Abstract Title: **Measuring the operational time of a tool**

A time measurement device 2 measures the cumulative amount of time a tool 30 has been in use and is able to transmit data relating to the measured time to a data collection device (e.g., PDA) 5. The transmission may be wireless (e.g., radio frequency or infrared). The measurement device may be incorporated into the electric plug 31 of the tool 5 and may comprise a sensor which detects the flow of current to the tool. The elapsed time may be visually displayed. Alternatively the sensor may be an accelerometer which determines when the tool is operating by sensing vibrations. The vibration exposure of the operator of the tool may be displayed. Alternatively, in the case of a compressed air tool, the sensor may detect the flow of air through the tool.
TIME MEASUREMENT DEVICE

Technical Field of the Invention

The invention relates to a time-measurement device, and in particular relates to a device that measures the length of time that a tool attached to the device is active.

Background to the Invention

One of the major industrial diseases affecting workers in mining, construction, and engineering is Hand Arm Vibration Syndrome (HAVS) or Vibration White Finger, which affects the circulatory and muscular systems. The primary cause of this disease is the transfer of vibration from powered handheld tools.

In order to ascertain the exposure of individual tool operators to vibration it is recommended that a regime be introduced that allows the time that an individual uses a tool to be recorded. Such information can, by means of a standard calculation, be used to determine the total daily vibration exposure level for an operator.

In addition, it is desirable to monitor the cumulative amount of time that a tool has been in use, in order to determine if it is necessary to perform a regular maintenance operation on the tool.

This operational time data can also be used by companies, for example hire companies that lend tools, to charge their clients an appropriate amount of money based on the length of time that a tool was used.

Any device that provides this type of information must be able to withstand both the inherent vibration of the tool and the physical abuse which such tools undergo in their working environment. In addition, such a device must permit easy collection and analysis of the time data.

Summary of the Invention

According to a first aspect of the present invention, there is provided a time measurement device comprising means for measuring the length of time that a tool
attached to the device is active; and means for allowing data relating to the measured length of time to be transferred to a data collection device.

Preferably, the means for measuring the length of time that a tool attached to the device is active is further adapted to measure the cumulative time that the tool is active over a number of active periods.

Preferably, the means for measuring the length of time that a tool attached to the device is active further comprises means for resetting the measured time.

Preferably, the time measurement device further comprises a display for indicating the measured time.

Preferably, the display is adapted to provide an indication of the vibration exposure of an operator of the tool.

Alternatively, the display is adapted to provide an indication of when a maintenance operation should be performed on the tool.

Preferably, the means for allowing data relating to the measured length of time to be transferred to a data processing device is adapted to transfer the data over an air interface.

Preferably, the time measurement device further comprises means for receiving data from a data collection device.

Preferably, the means for receiving data from the data collection device is adapted to receive data over an air interface.

In a preferred embodiment, the tool is an electric tool, and the means for measuring the length of time that a tool attached to the device is active comprises a sensor that detects the flow of current to the tool.

Preferably, the sensor is adapted to measure the flow of current without breaking the continuity of the current flow to the tool.
Preferably, the sensor comprises a current transformer.

Alternatively, the sensor comprises a Hall Effect device.

Preferably, the time measurement device is incorporated into an electric plug attached to the tool.

Alternatively, the time measurement device is incorporated into an electric cable attached to the tool.

In an alternative preferred embodiment, the tool is an air-powered tool, and the means for measuring the length of time that a tool attached to the device is active comprises a sensor that detects the flow of air through the tool.

Preferably, the sensor comprises a piston within a cylinder that is adapted to move relative to a sensing component when air flows through the tool.

Preferably, the piston comprises a magnet and the sensing component detects the proximity of the magnet.

Alternatively, the sensor comprises a plurality of blades mounted on a shaft that rotates when air flows through the tool.

Preferably, the sensor comprises a sensing component that detects the proximity of each blade as the shaft rotates.

Preferably, the time measurement device is connected between the tool and an air supply.

In another alternative embodiment, the means for measuring the length of time that a tool attached to the device is active comprises a sensor that detects the vibration of the tool.

Preferably, the time measurement device is connected directly to the tool.
Preferably, the sensor is adapted to detect vibration at a specific frequency or frequency band.

Preferably, the sensor comprises an accelerometer.

