 the first to third aspects of the present invention.

15 According to the fifth aspect of the present
16 invention there is provided a hand held tool monitoring
17 method comprising the steps of: providing a vibration
18 sensor of the hand held tool monitoring apparatus as part
19 of a hand held tool; operating the vibration sensor to
20 sense vibration of the hand held tool and provide a
21 vibration signal in response to sensed vibration;
22 operating a timer of the hand held tool monitoring
23 apparatus in dependence on the vibration signal to record
24 a duration of vibration of the hand held tool; displaying
25 a message on a display of the hand held tool monitoring
26 apparatus, the message being based on at least one of: a
27 recorded duration of vibration; and information relating
28 to a sensed vibration level.

29 In use, the method according to the fifth aspect of
30 the present invention can show an operator his vibration
31 exposure during use of a particular tool. Thus, the
32 apparatus may be configured to clear the display and to
33 display a further recorded duration. Such further

1 recorded duration may, for example, be as a consequence
2 of further use of the same hand held tool or use of a
3 different hand held tool.

4 More specifically, the vibration sensor may form
5 part of a mount.

6 More specifically, the mount may be configured to be
7 attached to the hand held tool.

8 Alternatively or in addition, the mount may form an
9 integral part of the hand held tool.

10 Alternatively or in addition, the information
11 relating to a sensed vibration level may comprise at
12 least one of: an accumulated vibration level (based on
13 recorded duration or measured vibration level) from a
14 plurality of uses by a user of at least one hand held
15 tool; and a vibration level (based on recorded duration
16 or measured vibration level) for a previous use of the
17 hand held tool monitoring apparatus.

18 More specifically, where the information relating to
19 a sensed vibration level comprises an accumulated
20 vibration level, the information may be displayed when
21 the monitoring component is attached to the mount.

22 Alternatively or in addition, where the information
23 relating to a sensed vibration level comprises a
24 vibration level for a previous use, the information may
25 be displayed when the monitoring component is detached
26 from the mount.

27 Alternatively or in addition, the message based on a
28 recorded duration of vibration may be a remaining
29 exposure value for a user for a current day of use.

30 Alternatively or in addition, the information
31 relating to a sensed vibration level may comprise at
32 least one of: a vibration level measured by the vibration
33 sensor; a warning condition at which use by a user of

1 vibrating hand held tools should be reduced; and an alarm
2 condition at which use by user of vibrating hand held
3 tools should be stopped.

4 Alternatively or in addition, a message based on a
5 recorded duration of vibration and a message based on
6 information relating to the sensed vibration level may be
7 displayed alternately.

8 Embodiments of the fifth aspect of the present
9 invention may comprise one or more features of the first
10 to fourth aspect of the present invention.

11 According to a sixth aspect of the present
12 invention, there is provided communications apparatus
13 comprising first and second Radio Frequency
14 Identification (RFID) transceivers, the first and second
15 RFID transceivers being configured to wirelessly transmit
16 data between the first and second RFID transceivers.

17 Known RFID configurations comprise an RFID
18 transceiver and at least one RFID transponder. The RFID
19 transceiver irradiates the RFID transponder with an RF
20 field modulated with a transmission request, to which the
21 RFID transponder responds by modulating the incident RF
22 field by means of a variable load. The RFID transceiver
23 may also be used to transmit data to the RFID
24 transponder, the transmitted data being stored in the
25 RFID transponder. Thus, the known RFID transceiver has a
26 data read/write capability. According to the sixth
27 aspect of the present invention, two known RFID
28 transceivers are configured to transmit data from one of
29 the RFID transceivers to the other.

30 More specifically, the first and second RFID
31 transceivers may be configured for operation at at least
32 one of: 125 kHz and 13.56 MHz.

1 Alternatively or in addition, one of the first and
2 the second RFID transceivers may be configured by having
3 its emanated RF field turned off. Thus, of the two RFID
4 transceivers only one may have its emanated field turned
5 on, namely the RFID transceiver that is transmitting
6 data.

7 More specifically, where the RFID transceivers are
8 operable at 125 kHz, the emanated field may be turned off
9 by writing an appropriate command to the RFID
10 transceiver.

11 Alternatively, where the RFID transceivers are
12 operable at 13.56 MHz, the emanated field may be turned
13 off by writing a series of '1's to the RFID transceiver
14 after a control word containing option bits is written to
15 the RFID transceiver.

16 Alternatively or in addition, the first and second
17 RFID transceivers may be configured for handshaking
18 between them before transmission of data from one to the
19 other.

20 More specifically, the communications apparatus may
21 comprise an RFID transponder disposed nearby the first
22 RFID transceiver and the second RFID transceiver may be
23 configured to receive data from the RFID transponder.
24 When the second RFID transceiver receives data from the
25 RFID transponder, the second RFID transceiver may be
26 configured to wait for the first RFID transceiver to
27 transmit data.

28 Alternatively or in addition, the first and second
29 RFID transceivers may be configured for duplex
30 transmission of data between them.

31 Alternatively or in addition, the first RFID
32 transceiver may form part of a first unit and the second
33 RFID transceiver may form part of a second unit, the

1 first and second units being movable in relation to each
2 other.

3 More specifically, the second unit may form part of
4 monitoring apparatus configured to monitor vibration of a
5 hand held tool.

6 More specifically, the first unit may form part of a
7 base component configured to receive data from the
8 monitoring apparatus.

9 Alternatively or in addition, the communications
10 apparatus may comprise a transponder, the communications
11 apparatus being configured to write data from the first
12 RFID transceiver to the transponder and for the second
13 RFID transceiver being configured to read the data
14 written to the transponder from the transponder. Thus
15 data is conveyed from the first transceiver to the second
16 transceiver via the transponder. According to this form,
17 there is no need to turn off the emanated field of a
18 transceiver.

19 Further embodiments of the sixth aspect of the
20 present invention may comprise one or more features of
21 the first to fifth aspects of the present invention.

22 Brief description of drawings

23
24
25 Further features and advantages of the present
26 invention will become apparent from the following
27 specific description, which is given by way of example
28 only and with reference to the accompanying drawings, in
29 which:

30 Figure 1 is a view of components of a first
31 embodiment of the present invention;

32 Figures 2A to 2C are detailed view of certain
33 components shown in Figure 1;

Figure 3 is a block diagram schematic for a monitoring component according to the first embodiment;

Figure 4 is a block diagram schematic for a base component of the first embodiment;

Figure 5 is a flow chart illustrating a sequence of steps of operation of the base component of the first embodiment;

Figure 6 is diagram illustrating typical daily use of the first embodiment;

Figure 7 is a representation of a second embodiment of the invention; and

Figure 8 is a representation of a third embodiment of the invention.

Specific description

A hand held apparatus 10 according to a first embodiment of the present invention is shown in Figure 1. The hand held apparatus 10 comprises a monitoring component 12, which has a vibration sensor and a timer, a base component 14, a user identification (ID) card 16 (which constitutes a user identification component), a Multimedia Card (MMC) 18 and a Personal Computer 20. In this instance the hand held apparatus 10 is being used with a pneumatic drill 22.

The user ID card 16 is used to identify the user, e.g. an employee and store information relating to the user. The user ID card is of a Hi Coercivity Magstripe type, which means that it will be more difficult for a user to remove the data by putting the card close to a magnetic field. The user ID card can be printed and encoded by a combination printer according to a predetermined format, e.g. by an employer. A card can

store 1288 bits of information comprising user information to a total of 56 bits with the remainder of the data space available for training and/or Health and Safety information. The user information comprises: an ID card identification number (of 64 bits); a 10 digit user identification number (of 64 bits); a sensitivity level for the user (of 8 bits); an exposure action value (of 16 bits); an exposure limit value (of 16 bits); and an error reporting code (of 16 bits).

In addition to user ID cards, an authorisation card may be used. Use of an authorisation card provides for additional functionality of the base component 14. More specifically, the authorisation card can be used to:

- i) Set the real time clock;
- ii) Manually release a monitoring component from the base component; and
- iii) Enable and disable the base component for all users.

The data structure of the authorisation card is as follows:

Data	Size and Type	Description
Person ID	64-bit Integer	A unique identifier for the person who is using the authorisation card
Action Code	8-bit Integer	A series of flags indicating what was done in the authorisation mode. The possible actions are: 1. Manual entry of a user 2. Change date 3. Change time 4. Change data copy timer 5. Change of authorisation requirement
Time	16-bit Integer	Value giving the time of day the authorisation card was used

Date	16-bit Integer	Value giving the date that the authorisation card was used
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Figures 2A to 2C provide detailed views of the monitoring component 12 and the base component 14 shown in Figure 1 along with a mount 24 for attaching the monitoring component 12 to the pneumatic drill 22 of Figure 1. In use, the mount 24 is attached to the pneumatic drill 22, although the mount is not evident from Figure 1.

In an alternative (un-illustrated) form of the invention, the mount is formed integrally with the pneumatic drill with the casing of the mount forming an integral part of the casing of the pneumatic drill.

Figure 2A shows the monitoring component 12 and the mount 24. The monitoring component 12 and the mount 24 have respective cooperating magnetic components (not shown) that in use provide for releasable attachment of the monitoring component 12 to the mount 24. Also, the mount 24 has a generally concave surface profile 26, which is shaped to receive a generally convex surface profile 28 of the monitoring component 12. The monitoring component 12 has three visual indicators (which constitutes an indicator configured to indicate a vibration value in dependence on the vibration signal), which respectively display green, amber and red. Operation of the green indicator indicates that a vibration level is below a warning level value, operation of the amber indicator indicates that a vibration level is above the warning level value and operation of the red indicator indicates that a vibration level is above an exposure limit value.