According to a second aspect of the present invention, there is provided a system for monitoring the usage of a plurality of tools, the system comprising a plurality of time measurement devices as described above, each device being attached to a respective one of the said plurality of tools; and at least one data collection device having means for receiving and storing data from each of said time measurement devices.

According to a third aspect of the present invention, there is provided a method of monitoring the usage of a tool, the method comprising: measuring the length of time that a tool is active; and transferring data relating to the measured length of time to a data collection device.

The preferred features set out above in relation to the first aspect of the invention may also be applied to the second and third aspect of the invention.

**Brief Description of the Drawings**

For a better understanding of the present invention and to show how it may be put into effect, reference will now be made by way of example to the accompanying drawings, in which:

Figure 1 is a schematic representation of a device according to the present invention;

Figure 2 shows a device according to the present invention incorporated into a connector for an electric tool;

Figure 3 is a schematic representation of the device of Figure 2 in use;

Figure 4 is an illustration of a first type of sensor for detecting the flow of air in an air-powered tool in accordance with the invention;
Figure 5 is an illustration of a second type of sensor for detecting the flow of air in an air-powered tool in accordance with the invention;

Figure 6 is a schematic representation of a sensor for detecting the vibration of a tool in accordance with the invention; and

Figure 7 is a schematic representation of a system in accordance with the invention.

**Detailed Description of the Preferred Embodiments**

Referring to Figure 1, the device 2 comprises a means 3 for measuring the length of time that a tool attached to the device is active and a means 4 for allowing data relating to the measured length of time to be wirelessly transferred to a data collection device 5.

The device 2 may be adapted to be attached directly to a tool, or, where the tool is electrically operated by a remote power source, the device 2 may be incorporated into an electric plug or connector, or into the cable connecting the tool to the power source. An electric plug or connector incorporating the device 2 according to the present invention is designed to replace the conventional plug or connector fitted to the power supply conductor of any item of electrically operated equipment that is not battery operated.

The means 3 for measuring the length of time that a tool attached to the device is active comprises a sensor 6 for detecting when the attached tool is active and a timer 7 for recording the length of time that the sensor 6 indicates that the tool is active. The type of sensor 6 used will depend on the type of tool that the device 2 is intended to be used with.

For example, if the device 2 is intended for measuring the length of time that electric tools are active, the sensor 6 can measure whether current is flowing from the power source of the tool. Alternatively, if the device 2 is intended for measuring the length of time that compressed-air powered tools are active, the sensor 6 can measure whether air is flowing through the tool. Alternatively, if the device 2 is intended to be mounted directly on the tool, the sensor 6 can measure whether the tool is vibrating.
The means 4 for allowing data relating to the measured length of time to be wirelessly transferred to a data processing device comprises a processor 8 and transmitter or transceiver circuitry 10.

In some embodiments of the invention, the device 2 comprises circuitry 10 for transmitting data, whilst in other embodiments of the invention, the device 2 comprises circuitry 10 for both transmitting and receiving data.

In embodiments of the invention where the device 2 comprises circuitry 10 for transmitting data only, the circuitry 10 may be a passive radio frequency identification (RFID) tag. Alternatively, the circuitry 10 may comprise other types of transmitter circuitry, for example, RF or infrared transmitters.

In embodiments of the invention where the device 2 comprises circuitry 10 for transmitting and receiving data, the circuitry 10 may be an active radio frequency identification (RFID) tag. Alternatively, the circuitry 10 may comprise other types of transceiver circuitry, for example, RF or infrared transmitters.

The device 2 may also comprise a memory 12 for storing the time measured by the sensor 6 and timer 7, and, where the device 2 includes transceiver circuitry 10, the memory 12 may store data received from the data collection device 5.

In further embodiments of the invention, the device 2 may include a display 14 for providing a visual indication of data relating to the operation of the tool. The display 14 may be a series of visual indicators, such as LEDs, or may be a full display, such as a LCD.

The display 14 may show, for example, the time that the tool has been continuously active (or provide an indication of the active time when the display 14 is a series of visual indicators), the cumulative time that the tool has been active since the last time the device 2 was reset or the level of vibration exposure of the user of the tool. Alternatively, or in addition, the device 2 may be configured to display other data relating to the operation of the attached tool. For example, if the tool is an electric tool, the device 2 may calculate and display the power consumed by the tool.
The data displayed by the device 2 other than the time data may be calculated by the processor 8 in the device 2, or may be provided by the data processing device 5.

The device 2 may be provided with means for resetting the data held in the memory 12. The means for resetting may be activated by receiving a signal from the data collection device 5, or may comprise a button on the device 2 which can be directly pressed by a user.

As described above, the data collection device 5 receives data from, and in some embodiments of the invention, transmits data to, the device 2. The data received from the device 2 may comprise data relating to the length of time that the device has been active.

The data collection device 5 comprises transceiver circuitry 16 for communicating with the device 2, a processor 18 for controlling the operation of the data collection device 5, a memory 20 for storing the data received from the device 2, a display 22 and user interface 24.

As there may be several different tools in use at any time in a workplace, each device 2 is provided with a unique identification code. This unique identification code is transmitted to the data collection device 5 by the device 2 with the active time data. This allows the data collection device 5 to collect and store data for a number of different tools.

The data collection device 5 may, for example, be a personal digital assistant (PDA), personal computer equipment or a dedicated device at a fixed location, for example at a doorway, or entry point to a store room.

The data collection device 5 may include software for analysing the data received from the plurality of devices 2, or alternatively, the data collection device 5 can transfer the collected data to a central terminal for analysis.

The data can be analysed to monitor the exposure of a tool operator to vibration, or determine whether a routine maintenance operation should be performed on the tool.
Figure 2 shows an exemplary device 2 according to the present invention incorporated into a connector for an electric tool 30. The device 2 comprises part of a plug 31 for connecting the tool 30 to a power supply. The tool 30 and the plug 31 are linked by an electric cable 32.

Figure 3 shows the connector of Figure 2 in more detail.

In this illustrated embodiment, the plug 31 comprises male electrical connections 34. Although a three-pin male connection is shown, it will be appreciated that any other type of connection may be used.

The plug 31 is attached to electric cable 32 which comprises a plurality of conducting wires. As shown in Figure 2, the electric cable 32 is connected to an electrically operated tool or other piece of electrically powered equipment 30.

To provide electrical energy to the equipment 30, the male electrical connections 34 are engaged with female electrical connections 36, which are connected by a plurality of conducting wires to an electrical energy source 38.

The operation of the electrically operated equipment 30 is controlled by a switch 39. When the switch 39 is closed, an electrical current passes from the electrical energy source 38 through the female electrical connections 36, male electrical connections 34 and a live conducting wire 40 to energise one or more components 42 within the electrically operated equipment 30. Such a component 42 may be, by way of example, an electric motor. The electrical circuit is completed by a neutral conducting wire 44 through the male electrical connections 34 and female electrical connections 36 to electrical energy source 38.

The plug 31 comprises a sensor 6 as described above for sensing when the attached tool is active. The sensor 6 is positioned so that current flowing through the live conducting wire 40 causes an electrical response from the sensor 6. This electrical response is sent to timer circuit 7. On sensing the electrical signal input from the sensor 6, the timer circuit 7 starts measuring time, which represents the time the electrically operated equipment 30 has been operating or Active.
The output of the timer circuit 7, in the form of measured elapsed time, is passed to timer memory 46 where it is stored. Alternatively, or in addition, the measured elapsed time can be added to any previously measured elapsed time to be represent the total accrued elapsed operating time for the electrically operated equipment 30.

A display 14, such as a liquid crystal display, provides a visual display of the elapsed time, or alternatively the cumulative elapsed time.

When the switch 39 in electrically operated equipment 30 is opened, the live conducting wire 40 ceases to pass an electrical current to the electrically operated equipment 30. The sensor 6 ceases to generate an electrical response, and the timer circuit 7 stops measuring elapsed time.

The timer memory 46 retains the total accrued elapsed operating time for the electrically operated equipment 30 when the power is removed from the equipment 30. A reset switch 48 is provided to return the timer memory 46 to zero, typically by the momentary application of electrical energy from source 38 or from a battery or batteries contained within the plug 31.

As described above, the plug 31 comprises means 4 for allowing data relating to the measured length of time to be wirelessly transferred to a data collection device 5. The means 4 comprises a transceiver 10, control circuitry 8, memory circuit 12, and a data coder/decoder circuit 50 for encoding or decoding data for transmission or reception. As described above, the transceiver 10 may use radio frequency or infra red signals to wirelessly transmit and receive data.