In an un-illustrated embodiment, the monitoring component 12 has a three digit display in addition to the three visual indicators. The three digit display is of conventional design and operation. In use, the three digit display displays a remaining exposure value for the user for the current day of use on an alternating basis with either an accumulated exposure value for the user (for uses with two or more tools on the current day of use) or the last exposure value for the most recently used tool. The accumulated exposure value for the user is displayed when the monitoring apparatus is attached to a tool. The last exposure value is displayed when the monitoring apparatus is detached from a tool. The appropriate exposure values alternate with each other at five second intervals. The exposure values are displayed on the three digit display in accordance with a points system devised by the United Kingdom Health and Safety Executive. Thus, the remaining exposure value is displayed in terms of points left for the current day out of a maximum of 400, which represents the safe daily limit for the user. The following table provides a summary of the messages displayed on the three-digit display:

State	Description	Cancel Condition
Show Nothing	Nothing is shown on the screen	-
Last Tool Points	Number of points used whilst on the last tool	-
Total Points Used	Total number of points used that day	-
Tool Total Points	Total points used on this tool covering all uses during the day	-
"BAT"	Indicates that the battery is low screen, literally	-

	shows, 'BAT', although, the T will be displayed as a 7 because a seven segment can't display a full, 'T'	
"HI"	Indicates the overdose level for this tool has been exceeded, literally shows, 'HI'	-
"CAL"	Indicates that the device is in a calibration mode, literally shows, 'CAL'. This is for use during calibration activities	-
"E01"	HAV unit has been removed from base station without swipe card identification and has been attached to a valid tool	Remove HAV unit from tool
"E02"	HAV unit has been placed on a base station which has not responded correctly	Remove HAV unit from base station
"E03"	HAV unit has been placed on an unknown device which has triggered the connection detect	Remove HAV unit from unknown device

1
2 The monitoring component 12 (which is termed a 'HAV
3 unit' in particular in the tables) has a permanently
4 installed internal rechargeable battery (not shown) of a
5 kind that does not suffer from battery memory problems.
6 Charging of the rechargeable battery is by way of either
7 a wired coupling or an inductive coupling between the
8 monitoring component 12 and the base component 24, which
9 is shown in Figure 2B. The wired and inductive couplings
10 between the monitoring component 12 and the base
11 component 24 (which is termed 'base station' in
12 particular in the tables) are of conventional design and
13 operation. The rechargeable battery has the capacity to
14 power the monitoring component 12 in full use for a
15 minimum of 16 hrs between recharges. This is considered
16 sufficient for use over an employee user's full working

1 shift plus extra power for overtime. It is expected that
2 most period of use of the monitoring component 12 is
3 around 9 hours. Thus, most recharges will be from a 40%
4 charge level. Thus, the battery has a fast recharge over
5 the commonly used first 60% of charge at a ratio of 1:4
6 for recharge: discharge times. Also, the battery has a
7 slower recharge speed for charging to the 40% level at a
8 ratio of 1:2 for recharge: discharge times.

9 Figure 2B shows the base component 14, which
10 comprises a display 32 consisting of an array of dot
11 matrix characters. The dimensions of the array are 25x4
12 (width by height) with each dot matrix character being at
13 least 8x5 pixels in at least a 5x3 mm area. The base
14 component 14 also has a keypad 34 having the standard
15 twelve button telephone keys with the hash and star keys
16 replaced with left and right arrows. A further key (not
17 shown) is provided to function as an enter key.
18 Appropriate graphics are displayed on the keys. The base
19 component 14 has an array of docking bays 36, each of
20 which is configured to receive a monitoring component 12.
21 In addition, the base component 14 has an RFID read/write
22 device 38 for communicating with a monitoring component
23 12.

24 In addition, the base component 14 has a magnetic
25 strip card reader for reading the user ID card 16, which
26 is shown in Figure 1. The base station is capable of
27 receiving power from a 12V DC power supply (not shown).
28 One configuration involves use of external power supply
29 units which connect to generator supplies or to the
30 mains. Another configuration involves use of automobile
31 DC voltage supplies.

32 Figure 2C shows an alternative form of the mount 24
33 according to which the concave surface profile 26 is

shaped to completely encircle the convex surface profile
28 of the monitoring component 12.

Both the monitoring component 12 and mount 24 have a
plastics enclosure that is capable of being repeatedly
covered in concrete splashes and cleaned whilst
maintaining reliable operation. The enclosure of the
monitoring component 12 and mount 24 are rated to IP65.
The enclosure of the base component 14 rated to IP54.

The monitoring component 12 is shown in Figure 3 in
block diagram form. The monitoring component 12 has
three coloured indicators 30, a microprocessor 52, memory
54, two tri-axial accelerometers 56 (which constitute a
vibration sensor), a reed switch 58 and an RFID interface
60. The microprocessor 52 controls the operation of the
monitoring component 12 and amongst other things performs
a timer function. The microprocessor 52 is an Analog
Devices 400MHz DSP enabled Blackfin (BF531SBBCZ400).
Firmware code is stored in the monitoring component in
the memory 54, namely ST Microelectronics 1Mb low voltage
serial flash memory with an SPI interface. The maximum
'on' state that the accelerometers 56 reliably detect is
not above the accelerometers' maximum acceleration
rating. Signals from the accelerometers 56 are converted
from an analogue to a digital form by a National
Semiconductor ADC124S021 analogue-to-digital converter.
The accelerometers have typical dimensions of about
8x8x3mm. The specifications for the first kind of
accelerometer are shown in the following table:

Parameter	Min	Max
Freq range (Hz)	1	1500
Peak acceleration range (m/s ²)	-	6
Dimensions (mm)	-	5.5*5.5*1.5
Abs Noise (m/s ²)	-	0.5

The first kind of accelerometer is an LIS3L06AL from ST Microelectronics, which is tri-axial.

The second kind of accelerometer has the following specifications:

Parameter	Min	Max
Freq range (Hz)	1	1500
Peak acceleration range (m/s ²)	-	60
Dimensions (mm)	-	5.5*5.5*1.5
Abs Noise (m/s ²)	-	0.1

An MMA1200 from Freescale is used for the z-axis and an ADXL193 from Analog Devices is used for each of the other two axes (i.e. x and y) of the second kind of accelerometer.

The microprocessor is operative to select vibration signals produced by one of the above two types of accelerometer on the basis of the maximum acceleration detectable by each accelerometer. Thus, for example, if the vibrations produced by a tool being monitored have acceleration values below a low maximum value of acceleration vibrations from the accelerometer having the lower maximum detectable acceleration will be selected. The reed switch 58 is operative to power up the monitoring component 12 when it is received in the mount 24. In a form of the invention, a push button switch may be used instead of the reed switch. In this form of the invention, the push button switch is located such when the monitoring component is attached to the mount the push button switch is actuated.

When the monitoring component 12 is received in the mount the RFID interface 60 is operative to actuate a passive RFID tag contained in the mount (not shown) thereby triggering the transmittal of information relevant to the hand held tool, including information on

vibration, to the monitoring component. The three coloured indicators 30 are operated as shown in the following table:

Dose level (greater than)	Alarm	Employee action (person at normal risk)
Zero	GREEN light - solid on	
Exposure Action Value [EAV A(8)]	ORANGE light - slow flashes	Reduce use of vibrating tools
Exposure Limit Value [ELV A(8)]	RED light - fast flashes	Stop use of vibrating tools for the day

To differentiate visual warnings for those who are colour blind the indicators operate in accordance with the above table. Alarm levels are adjusted for individuals having increased 'sensitivity' due to signs of HAV damage.

Light Sequence	Event	Action
No Lights (whilst connected to a tool)	Monitoring component is broken or out of batteries	If recharging is not effective send monitoring component for repair
Solid Green Light (whilst connected to a tool)	Monitoring component functioning correctly. Under EAV	None
Solid Green Light (whilst connected to base component)	Monitoring component recharged and ready for use	None
Slow Flashing Amber Light	Action level has been reached.	Reduce usage of high vibration equipment
Fast Flashing Red Light	Limit level has been reached	Stop use of all vibrating equipment

Flashing Green Light	Monitoring component is running low	Return unit for a recharge
All lights flashing simultaneously	Tool needs servicing	Disconnect monitoring component and retest tool then inform foreman Select a different tool
Strobe across lights for 30 secs (whilst connected to base component)	Monitoring component is recharging in the base component	Do not remove from base component
All lights illuminated (whilst connected to base station)	Identifies the monitoring component that should be removed from the base station	Remove monitoring component for use

1
2 The base component 14 is shown in Figure 4 in block
3 diagram form. The base component 14 comprises a
4 microprocessor 72, a display driver 74 and display 32, an
5 MMC card interface 76, a clock 78, an RFID interface 38,
6 a keypad 34 and LEDs 80. The microprocessor 72 in the
7 base component 14 is an 8-bit 16 MHz microprocessor,
8 namely an Atmel AT Mega 325-16. Memory is integral to
9 the microprocessor 72.

10 Firmware for both the monitoring component 12 and
11 the base component 14 is stored in local memory having
12 been developed in a computer-based environment before
13 being compiled and downloaded to local memory. The steps
14 of firmware development, compilation and download into
15 local memory are in accordance with practice that is well
16 known to the skilled person.

17 The data storage format for the first embodiment
18 will now be described.

The time and date format used in the monitoring component 12 and the base station 14 is as follows. Time is stored as a 16-bit integer. The value of this integer is multiplied by the tick speed of the system of 1.32 seconds to obtain the number of seconds that have passed since the start of the day. The date is also stored in a 16-bit integer format as per the table below:

Day	Month	Year
5-Bit Integer	4-Bit Integer	7-Bit Integer

Within the monitoring component 12 the following table shows data permanently held within the component:

Data	Size and Type	Description
Unit ID	64-bit Integer	A unique identifier given to each monitoring component 12 when it is produced
Version	32-bit Integer	A version number for the device firmware, this is used to check that the base component 14 and monitoring component 12 are compatible

The Unit ID should be uploaded to the base component 14 just before the monitoring component 12 is removed from the base component 14. This allows the base component to track monitoring components. The following table shows data transmitted to the monitoring component 12 just before it is removed from the base component 14:

Data	Size and Type	Description
Person ID	64-bit Integer	The unique identifier from the user ID card 16
Sensitivity	8-bit Integer	Values 0 and 1 will cause the normal EAV and ELV to be used.

		Higher values will cause the EAV to be set as $\frac{1}{2}$ the EAV and the ELV to be replaced with the EAV
Init. Base ID	64-bit Integer	A 64-bit unique identifier for the base component the monitoring component was removed from
Init. Time	16-bit Integer	Value giving the time of day the monitoring component was removed from the base component, read from the base component clock
Init. Date	16-bit Integer	Value giving the date the monitoring component was removed from the base component, read from the base component clock
EAV value		
ELV value		

1

2 The following data is collected during use of the
3 monitoring component and relates to broken tool, e.g. the
4 pneumatic drill 22 of Figure 1, and vibration data:

Data	Size and Type	Description
Action Time	32-bit Integer	Time stamp written when the user reaches his action value
Limit Time	32-bit Integer	Time stamp written when the user reaches his limit value
Exposure	16-bit Integer	Current A(8) exposure value of user
Broken Tools	10x 48-bit Integers	An array of up to 10 Tool IDs, as read from the tools. Tool IDs will be written into this list if the tool is determined to need servicing
Vibration Record	1000 x 152-bit Structures	An array of tool usage records. Defined in the table immediately below

5

- 1 Each entry in the vibration record consists of the
 2 following fields:

Data	Size and Type	Description
Tool ID	64-bit Integer	Tool ID of the tool that the monitoring component was connected to
Tag ID	64-bit Integer	Identifier for the RFID tag in the tools cradle
Connect	32-bit Integer	Time stamp of when the tool was connected to the monitoring component
Disconnect	32-bit Integer	Time stamp of when the tool was disconnected from the monitoring component
Trigger Time	16-bit Integer	Total amount of trigger time whilst connected to the tool
Tool Dose	32-bit Float	The dose rating taken off the mount
Vibration Indicator	32-bit Float	An indicator of how close the tool is to its rated level
Flags	8-bit integer	Status flags. One flag indicates whether or not a vibration overdose occurred during use of the tool

3
 4 The structure of data stored in the mount's RFID tag
 5 is set out in following table.

Data	Size and Type	Description
Tag ID	64-bit Integer	A unique identifier for this tag.
Tool ID	64-bit Integer	A unique identifier for the tool.
C _{xn1}	16-bit Integer	X axis isolation filter, coefficient.
C _{xn2}	16-bit Integer	X axis isolation filter, coefficient.
C _{xn3}	16-bit Integer	X axis isolation filter, coefficient.
C _{xd2}	16-bit Integer	X axis isolation filter, coefficient.
C _{xd3}	16-bit	X axis isolation filter,

	Integer	coefficient.
G _x	16-bit Integer	X axis isolation filter, gain.
C _{yn1}	16-bit Integer	Y axis isolation filter, coefficient.
C _{yn2}	16-bit Integer	Y axis isolation filter, coefficient.
C _{yn3}	16-bit Integer	Y axis isolation filter, coefficient.
C _{yd2}	16-bit Integer	Y axis isolation filter, coefficient.
C _{yd3}	16-bit Integer	Y axis isolation filter, coefficient.
G _y	16-bit Integer	Y axis isolation filter, gain.
C _{zn1}	16-bit Integer	Z axis isolation filter, coefficient.
C _{zn2}	16-bit Integer	Z axis isolation filter, coefficient.
C _{zn3}	16-bit Integer	Z axis isolation filter, coefficient.
C _{zd2}	16-bit Integer	Z axis isolation filter, coefficient.
C _{zd3}	16-bit Integer	Z axis isolation filter, coefficient.
G _z	16-bit Integer	Z axis isolation filter, gain.
Primary-axis	8-bit Integer	Indicates which of the 3 axes is the primary vibration axis for this tool and hence, should be used for on/off detection.
On-limit	16-bit Integer	Gives the level that should be used as a threshold to determine if the tool is in use.
Off-limit	16-bit Integer	Gives the level that should be used as a threshold to determine if the tool is no longer in use.
On-duration	16-bit Integer	The length of time use to determine when the tool is no longer in use.
Over-dose	16-bit Integer	Gives an RMS level that should be used as a threshold to determine when the tool is exceeding acceptable vibration levels.
Dose-level	16-bit Integer	Gives the vibration level, in scaled points, that should be used for vibration dose

		calculations on this tool.
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The above data allows several aspects of tool usage to be investigated. The tool ID allows for identification of the tool that has been used. Connect and disconnect time show the time of day the tool was used and how long the user spent using this tool. Trigger time and tool dose can be used together to calculate a user's vibration exposure whilst using the tool. Furthermore, connect and disconnect time can be combined with trigger time to show the ratio of time spent on the tool to the time the tool was actually being used. Also, the vibration indicator can be used to assess the vibrations produced by the tool in relation to its rated vibration level (see following section).

The data detailed in the four tables above is written back to the base component 14 when the monitoring component 12 device is returned at the end of the day.

Permanent data held on the base component 14 is listed in the following table. With the exception of device identification data, this data consists of initial base station data and final base station data.

Data	Size and Type	Description
Device ID	8-bit Integer	An identifier indicating that this is a base component. Two base component identifiers exist one indicating a simple recharge base component and the other indicating a full base component. This is the only information held on the passive RFID tag contained within the base component
Base ID	64-bit Integer	A unique identifier given to each base component when it is produced
Version	32-bit Integer	Indicates the version number of the base component software

Time	n/a	The current time, this is accessed on the external clock module. Although, this will be converted into a 16-bit time stamp, before being given to a monitoring component, as discussed above
Date	n/a	The current date, this is accessed on the external clock module. Although, this will be converted into a 16-bit format, before being given to a monitoring component HAV, as discussed above

1

2 When a monitoring component 12 is about to be removed
3 from the base component 14 the information in the table
4 above will be downloaded to that unit, as well as the
5 information read from the user ID card 16. The time and
6 date are converted into their 16-bit representations
7 before being transferred on.

8 A list of monitoring components that have been
9 removed from the base component is maintained within the
10 base component. This is shown in the following table:

11

Data	Size and Type	Description
HAV ID	64-bit Integer	A unique identifier for the monitoring component that was removed, this must be read from the monitoring component just before it is removed
Person ID	64-bit Integer	A unique identifier for the person that removed the monitoring component, taken from the user ID card
Time	16-bit Integer	A time stamp indicating the time the monitoring component was removed
Date	16-bit Integer	A time stamp indicating the date on which the monitoring component was removed

12

1 Upon return of the monitoring component 12 to the
2 base component 14 the data is transmitted from the
3 monitoring component 12 to the base component 14 and then
4 stored on the MMC card 18 of Figure 1. All
5 communications between the base component and the
6 monitoring component are error checked using a Cyclic
7 Redundancy Code (CRC) or similar Forward Error Correction
8 (FEC) code. Data is resent should it not arrive intact.
9 The structure of the data downloaded to the base
10 component is given in the following table:
11

Data	Size and Type	Description
Base ID	64-bit Integer	A unique identifier for this base station
Return Time	16-bit Integer	Value giving the time of day the unit was returned to the base station
Return Date	16-bit Integer	Value giving the date that the unit was returned to the base station

12
13 The following table lists error messages the base
14 component can present. The table also describes the
15 situation in which these messages appear. #bay refers to
16 the number of the docking bay 36 of the base component
17 that the monitoring component 12 is located in.
18

Code	Text	Cancel Condition	Description
M1	"Communications to HAV unit failed: #bay"	30 second timeout	The base station was unable to download the information from the HAV unit in the given bay
M2	"HAV Unit not collected"	5 second timeout	Someone asked for a HAV unit but never collected it from the base station. Accompanied by a red

			LED.
M3	"Copying data to memory card..."	Memory card full	Someone has inserted a memory card and data is being copied to it
M4	"Copying complete"	5 second timeout	All data awaiting transfer has been successfully uploaded, accompanied by green LED
M5	"Change memory card"	Memory card is replaced or alarm is turned off	The memory card should be replaced with a fresh one
M6	"Swipe card invalid"	5 second timeout	A card was swiped that was not recognised
E1	"All HAV units in use or charging"	5 second timeout	A HAV unit can't be released because they are all charging or in use. Accompanied by a red LED
E2	"Unknown release error"	5 second timeout	A HAV unit can't be released for unknown reasons, units where available, however, the release process failed. Accompanied by a red LED
E3	"Memory card corrupted"	Memory card is removed	An invalid memory card has been inserted or the card has broken. Accompanied by a red LED
E4	"Memory card transfer failed."	5 second timeout	A memory card has been removed or broken during data transfer. Accompanied by a red LED
E5	"Memory card full - please insert another card"	Memory card removed	A memory card is already full and there is further data to transfer.

			Accompanied by a red LED
E6	"Internal memory card corrupted"	Memory card is replaced	An invalid memory card has been inserted or the card has broken. Accompanied by a red LED
E7	"Unknown fatal error"	Can't be cleared	An error has occurred which requires the HAV unit to be returned to the manufacturers. Accompanied by a red LED

1
2 The base component 14 memory storage subsystem
3 consists of two MMC cards 18. The first of these cards
4 is easily removable and intended to allow data from the
5 base component to be transported to a Personal Computer
6 20, which functions as a central server. The second card
7 is internal with some access to the second card being
8 provided for upgrade purposes. The internal card is much
9 larger in storage capacity than the external card and
10 acts as a data back-up facility to prevent permanent loss
11 of data in the event of damage or loss of external card.
12 The internal card contains two types of file. The first
13 type of file will have the extension, ".dat", and
14 contains vibration records. This file contains a header
15 and then a continuous list of vibration records. The
16 format of the header is given in the following table:

Name	Size	Description
Base Station ID	32-bit Integer	Unique identifier for the base component that recorded this file.
Base Station Version	32-bit Integer	The version number of the base component that recorded this file

- 1 The format of a record is given in the following table:

Name	Size	Description
Capture String	3x 8-bit Characters	A string consisting of the characters, "REC", stored in standard ASCII and used to identify the start of a record.
Initial Base Station Version	32-bit Integer	The version number of the initial base component.
Size	32-bit Integer	The size of the initial base component data.
Data	N/A	The actual data from the initial base component.
HAV Version	32-bit Integer	The version number of the monitoring component that took the recording.
Size	32-bit Integer	The size of the monitoring component data.
Data	N/A	The actual data from the monitoring component.
Final Base Station Version	32-bit Integer	The version number of the final base component.
Size	32-bit Integer	The version number of the final base component.
Data	N/A	The actual data from the final base component.
End String	3x 8-bit Characters	A string consisting of the characters, "END", stored in standard ASCII and used to identify the end of a record.

2

3 A new .dat file is started every time the external
4 card is replaced. This means that the files correspond
5 to data recorded between cards being taken to the central
6 server 20 making data recovery easier. The .dat files are
7 given an 8-digit number as an identifier. Thus, the
8 first file reads "00000001.dat". These file names should
9 increment each time a new file is created.

1 The second type of file has the extension ".rem".
2 This type of file contains a list of monitoring
3 components that have been removed from the base component
4 during the day. This type of file also contains a header
5 and a continuous list of records. Files are numbered in
6 the same manner as the .dat files and new files are
7 started at the same time. The header is identical to
8 that of the dat file. The format of the records is shown
9 in the table below:

Name	Size	Description
Capture String	3x 8-bit Characters	A string consisting of the characters, "REC", stored in standard ASCII and used to identify the start of a record.
Size	32-bit Integer	The size of the record.
Data	N/A	The actual data from the base component about monitoring component removal.
End String	3x 8-bit Characters	A string consisting of the characters, "END", stored in standard ASCII and used to identify the end of a record.

10

11 The arrangement of menus that are displayed on the
12 screen of the base component is shown in Figure 5. The
13 square boxes represent menu options and the diamonds
14 represent where user input is required. The "Main" state
15 as shown at the root of Figure 5 is the default state of
16 the display procedure. At any point should the display
17 procedure be left idle in one of the sub-states, for more
18 than 30 seconds, it will return to the main state. This
19 state displays the time and flashes through the list of
20 current warnings should any exist, displaying each
21 warning for 5 seconds. For each sub-state menu the
22 options can be iterated through using the left and right

1 keys on the base component and then selected using the
 2 enter key. Each of the data entry screens consist of a
 3 number of fields into which numbers can be typed from the
 4 keypad. These fields can be moved between using the left
 5 and right keys. Whichever field has the input focus will
 6 accept keypad data. After iterating past the last data
 7 entry field two further menu options are provided, namely
 8 Save and Cancel. The following table describes each of
 9 the diamond boxes in more detail:

Name	Description	OK Actions
Enter Time	Used for setting the time; contains 3 colon separated values (hours (0-24), minutes (0-60), seconds (0-60)).	Updates time on the base component.
Enter Date	Used for setting the date, contains 3 slash separated values (day(1-31), month(1-12), year (2000-2128))	Updates the date on the base component.
Enter Days	Used for setting certain timers, contains only 1 value (days). Displayed as the number followed by a space and the string "days".	Updates the relevant timer period.
Enter ID	Used for entering a Person ID in the advent of an employee forgetting one. Contains only one value (10 digit). Displays the string "PID:", followed by a space and then the digits appear as the user types them in.	
Enter Sens	Used for entering a person's sensitivity rating. Contains only one value (0-255). Used in place of swipe card for releasing a monitoring component. Displays the string "Sens:", followed by a space and then the digits appear as entered by the user.	Initiates a monitoring component release much as a card swipe would.