When the plug 31 attached to electrically operated equipment 30 is located sufficiently proximate to the data collection device 5, data may be exchanged between the plug 31 and the device 5 upon request by the device 5. A wireless signal is transmitted from the transceiver in the data collection device 5 and is received by the transceiver 10 in the plug 31. The control circuitry 8 initiates a response to the data collection device 5, which is transmitted from the transceiver circuitry 10 to the transceiver circuitry in the device 5. Such a response typically includes a unique identification code by which the data collection device 5 can identify the plug 31 and thus the electrically operated equipment 30 to which plug 31 is attached. The unique identification code information can be stored in the memory circuit 12.
The data collection device 5 may be used to transmit instructions or commands to the plug 31. The instructions or commands may, for example, instruct the plug 31 to illuminate a light-emitting device 14 whose colour indicates which of a vibration measurement band the electrically operated equipment 30 falls within, and hence how many hours the tool can be operated by a particular user in a single day. Alternatively, the instructions or commands may instruct the plug 31 to illuminate a light-emitting device 14 which indicates that it is time to perform a routine maintenance operation on the attached tool or equipment 30.

Data received from the data collection device 5 using transceiver circuitry 10 is passed by the control circuitry 8 to the coder/decoder circuit 50. The coder/decoder circuit 50 converts the data to an instruction, for example illuminate yellow light-emitting device 14, and sends the instruction to a status indicator circuit 52. When the plug 31 is connected to the power source 38, the status indicator circuit 52 will control the illumination of a light-emitting device 14.

In a preferred embodiment of the invention sensor 6 is configured without the need to break the continuity of the conducting wire carrying energy to the electrically operated equipment 30. In this illustrated embodiment of the invention, the sensor 6 may be a current sensor, such as a current transformer, a Hall Effect device, or any other sensor in which the presence of an electrical current in close proximity will cause a change in the electrical characteristics of the sensor.

The electric circuits in the plug 31 may be operated by electrical energy derived from the power source 38 or by a battery or batteries contained within the plug 31.

Referring now to Figure 4, an exemplary sensor 6 for detecting when an air-powered tool is active is described.

The sensor 6 comprises a body 56 of approximately cylindrical form that encloses a piston 58 containing a magnet 60. A spring 62 holds the piston 58 against a retaining ring 64 fitted into the body 56.

The sensor is preferably attached to an air inlet of an air-powered tool so that when the tool is activated, a flow of air, indicated by arrow 66, applies a force to the surface of
piston 58, causing the piston 58 to move, compressing spring 62 and allowing the air 66 to flow along the body 56 by means of an enlarged bore section 68.

The movement of the piston 58 within the body 56 results in the magnet 60 being moved into the proximity of a sensing component 70. Sensing component 70 may be, by way of example, a reed switch, a Hall effect device or any other means in which the proximity of a magnet may cause an electrical switching action. The sensing component 70 is connected to the timer circuitry 7 in the device 2, so that the electrical switching activates and deactivates the timer 7.

When the air-powered tool is deactivated, the air-flow 66 reduces or ceases altogether. The spring 62 is then able to force the piston 58 back against the retaining ring 64. This movement increases the distance between the magnet 60 and the sensing component 70 causing the switch state of the sensing component 70 to change.

In an embodiment of the invention, the body 56 may incorporate screw threads at each end to facilitate the positioning of the sensor 6 between the air-operated tool and the conduit supplying air to the tool.

Referring now to Figure 5, a second exemplary sensor 6 for detecting when an air-powered tool is active is described.

The sensor 6 comprises a body 72 of approximately cylindrical form that encloses a plurality of blades 74 mounted on a central shaft 76. In a preferred embodiment, the body 72 is manufactured from a non-metallic material, such as plastics material.

The shaft 76 is fixed concentrically within the body 72 by a support means 78, which may incorporate bearings or bushes 75 or other means by which shaft 76 and blades 74 can rotate freely.