10

11 The vibration levels are calculated within the
 12 monitoring component 12 in accordance with the following

1 procedure. It should be noted that tests with sample
 2 power tools have shown a very good correlation between
 3 vibration signatures seen in the position of a mount on
 4 the tool casing and those seen in the tool handle
 5 position. Vibration signatures at the tool handle
 6 position are necessary to meet United Kingdom HSE testing
 7 procedures for tool assessment. Recording of RMS values
 8 of vibration seen at the mount are another useful part of
 9 tool management and give a good indication of actual
 10 vibration levels being experienced by users. The
 11 procedure used to calculate the vibration levels at the
 12 mount follow the procedure outlined in legislation for
 13 HAV measurements on the handle. The vibration signals
 14 are filtered by an isolation filter to emulate the effect
 15 of an isolated handle on a power tool. It will
 16 automatically change the recorded vibration so that it
 17 better represents what would be experienced by the hands
 18 and arms of a user of the isolated tool. The isolation
 19 of the tool is characterised and represented numerically
 20 within the isolation filter. The isolation filter
 21 consists of a bank of three second order filters; one
 22 filter for each axis of vibration. The equation below
 23 shows the structure of the isolation filter. The
 24 eighteen coefficients in the equation, six for each
 25 filter, are stored in the mount 24 and are determined for
 26 each tool type having an isolated handle.

$$\begin{array}{l}
 27 \quad O = G \frac{c_{n_1} I z^0 + c_{n_2} I z^{-1} + c_{n_3} I z^{-2} - c_{d_2} O z^{-1} - c_{d_3} O z^{-2}}{c_{d_1}} \\
 28
 \end{array}$$

29 Subsequent procedure involves three steps:

1. The monitoring component weighting curve. The 3-axis vibration signal from one of the accelerometers is passed through a special filter that weights the different frequencies in relation to harmfulness. This filter is composed of a band-limiting filter cascaded with a frequency-weighting filter. Both the filters are defined in the standard Laplace representation. The band-limiting filter is defined as:

$$H_b(s) = \frac{s^2 4\pi f_2^2}{(s^2 + \frac{2\pi f_1 s}{Q_1} + 4\pi^2 f_1^2)(s^2 + \frac{2\pi f_2 s}{Q_1} + 4\pi^2 f_2^2)}$$

$$f_1 = 6.31, f_2 = 1258.9, Q_1 = 0.71$$

The frequency-weighting filter is defined as:

$$H_w(s) = \frac{(s + 2\pi f_3) 2\pi K f_4^2}{(s^2 + \frac{2\pi f_4 s}{Q_2} + 4\pi^2 f_4^2) f_3}$$

$$f_3 = 15.915, f_4 = 15.915, Q_2 = 0.64, K = 1$$

These two filters are cascaded as follows:

$$H(s) = H_b(s) \square H_w(s)$$

2. An RMS (Root Mean Square) of each axis. This produces a single figure that describes the amplitude of the vibration signal. An RMS is defined as (shown for the x-axis with the y and z axes defined in an identical fashion):

$$a_{hvx} = \sqrt{\frac{1}{N} \sum_{k=1}^N x_k^2}$$

3. Axis Averaging. The three axes of measurement are combined into a single figure, defined as:

$$a_{hv} = \sqrt{a_{hvx}^2 + a_{hvy}^2 + a_{hvw}^2}$$

The above procedure derives a single measure of tool vibration. Over time a picture can be built up of the distribution of vibration values simply by graphing the density of the values returned by the system whilst in the field. Comparison of these values to dose levels on the tools as measured in line with United Kingdom HSE testing procedures for tool assessment is tool specific and as such requires testing to determine the relationship for each tool.

The physical characteristics of the monitoring component 12, the base component 14, the user ID card 16 and the mount 24 are given in the following tables.

Monitoring component			
Size			
	Max	90×50×25	mm
	Preferred	50×30×20	mm
	Min	45×25×13	mm
Weight			
	Max	175	grams
	Min	30	

Base component			
Size			
	Max	810×450×225	mm
	Preferred	450×270×180	mm
	Min	405×225×117	mm
Weight			
	Max	5	Kg
Bay Spacing (HAV units mounted on ends)			
	Horizontal Max	60	mm
	Horizontal Preferred	80	mm
	Horizontal Min	100	mm
	Vertical Max	60	mm
	Vertical Preferred	80	mm

	Vertical Min	100	mm
--	--------------	-----	----

User ID Card			
Size			
	Max	90×60×1	mm
	Preferred	85×55×0.5	mm
	Min	80×50×0.5	mm

Mount			
Size			
	Max	95×55×10	mm
	Preferred	55×35×5 (monitoring component area + 10%)	mm
	Min	45×25×2	mm
Weight			
	Max	50	grams

Operation of the first embodiment of the present invention will now be described with reference to Figure 6.

The present invention performs three major complementary functions: health and safety management in accordance with UK HAV legislation; user management; and tool management.

Referring to Figure 6, a user reports for work at a site. The user enters the site hut (or site van) with his personal user ID card 16. He swipes his user ID card 16 at the base component 14 to uniquely identify himself to the system. If the user has forgotten his card he is able to identify himself to the system by keying in his payroll number using the keypad 34 on the base component. The base component saves the employee ID and the current time to one of the monitoring components 12 docked there, which is then released for use. The monitoring component has been fully charged while resting at the base component and is synchronised with the base component

1 clock. When the monitoring component has been removed,
2 the base component is then free to accept the next user's
3 user ID card 16 and release a further monitoring
4 component. The user carries the rugged, water resistant
5 monitoring component to the first tool he wants to use,
6 e.g. the pneumatic drill 22 of Figure 1, and clips it
7 onto the tool body where it is held firmly within a mount
8 24.

9 The reed switch 58 turns the monitoring component 12
10 on. The monitoring component is triggered to use its in-
11 built RFID (Radio Frequency Identification) read/write
12 interface 60 device to read information from the RFID tag
13 mounted in the mount 24. More specifically, the
14 monitoring component 12 reads the tool ID and the
15 vibration dosage rate for the tool. In addition, a value
16 representing the 'trigger on' vibration level is read
17 (which constitutes the vibration threshold value).

18 In an un-illustrated embodiment, the monitoring
19 apparatus has a transponder, with the monitoring
20 apparatus being configured to write data from a first
21 RFID transceiver (such as that in the monitoring
22 component) to the transponder and for the second RFID
23 transceiver (such as that in the base station) being
24 configured to read the written data from the transponder.
25 Thus data is conveyed from the first transceiver to the
26 second transceiver via the transponder. According to
27 this embodiment, there is no need to turn off the
28 emanated field of the transceiver receiving the data as
29 it operates in a known manner.

30 As the tool is used the tri-axial accelerometers of
31 the monitoring component produce a vibration signals for
32 each of three axes. The microprocessor 52 is operative
33 to select one or a combination of the three vibration

1 signals produced by the accelerometers on the basis of a
2 comparison amongst the vibration signals to determine the
3 strongest vibration signal. Alternatively, the RFID tag
4 in the mount 24 may transmit a vibration axis parameter
5 (which constitutes vibration axis information), which
6 regulates which measurement axis or combination of axes
7 is to be used. If vibrations detected by the selected
8 accelerometer exceed the 'trigger on' level the timer
9 contained in the monitoring component microprocessor 52
10 starts. The microprocessor then operates to multiply the
11 dose rate by the time the tool 20 is in use as measured
12 by the timer to produce a vibration exposure value, which
13 is added to a running total for the user for that shift.

14 The monitoring component 12 keeps a running total of
15 the vibration dose for the current user and when the user
16 is finished with that tool he removes the monitoring
17 component and the current dosage total is recorded into
18 monitoring component memory 54 along with the start and
19 end times for the tool's usage. In this way a time
20 history of vibration information seen by the monitoring
21 component is stored in the memory 54 along with the
22 current tool ID and employee ID. In addition, measured
23 vibration levels (as described above) are recorded and
24 stored.

25 A slow flashing green light indicates that the unit
26 has been connected, received a valid tool ID and has
27 sufficient battery power. The user can twist off the
28 monitoring component 12 from its mount 24 and use it on
29 different tools throughout the day. While the monitoring
30 component is not in use it can be held securely on a
31 locator/holster attached to the user's work belt.

32 If during tool use certain levels of cumulative HAV
33 doses are detected visual alarms will trigger as

described above. At each alarm a record will be written into memory of the time at which the user exceeded the relevant level. If during the use of each particular tool a level of vibration is detected in the monitoring component that is larger than the specified service level then the tool will be deemed to be producing too much vibration and is in need of service. At this point a visual alarm is triggered and a copy of the Tool ID written into a broken tools section in the monitoring component memory 54. The user should cut short his use of that tool and report the need for service of the tool. In addition to checking if the tool needs servicing the monitoring component records a value representing the average vibration levels seen on the tool as recorded by the accelerometer 56 and stores this in memory 54 against the tool's ID.

When the user is finished on site the monitoring component 12 is returned to an available docking bay 36 on the base component 14 and clocks out thereafter by re-swiping his user ID card 16. As soon as the monitoring component 12 is returned to a vacant docking bay 36, the base component can begin to recharge it. The monitoring component 12 knows it is in a vacant docking bay because the reed switch 58 of the monitoring component 12 is actuated by a magnetic contact in the docking bay 36. The docking bay is distinguished from a bay in a mount 24 by the monitoring component 12 performing a read of RFID tags in the vicinity. An RFID tag (such as the EM4135 from EM Microelectronic - Marin SA) provided in the docking bay responds to the reading action by modulating the RF signal with its stored data to thereby identify the base component to the monitoring component. The response also informs the monitoring component whether

1 the base component is of a simple form (i.e. is for re-
2 charging only and has no capability for onward
3 communication of data) or has communication capabilities.
4 Thereafter the base component waits for the monitoring
5 component to download the vibration information via the
6 RFID link. Thus the monitoring component memory is
7 cleared for further use. Data communication between the
8 monitoring component and the base station is via their
9 respective RFID transceivers. The RFID transceivers are
10 of conventional type operating according to the 125 kHz
11 standard (such as the EM4095 from EM Microelectronic -
12 Marin SA) or the 13.56 MHz standard (such as the EM4094
13 from EM Microelectronic - Marin SA). To provide for
14 communication, the emanated field in the receiving RFID
15 transceiver (i.e. the RFID transceiver in the base
16 component) is turned off by writing an appropriate
17 command word to the RFID transceiver in the case of a 125
18 kHz device or by writing a series of '1's after a command
19 word containing option bits is written to the RFID
20 transceiver in the case of a 13.56 MHz device. How this
21 is accomplished in either case will be readily apparent
22 to the skilled person upon reference to publicly
23 available data sheets for the EM4095 and EM4094 devices.

24 Only a single RFID read/write interface is needed in
25 the base component if there is a selectable antenna
26 located in each docking bay 36. The information is stored
27 on the base component on its internal memory card 18,
28 which can store at least 3 months of data. Every month a
29 message on the base component indicates that it is time
30 to remove and replace the internal memory card. The
31 replaced card 18 is sent off-site for storage on a
32 central database provided on the Personal Computer 20.

1 The card is read via a standard card reader connected to
2 the PC.

3 Recording vibration dose information facilitates the
4 gathering of historical information for further analysis
5 and acts as a permanent vibration health and safety
6 record for users. The system records the date and time
7 of exposure and the particular tool and level of usage.
8 This means that monitoring of and controls for users can
9 be tighter. If necessary, action can be taken to protect
10 personnel. Also, a central record of tools in need of
11 service can be kept which will aid tool management and
12 provide the means to reduce the likelihood that no user
13 is exposed to dangerous levels of vibration from damaged
14 equipment.

15 In the second embodiment of the invention
16 represented in Figure 7 the hand held tool monitoring
17 apparatus 10 comprises the same components as the first
18 embodiment. Therefore components common to drawings of
19 the first and second embodiments have the same reference
20 numerals. The area in Figure 7 designated by reference
21 numeral 90 indicates components that are fixed to the
22 tool, e.g. the pneumatic drill 22 of Figure 1, and the
23 area designated by reference numeral 92 indicates a
24 portable component. More specifically, the accelerometer
25 is fixed to the tool and provided with a robust connector
26 94. The portable component is a monitoring component 12,
27 which is the same as that of the first embodiment without
28 the accelerometer. The monitoring apparatus of the
29 second embodiment is operated in the same manner as the
30 first embodiment with the notable exception of the use of
31 the connector 94 instead of the RF link between the
32 components that are fixed to the tool and the portable
33 monitoring component 12.

1 In the third embodiment of the invention represented
2 in Figure 8 the hand held tool monitoring apparatus 10
3 comprises components in common with the first embodiment
4 that are designated by the same reference numerals. Also
5 in common with Figure 7, the area in Figure 8 designated
6 by reference numeral 90 indicates components that are
7 fixed to the tool, e.g. the pneumatic drill 22 of Figure
8 1, and the area designated by reference numeral 92
9 indicates a portable component. According to the third
10 embodiment, the accelerometers 56 are attached
11 permanently to a tool along with a processor unit 100
12 having a detachable rechargeable battery. The portable
13 component is a read/write RFID based user ID card 16,
14 which is used by a particular user in place of the
15 magnetic strip based Employee ID in other embodiments.
16 In use, the user inserts his RFID card 16 into the
17 processor unit 100 upon commencing use of a tool.
18 Vibration data is acquired by the processor unit 100 and
19 written to the RFID card 16. Thus, it will be understood
20 that the processor unit 100 comprises the necessary
21 processing and interface functions present in the
22 monitoring component 12 of the first and second
23 embodiments. Vibration and other data is stored on a
24 digital memory card (not shown). Recovery of stored data
25 from the processor unit 100 is by means of a RF link (not
26 shown) for storage in a central server, such as the
27 Personal Computer 20 of Figure 1. Otherwise, the third
28 embodiment operates in the same manner as the first
29 embodiment.

30
31
32
33

1 CLAIMS:

2
3 1. Hand held tool monitoring apparatus comprising a
4 mount, which in use of the hand held tool monitoring
5 apparatus forms part of a hand held tool, and a
6 monitoring component configured to be releasably attached
7 to the mount, the monitoring component comprising an
8 operative part of the hand held tool monitoring
9 apparatus, the hand held tool monitoring apparatus
10 further comprising a vibration sensor and a timer, the
11 vibration sensor being operable to sense vibration of the
12 hand held tool and provide a vibration signal in response
13 to sensed vibration when the monitoring component is
14 attached to the mount, and the timer being operative in
15 dependence on the vibration signal to record a duration
16 of vibration of the hand held tool.

17
18 2. Apparatus according to claim 1, in which the
19 monitoring component is configured to be carried by an
20 operator.

21
22 3. Apparatus according to claim 2, in which the
23 monitoring component is of a size that permits the
24 monitoring component to be received in a pocket of an
25 operator.

26
27 4. Apparatus according to any preceding claim, in which
28 the monitoring component is configured for use by a
29 particular operator by comprising a code identifying the
30 monitoring component as being for use by the particular
31 operator.

32

1 5. Apparatus according to any preceding claim, in which
2 the mount is configured to be attached to the hand held
3 tool.

4
5 6. Apparatus according to any preceding claim, in which
6 the mount forms an integral part of the hand held tool.

7
8 7. Apparatus according to claim 6, in which the hand
9 held tool and the hand held tool monitoring apparatus are
10 configured to switch off the hand held tool when a
11 predetermined condition is satisfied.

12
13 8. Apparatus according to claim 7, in which the hand
14 held tool and the hand held tool monitoring apparatus are
15 configured to switch off the hand held tool by stopping
16 supply of power to operate the hand held tool.

17
18 9. Apparatus according to claim 7 or 8, in which the
19 predetermined condition comprises at least one of: a
20 vibration level value being reached; and an incorrect
21 licence being provided for the hand held tool monitoring
22 apparatus.

23
24 10. Apparatus according to any preceding claim, in which
25 the mount and monitoring component are configured to be
26 detached from each other by a single manual operation by
27 a user.

28
29 11. Apparatus according to any preceding claim, in which
30 the monitoring component and the mount comprise
31 respective cooperating magnetic components that in use
32 provide for releasable attachment of the monitoring
33 component to the mount.

1
2 12. Apparatus according to any preceding claim, in which
3 the monitoring component and the mount have respective
4 surface profiles configured to engage with each other to
5 provide for releasable attachment of the monitoring
6 component to the mount.
7

8 13. Apparatus according to claim 12, in which the mount
9 defines a recess configured to receive at least a part of
10 a body of the monitoring component.
11

12 14. Apparatus according to any preceding claim, in which
13 the monitoring component comprises a power switch that is
14 configured to switch on the monitoring component when the
15 monitoring component is attached to the mount.
16

17 15. Apparatus according to claim 14, in which the power
18 switch comprises at least one of: an electrically
19 actuated switch; and a mechanically actuated switch.
20

21 16. Apparatus according to any preceding claim, in which
22 the mount comprises hand held tool information for the
23 hand held tool to which the mount is attached.
24

25 17. Apparatus according to claim 16, in which the mount
26 is configured to convey the hand held tool information to
27 the monitoring component.
28

29 18. Apparatus according to claim 17, in which the mount
30 comprises a communications component operable to
31 wirelessly convey the hand held tool information to the
32 monitoring component.
33

1 19. Apparatus according to claim 18, in which the
2 communications component is passive.

3
4 20. Apparatus according to claim 19, in which the
5 monitoring component is operable to actuate the passive
6 communications component and receive hand held tool
7 information conveyed from the mount.

8
9 21. Apparatus according to any one of claims 16 to 20,
10 in which the hand held tool information comprises hand
11 held tool identification information.

12
13 22. Apparatus according to any one of claims 16 to 21,
14 in which the hand held tool information comprises hand
15 held tool vibration information.

16
17 23. Apparatus according to claim 22, in which the hand
18 held tool vibration information comprises a predetermined
19 vibration dosage rate.

20
21 24. Apparatus according to any one of claims 16 to 23,
22 in which, where the vibration sensor is configured to be
23 responsive to vibrations in three mutually orthogonal
24 axes, the hand held tool vibration information comprises
25 vibration axis information regarding which measurement
26 axis or combination of axes is be used for measurement or
27 detection of vibrations.

28
29 25. Apparatus according to claim 23 or 24, in which the
30 monitoring component is configured to provide a vibration
31 exposure value in dependence upon the vibration dosage
32 rate conveyed from the mount and the duration of
33 vibration recorded by the timer.

1
2 26. Apparatus according to claim 25, in which the
3 monitoring component is configured to multiply the
4 vibration dosage rate by the duration of vibration
5 recorded by the timer to provide a vibration exposure
6 value.

7
8 27. Apparatus according to any preceding claim, in which
9 the vibration sensor comprises a plurality of vibration
10 sensors.

11
12 28. Apparatus according to any preceding claim, in which
13 the monitoring apparatus is configured to be operative in
14 dependence upon at least one of a plurality of vibration
15 signals.

16
17 29. Apparatus according to claim 28, in which the
18 monitoring apparatus is configured to be operative in
19 dependence upon a selected one of the plurality of
20 vibration signals.

21
22 30. Apparatus according to any preceding claim, in which
23 the vibration sensor is configured to be responsive to a
24 plurality of ranges of detectable acceleration and to
25 provide a vibration signal for each range.

26
27 31. Apparatus according to any preceding claim, in which
28 the vibration sensor is configured to be responsive to
29 vibrations in three mutually orthogonal axes and to
30 provide a vibration signal for each axis.

31

32. Apparatus according to claim 31, in which the monitoring apparatus is configured to select one of the three vibration signals.

33. Apparatus according to claim 32, in which the monitoring apparatus is operative to select a vibration signal on the basis of a comparison amongst the three vibration signals.

34. Apparatus according to any preceding claim, in which a root mean square (RMS) value of a vibration signal is taken.

35. Apparatus according to any one of claims 32 to 34, in which the monitoring apparatus is configured to operate the timer in dependence upon the selected one of the vibration signals.

36. Apparatus according to any preceding claim, in which the monitoring component is configured to provide for accumulated storage of data.

37. Apparatus according to any one of claims 22 to 36, in which the hand held tool vibration information comprises a predetermined vibration threshold value and the monitoring component is configured to operate the timer in dependence upon the predetermined vibration threshold value.

38. Apparatus according to claim 37, in which the monitoring component is operative to compare the vibration signal provided by the vibration sensor with

1 the vibration threshold value and to operate the timer in
2 dependence upon the comparison.

3
4 39. Apparatus according to claim 38, in which, where the
5 vibration sensor is configured to be responsive to
6 vibrations in three mutually orthogonal axes and to
7 provide a vibration signal for each axis and the hand
8 held tool vibration information comprises vibration axis
9 information, the monitoring component is operative to
10 select a vibration signal or a combination of vibration
11 signals on the basis of the vibration axis information.