As described above with reference to Figure 4, the sensor 6 is preferably attached to an air inlet of an air-powered tool so that when the tool is activated, a flow of air, indicated by arrow 80, applies a force to the surface of blades 74 which are shaped so as to cause the shaft 76 to rotate as the air 80 flows through the body 72.
A sensing component 82 is mounted on or within the body 72 which experiences an effect when each of the blades 74 pass in close proximity. The blades 74 may be magnetic, the movement of which induces a current in the sensing component 82. The sensing component 82 converts this effect into an electrical signal which is passed by means of one or more conductors to an electrical circuit 84. The electrical signal may be, by way of example, an electrical pulse induced each time a blade passes in proximity to the sensing component 82, and will therefore vary in frequency according to the speed of the rotation of shaft 76. This rotation is in turn related to the rate of air 80 flowing through the sensor 6.

The electrical circuit 84 is connected to the timer circuitry 7 in the device 2, and is configured so that it converts the electrical signal pulses into a switch effect which indicates when the shaft 76 is rotating and when the shaft 76 ceases to rotate. This switch effect activates and deactivates the timer 7 accordingly.

Again, in an embodiment of the invention, the body 72 may incorporate screw threads at each end to facilitate the positioning of the sensor 6 between the air-operated tool and the conduit supplying air to the tool.

Figure 6 shows a schematic representation of a sensor for detecting the vibration of a tool.

The sensor 6 comprises a vibration detector 86 mounted directly onto a tool 88. The vibration detector 86 detects directly the vibration of the tool 88 when it is activated. The vibration detector 86 may be, by way of example, an accelerometer. The tool 88 may be any type of tool, for example, an electrically-powered tool, a battery-powered tool, an air-powered tool or a tool driven by an internal combustion engine.

The activation of the tool 88 will result in an inherent vibration being generated by the moving parts of the tool 88. This vibration will typically be constant for a particular tool 88, or will be within a particular frequency band.

The sensor 6 includes an attenuator circuit 90 which receives an electrical signal from the vibration detector 86. The attenuator circuit 90 is connected to a switch circuit 92. The attenuator circuit 90 is configured to pass electrical signals to the switch circuit 92 when the signals provided by the vibration detector 86 are at the frequency or within
the frequency band that corresponds with the frequency of vibration generated by the tool 88 in normal operation. If the vibration detector 86 detects vibration at a frequency outside of the normal frequency band of the tool 88, the attenuator circuit 90 does not pass the signal to the switch circuit 92.

The switch circuit 92 converts the electrical signal received from the attenuator circuit 90 into a switch effect which indicates when the tool 88 is operating and when the tool 88 ceases to operate. The switch circuit 92 is connected to the timer circuitry 7 in the device 2, and the generated switch effect activates and deactivates the timer accordingly.

In a preferred embodiment, the sensor 6 includes an adjustment module 94 which allows the upper and lower limits of the acceptable frequency band to be adjusted in the attenuator circuit 90.

Preferably, devices 2, incorporating a sensor 6 as described above with reference to Figures 4, 5 and 6, comprise a battery for powering the electrical circuitry.

Referring to Figure 7, the system 96 includes a plurality of tools 98, each of which may be, for example, electrically powered, battery-powered, air-powered, or be driven by an internal combustion engine. Each of the tools 98 has an appropriate time-measurement device 2 as described above.

At least one data-collection device 5 is provided which can receive time data from the respective devices 2. As described above, in a preferred embodiment, the at least one data collection device 5 can transmit instructions or commands to the devices 2. These commands may include a reset command, or a command to indicate to a user that a predetermined vibration exposure level has been reached, or that a routine maintenance operation should be performed.

Once the at least one data collection device 5 has collected the time data, the data is uploaded to a central computer 100 which stores the data for analysis. This analysis may include determining a vibration exposure level for particular users, determining a charging rate for hire-tools and/or determining when it is necessary to perform a maintenance operation on a tool or tools.
It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. The word "comprising" does not exclude the presence of elements or steps other than those listed in a claim, "a" or "an" does not exclude a plurality, and a single processor or other unit may fulfil the functions of several units recited in the claims. Any reference signs in the claims shall not be construed so as to limit their scope.
Claims

1. A time measurement device comprising:
   means for measuring the length of time that a tool attached to the device is active; and
   means for allowing data relating to the measured length of time to be transferred to a data collection device.

2. A time measurement device as claimed in claim 1, wherein the means for measuring the length of time that a tool attached to the device is active is further adapted to measure the cumulative time that the tool is active over a number of active periods.

3. A time measurement device as claimed in claim 1 or 2, wherein the means for measuring the length of time that a tool attached to the device is active further comprises means for resetting the measured time.