12
13 40. Apparatus according to claim 38 or 39, in which,
14 where the vibration sensor is configured to be responsive
15 to vibrations in three mutually orthogonal axes and to
16 provide a vibration signal for each axis, the monitoring
17 component is operative to select at least one of: a
18 vibration signal; and a combination of vibration signals
19 based on a comparison amongst the three vibration
20 signals, and to use the selected at least one vibration
21 signal in the comparison with the vibration threshold
22 value.

23
24 41. Apparatus according to claim 40, in which the
25 monitoring component is operative to select at least one
26 vibration signal that is representative of a strongest
27 vibration.

28
29 42. Apparatus according to any preceding claim, in which
30 the hand tool monitoring apparatus further comprises an
31 indicator configured to indicate at least one vibration
32 value in dependence on the vibration signal.

33

1 43. Apparatus according to claim 42, in which the at
2 least one indicated vibration value comprises at least
3 one vibration exposure value.

4
5 44. Apparatus according to claim 43, in which the at
6 least one vibration exposure value comprises a remaining
7 exposure value for the current day of use of the
8 monitoring apparatus by a user.

9
10 45. Apparatus according to claim 43 or 44, in which the
11 at least one vibration exposure value comprises a user's
12 accumulated exposure value over a plurality of uses.

13
14 46. Apparatus according to any one of claims 43 to 45,
15 in which the at least one vibration exposure value
16 comprises a user's last exposure value during use of the
17 monitoring apparatus with a most recently used tool.

18
19 47. Apparatus according to any one of claims 42 to 46,
20 in which the indicator comprises a plurality of digits
21 operative to display the at least one vibration exposure
22 value.

23
24 48. Apparatus according to claim 47, in which where the
25 at least one vibration exposure value comprises a
26 remaining exposure value for the current day of use, an
27 accumulated exposure value, and a last exposure value,
28 the indicator is operative to display at least two of
29 these exposure values simultaneously.

30
31 49. Apparatus according to any one of claims 42 to 48,
32 in which the indicator is operative to display at least
33 two of the exposure values on an alternating basis.

1
2 50. Apparatus according to claim 49, in which the
3 indicator is operative to display the remaining exposure
4 value alternatively with either the accumulated exposure
5 value or the last exposure value.
6

7 51. Apparatus according to claim 50, in which the
8 monitoring apparatus is operative to select the
9 accumulated exposure value for display when the
10 monitoring apparatus is attached to a tool.
11

12 52. Apparatus according to claim 50 or 51, in which the
13 monitoring apparatus is operative to select the last
14 exposure value for display when the monitoring apparatus
15 is detached from a tool.
16

17 53. Apparatus according to any one of claims 42 to 52,
18 in which the indicator is configured to indicate a
19 plurality of categories of vibration value.
20

21 54. Apparatus according to claim 53, in which the
22 indicator comprises a plurality of visual indicators,
23 each visual indicator being operative to indicate one of
24 the plurality of categories of vibration value.
25

26 55. Apparatus according to claim 54, in which the visual
27 indicators are operative to display different colours.
28

29 56. Apparatus according to any preceding claim, in which
30 the monitoring component comprises the vibration sensor
31 and the timer.
32

1 57. Apparatus according to any one of claims 1 to 55, in
2 which the mount comprises the vibration sensor and the
3 monitoring component comprises the timer.
4

5 58. Apparatus according to any one of claims 1 to 55, in
6 which the mount comprises the vibration sensor and the
7 timer.
8

9 59. Apparatus according to claim 58, in which the
10 monitoring component comprises a data storage memory.
11

12 60. Apparatus according to claim 59, in which the
13 monitoring component is configured to periodically store
14 a vibration based on the vibration signal in the data
15 storage memory.
16

17 61. Apparatus according to any preceding claim, in which
18 the hand tool monitoring apparatus further comprises a
19 user identification component configured to identify one
20 of a plurality of possible users.
21

22 62. Apparatus according to claim 61, in which the user
23 identification component comprises: a specific user
24 component comprising information for a specific user, the
25 user identification component being configured to be
26 carried by the specific user; and the monitoring
27 apparatus comprises a separate, specific user
28 configurable component associated with the vibration
29 sensor to which information for the specific user can be
30 conveyed.
31

32 63. Apparatus according to any preceding claim, in which
33 the hand tool monitoring apparatus further comprises a

1 base component configured for use at a central location
2 spaced apart from a location of use of the vibration
3 sensor on a hand held tool.

4 64. Apparatus according to claim 63, in which the base
5 component and the vibration sensor are configured for
6 transmission of a transmission signal between the base
7 component and the vibration sensor.

8
9 65. Apparatus according to claim 64, in which the base
10 component and the vibration sensor are configured for
11 transmission of the transmission signal by at least one
12 of a wired coupling and an inductive coupling.

13
14 66. Apparatus according to claim 64 or 65, in which the
15 transmission signal comprises at least one of a power
16 signal and a data signal.

17
18 67. Apparatus according to any one of claims 63 to 66,
19 in which the base component is configured to provide for
20 at least one of: storage of the vibration sensor when not
21 in use; re-charging of a battery power supply associated
22 with the vibration sensor; storage of data recorded in
23 use of the vibration sensor on a hand held tool; and
24 configuring of a vibration sensor for use by a specific
25 user by means of specific user information.

26
27 68. Apparatus according to claim 67, in which the base
28 component is configured for use with a plurality of
29 vibration sensors.

30
31 69. Apparatus according to any preceding claim, in which
32 the operative part of the hand held tool monitoring

1 apparatus comprises at least one of: the vibration
2 sensor, the timer and data storage memory.

3
4 70. Apparatus according to any preceding claim, in which
5 the monitoring apparatus further comprises communications
6 apparatus comprising first and second Radio Frequency
7 Identification (RFID) transceivers, the first and second
8 RFID transceivers being configured to wirelessly transmit
9 data between the first and second RFID transceivers, the
10 first RFID transceiver forming part of the base component
11 and the second RFID transceiver forming part of the
12 monitoring component.

13
14 71. Apparatus according to claim 70, in which the first
15 and second RFID transceivers are configured for operation
16 at at least one of: 125 kHz and 13.56 MHz.

17
18 72. Apparatus according to claim 70 or 71, in which one
19 of the first and the second RFID transceivers is
20 configured by having its emanated RF field turned off.

21
22 73. Apparatus according to claim 72, in which where the
23 RFID transceivers are operable at 125 kHz, the emanated
24 field is turned off by writing an appropriate command to
25 the RFID transceiver.

26
27 74. Apparatus according to claim 72, in which where the
28 RFID transceivers are operable at 13.56 MHz, the emanated
29 field is turned off by writing a series of '1's to the
30 RFID transceiver after a control word containing option
31 bits is written to the RFID transceiver.

32

1 75. Apparatus according to any one of claims 70 to 74,
2 in which the first and second RFID transceivers are
3 configured for handshaking between them before
4 transmission of data from one to the other.

5 76. Apparatus according to claim 75, in which the base
6 component comprises an RFID transponder and the second
7 RFID transceiver is configured to receive data from the
8 RFID transponder.

9
10 77. Apparatus according to any one of claims 70 to 76,
11 in which the first and second RFID transceivers are
12 configured for duplex transmission of data between them.

13
14 78. Apparatus according to any preceding claim, in which
15 the hand held tool monitoring apparatus further comprises
16 an isolator operative to change the vibration signal to
17 take account of a change in a vibration characteristic
18 between the hand held tool and the operator.

19
20 79. Apparatus according to claim 78, in which the
21 isolator comprises at least one filter.

22
23 80. Apparatus according to any preceding claim, in which
24 the hand held tool monitoring apparatus is operative to
25 store the vibration signal.

26
27 81. Apparatus according to any preceding claim, in which
28 the hand held tool monitoring apparatus is configured to
29 store data that is at least one of: time stamped and date
30 stamped.

31
32 82. A hand held tool monitoring method using monitoring
33 apparatus comprising a mount and a monitoring component,

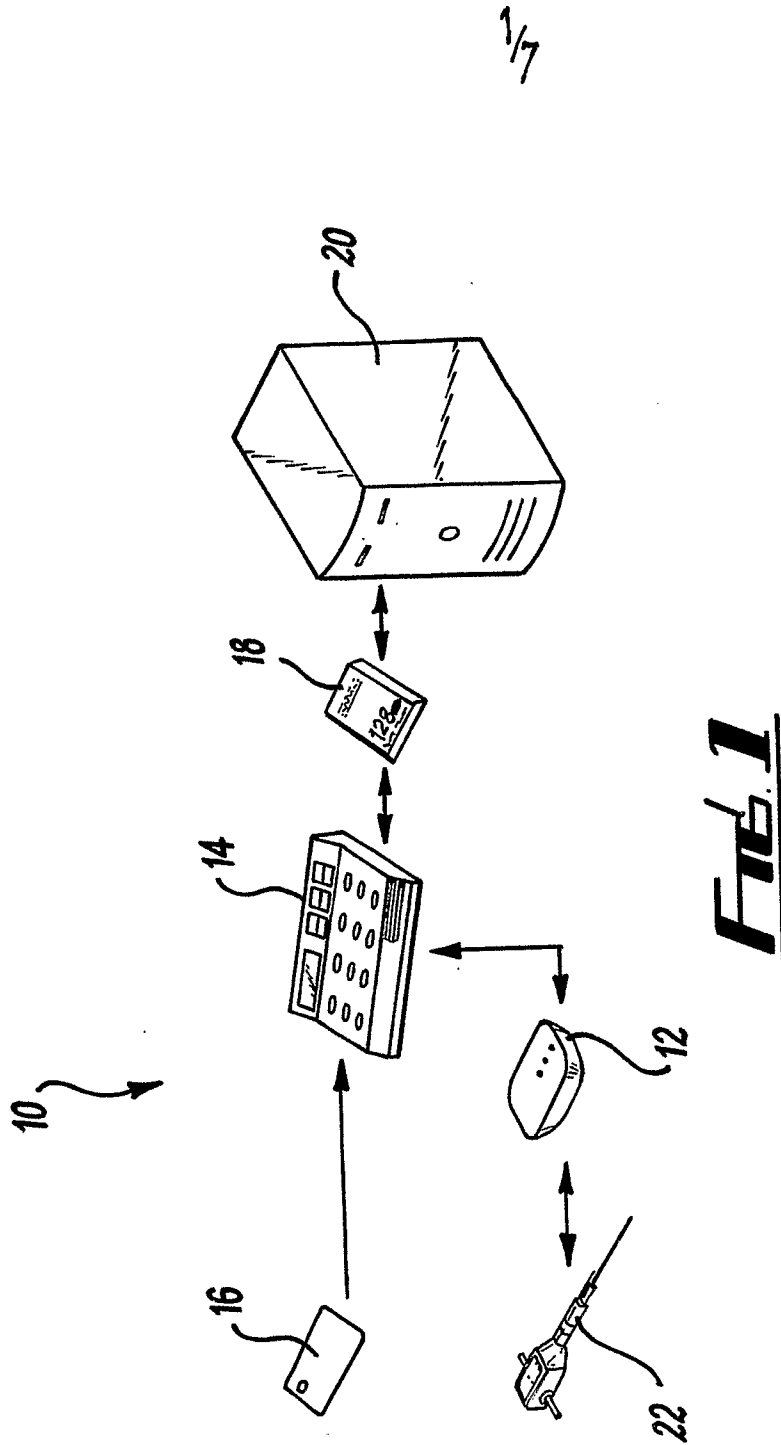
1 the method comprising the steps of: attaching the
2 monitoring component, which comprises an operative part
3 of the hand held tool monitoring apparatus, to the mount,
4 the mount, in use, forming part of the hand held tool,
5 the monitoring component and mount being configured for
6 releasable attachment of the monitoring component to the
7 mount; operating a vibration sensor of the hand held tool
8 monitoring apparatus to sense a vibration of the hand
9 held tool and to provide a vibration signal in dependence
10 upon the sensed vibration; operating a timer of the hand
11 held tool monitoring apparatus in dependence upon the
12 vibration signal to record a duration of vibration of the
13 hand held tool; and removing the monitoring component
14 from the mount.

15
16 83. A method according to claim 82, in which the step of
17 attaching the mount to the hand held tool comprises
18 attaching the mount at a location on the hand held tool
19 spaced apart from a location where an operator engages
20 the hand held tool when the tool is in use.

21
22 84. Apparatus according to claim 83, in which the step
23 of attaching the mount to the hand held tool comprises
24 attaching the mount at a location on the hand held tool
25 that is as close as is practical to a location where an
26 operator engages the hand held tool when the tool is in
27 use.

28
29 85. A hand held tool comprising hand held tool
30 monitoring apparatus according any one of claims 1 to 81.

31
32
33



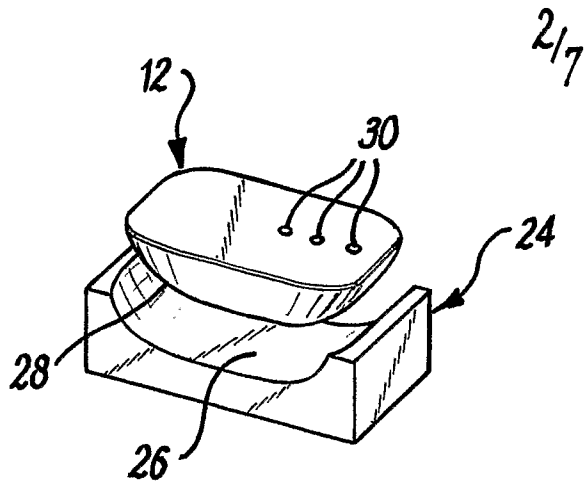


FIG. 2A

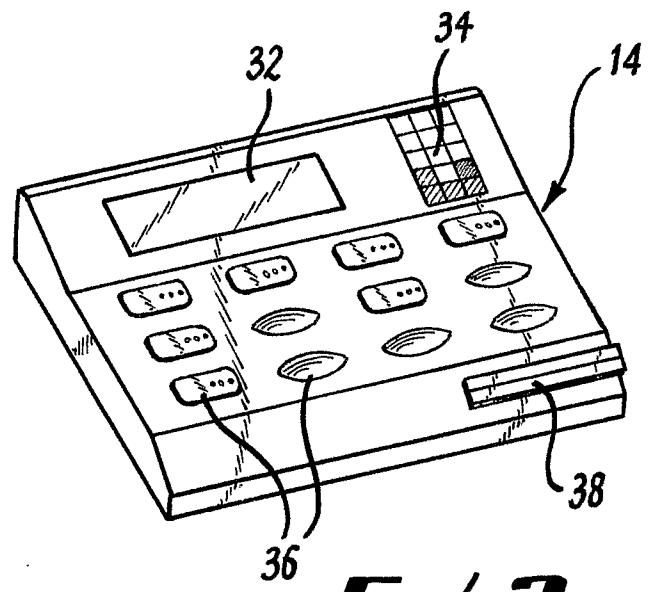


FIG. 2B

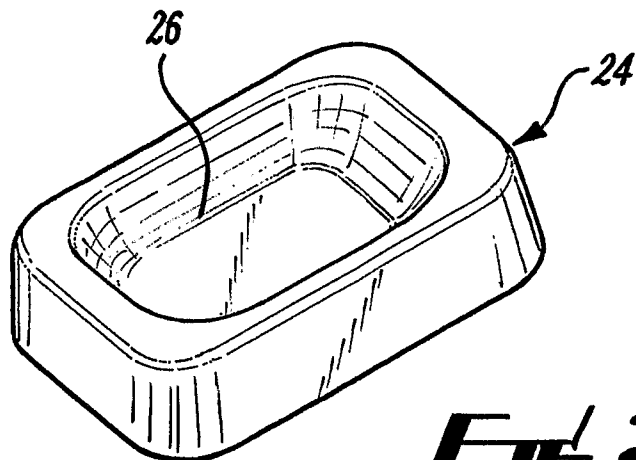
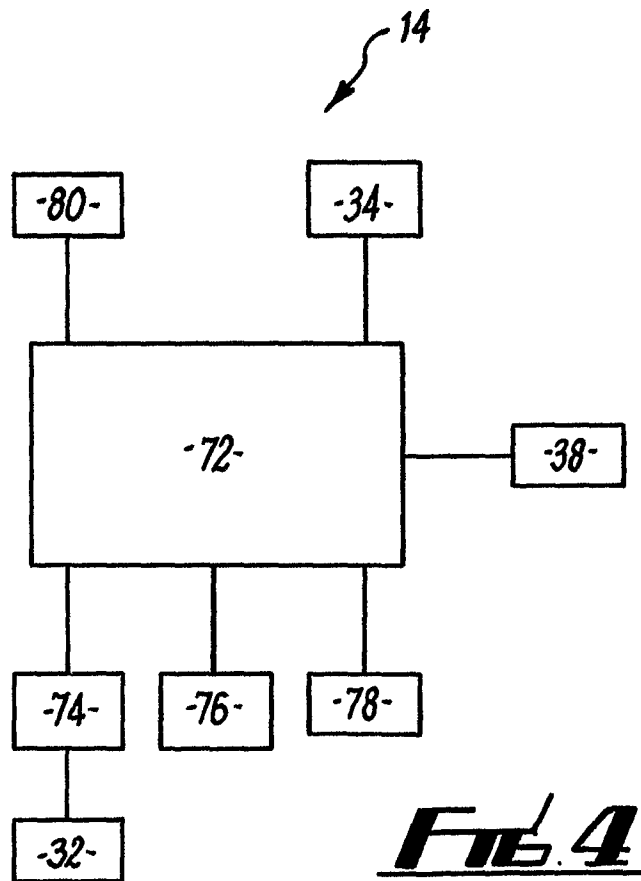
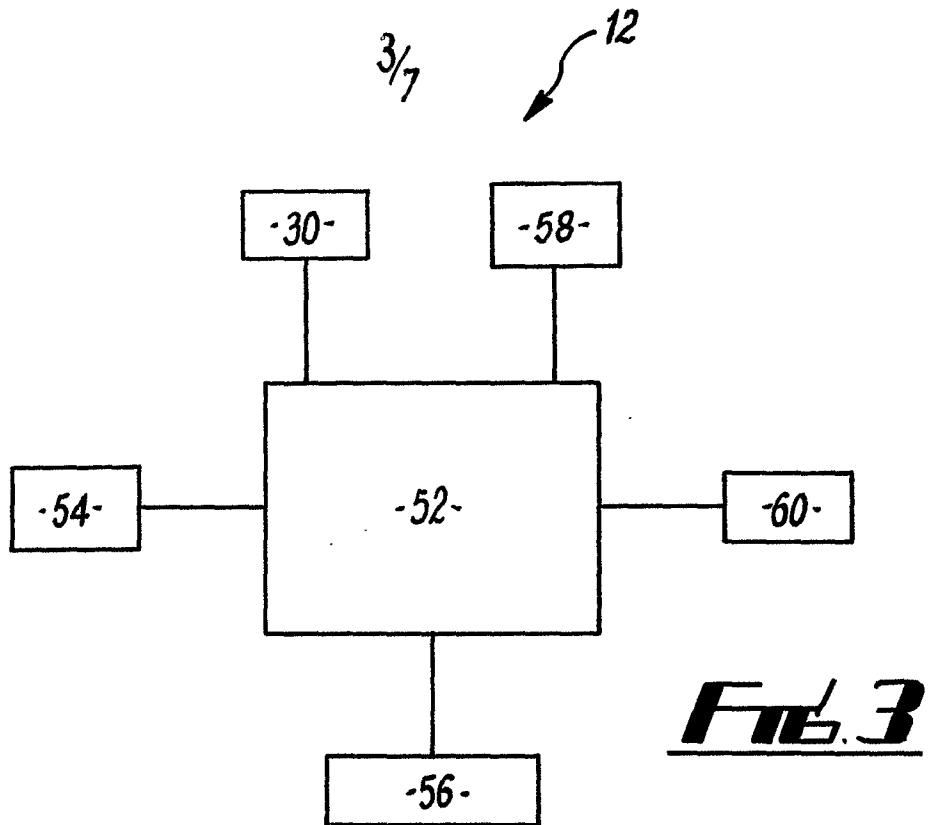