4. A time measurement device as claimed in claim 1, 2 or 3, wherein the time measurement device further comprises a display for indicating the measured time.

5. A time measurement device as claimed in claim 4, wherein the display is adapted to provide an indication of the vibration exposure of an operator of the tool.

6. A time measurement device as claimed in claim 4, wherein the display is adapted to provide an indication of when a maintenance operation should be performed on the tool.

7. A time measurement device as claimed in any preceding claim, wherein the means for allowing data relating to the measured length of time to be transferred to a data processing device is adapted to transfer the data over an air interface.

8. A time measurement device as claimed in any preceding claim, wherein the time measurement device further comprises means for receiving data from a data collection device.
9. A time measurement device as claimed in claim 8, wherein the means for receiving data from the data collection device is adapted to receive data over an air interface.

10. A time measurement device as claimed in any preceding claim, wherein the tool is an electric tool, and the means for measuring the length of time that a tool attached to the device is active comprises a sensor that detects the flow of current to the tool.

11. A time measurement device as claimed in claim 10, wherein the sensor is adapted to measure the flow of current without breaking the continuity of the current flow to the tool.

12. A time measurement device as claimed in claim 11, wherein the sensor comprises a current transformer.

13. A time measurement device as claimed in claim 11, wherein the sensor comprises a Hall Effect device.

14. A time measurement device as claimed in one of claims 10 to 13, wherein the time measurement device is incorporated into an electric plug attached to the tool.

15. A time measurement device as claimed in one of claims 10 to 13, wherein the time measurement device is incorporated into an electric cable attached to the tool.

16. An electrical connector comprising a time measurement device as claimed in any one of claims 1 to 13.

17. A time measurement device as claimed in one of claims 1 to 9, wherein the tool is an air-powered tool, and the means for measuring the length of time that a tool attached to the device is active comprises a sensor that detects the flow of air through the tool.

18. A time measurement device as claimed in claim 17, wherein the sensor comprises a piston within a cylinder that is adapted to move relative to a sensing component when air flows through the tool.
19. A time measurement device as claimed in claim 18, wherein the piston comprises a magnet and the sensing component detects the proximity of the magnet.

20. A time measurement device as claimed in claim 17, wherein the sensor comprises a plurality of blades mounted on a shaft that cause the shaft to rotate when air flows through the tool.

21. A time measurement device as claimed in claim 20, wherein the sensor comprises a sensing component that detects the proximity of each blade as the shaft rotates.

22. A time measurement device as claimed in one of claims 17 to 20, wherein the time measurement device is connected between the tool and an air supply.

23. A time measurement device as claimed in one of claims 1 to 9, wherein the means for measuring the length of time that a tool attached to the device is active comprises a sensor that detects the vibration of the tool.

24. A time measurement device as claimed in claim 23, wherein the time measurement device is connected directly to the tool.

25. A time measurement device as claimed in claim 23 or 24, wherein the sensor is adapted to detect vibration at a specific frequency or frequency band.

26. A time measurement device as claimed in claim 23, 24 or 25 wherein the sensor comprises an accelerometer.

27. A system for monitoring the usage of a plurality of tools, the system comprising:
   a plurality of time measurement devices as claimed in any one of claims 1 to 26, each device being attached to a respective one of the said plurality of tools; and
   at least one data collection device having means for receiving and storing data from each of said time measurement devices.

28. A time measurement device as described with reference to, and as shown in, Figures 1, 2, 3, 4, 5 and 6 of the accompanying drawings.
29. A system for monitoring the usage of a set of tools as described with reference to, and as shown in Figure 7 of the accompanying drawings.

30. A method of monitoring the usage of a tool, the method comprising:

- measuring the length of time that a tool is active; and
- transferring data relating to the measured length of time to a data collection device.

31. A system for monitoring the usage of a set of tools as described with reference to, and as shown in, the accompanying drawings.
Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

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<th>Category</th>
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<td>US 6252823 B1 [McDonald et al] see abstract, column 1 lines 4-6, column 7 lines 14-33, column 7 lines 66 - column 8 line 4, column 10 lines 14-18</td>
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<td>DE 2922798 A1 [Nikolai] see figure 1</td>
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<td>EP 1050749 A1 [Fuji Air Tools], see whole document</td>
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