FIG. 2C



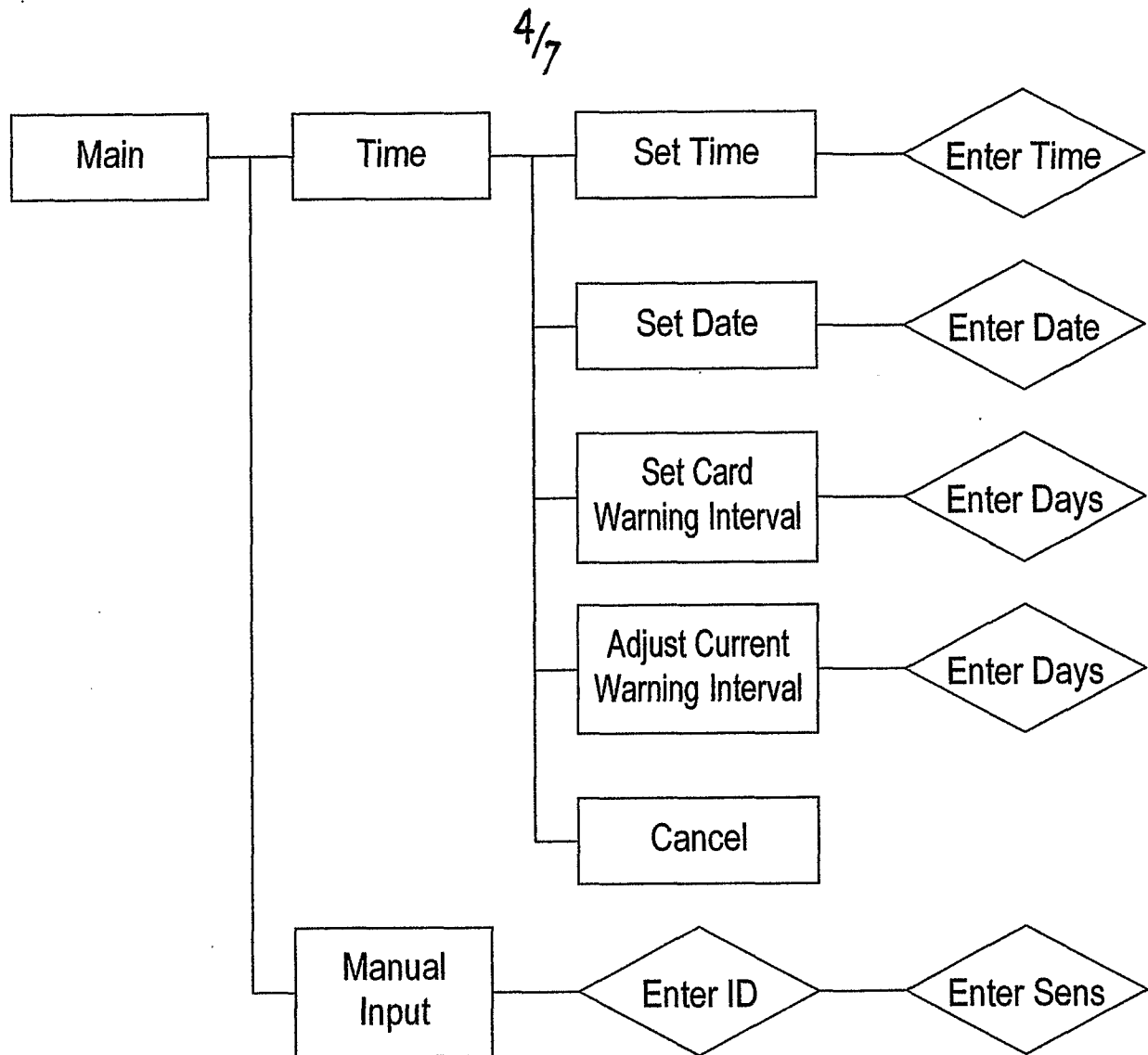


FIG. 5

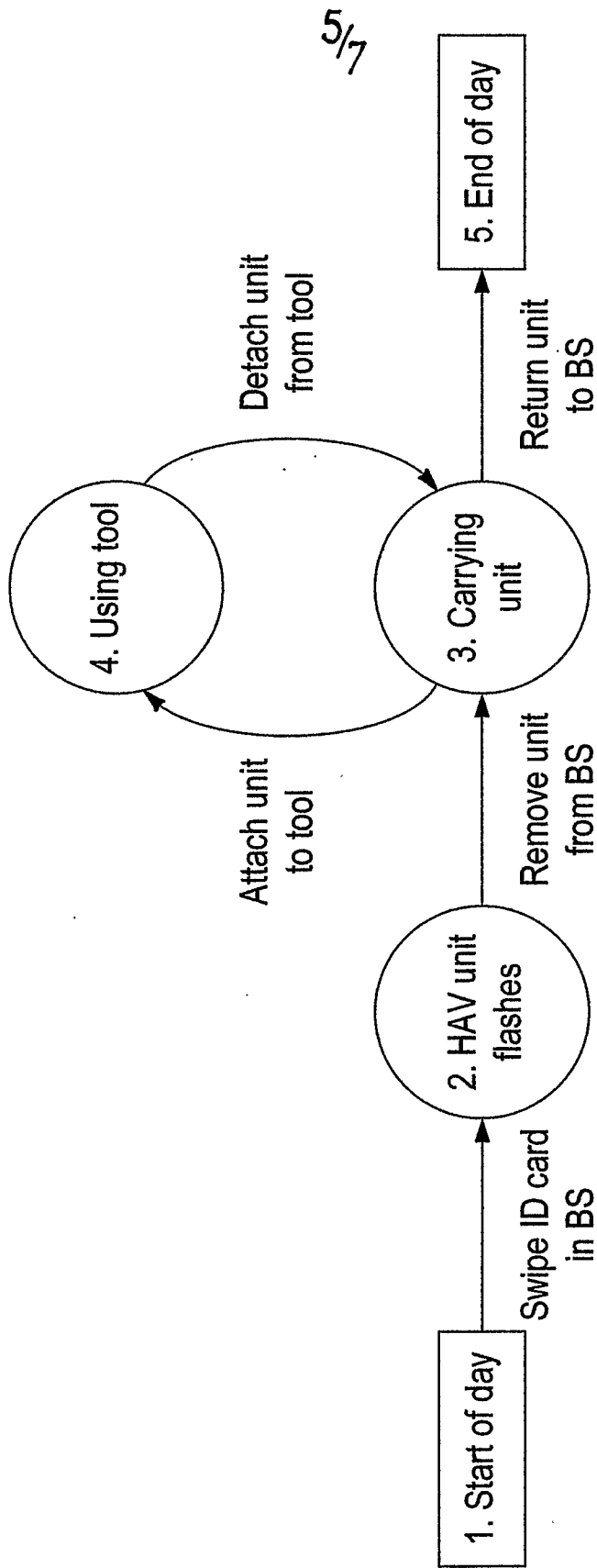


Fig. 6

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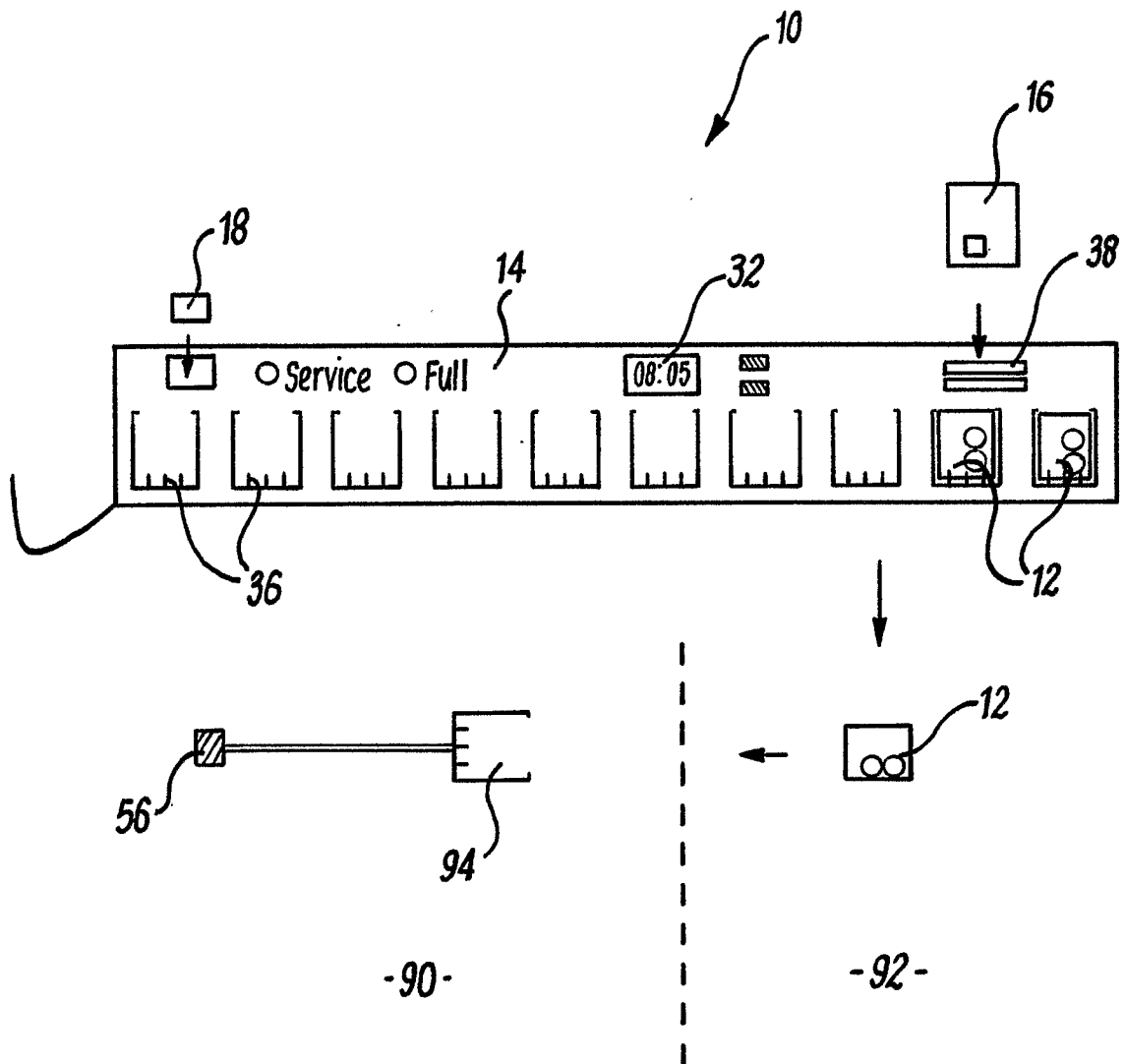


FIG. 1

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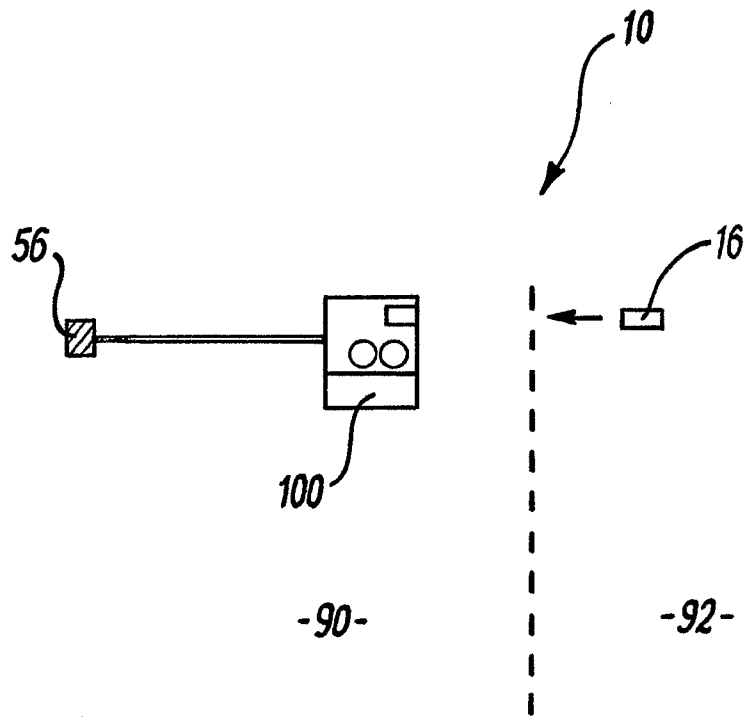


FIG. 8