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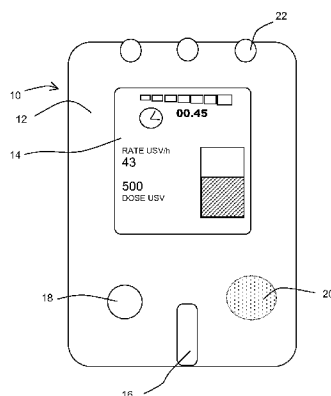
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(54) Title: RADIATION MONITOR



(57) Abstract: The invention comprises a dose meter instrument (10), capable of measuring and displaying a dose rate and/or total dose of ionising radiation, comprising a portable housing (12), a radiation detector, a power source, a signal processor and a display (14), said radiation detector, power source, signal processor and display being housed within said housing, characterised in that said display comprises a multicolour, pixel-addressable display.

Radiation monitor

The present invention relates to monitors for radioactivity, in particular to radiation dose meters.

Radiation dose meters are common for use in industries in which the presence of and
 5 exposure to low levels of radioactive materials is a hazard. For example, in the nuclear industry or other environments in which the exposure of personnel to radiation in excess of background levels is a potential risk it is necessary to monitor the amount of radiation to which an individual is exposed over a period of time. Emergency services personnel may also encounter situations in which they may risk exposure to radiation and require a means of
 10 monitoring such exposure. In some environments, it is necessary to use intrinsically safe equipment in order to eliminate the risk of igniting combustible gases through sparking.

Personal dose meters are widely available. These instruments are relatively compact and intended for attachment to the person being monitored and typically include a liquid crystal display to show the dose rate, total radiation measured etc. It is an object of the invention to
 15 provide an improved personal dose meter.

According to the invention we provide a dose meter instrument, capable of measuring and displaying a dose rate and/or total dose of ionising radiation, comprising a portable housing, a radiation detector, a power source, a signal processor and a display, said radiation detector, power source, signal processor and display being housed within said housing, characterised in
 20 that said display comprises an organic LED display.

In this specification "dose rate" is used to mean personal radiation equivalent dose rate and "total dose" is used to mean personal radiation equivalent dose $H_T = \sum_R \omega_R D_{T,R}$ where $D_{T,R}$ is the absorbed dose averaged over a tissue or organ T because of radiation R and ω_R is a dimensionless radiation weighting factor. For low linear energy transfer radiation such as γ -
 25 rays, X-rays and electrons (β -particles), ω_R is unity for all energies.

In a preferred embodiment, the housing comprises a sealed instrument housing formed from a material which is resistant to static discharge. It is further preferred that at least some of the electronic components of the dose meter, including the display, are encapsulated in order to avoid contact of said electronic components with atmospheric gases. It is further preferred to
 30 limit possible ignition energies due to electrical faults to less than about 40 μ J. The instrument is preferably suitable for use in hazardous areas, zones 0, 1 and 2. The instrument preferably incorporates intrinsically safe materials and design. The power, processor and display circuits are preferably not capable of igniting explosive atmospheres. The power supply is preferably potted. The housing is preferably sealed to prevent the ingress of liquid. The instrument is

preferably resistant to normal impact shocks such as may be experienced when the instrument is dropped so the housing is preferably rugged and formed from a tough, e.g. impact-modified plastics, material. Preferably the housing is formed completely or mostly from a non-metallic material which is resistant to static discharge or is coated with such a material.

- 5 If metal parts are used they should be formed from a metal or alloy which is acceptable for use in hazardous zones. The housing incorporates a window of material which is minimally attenuating of radiation in the region of the radiation detector. This is to ensure, so far as is practicable, that the absorption of low-energy radiation, especially low-energy X-rays, by the housing material is minimised.
- 10 The instrument according to the invention is preferably capable of meeting the relevant standards for electrical apparatus for use in explosive gas atmospheres, including IEC 60079-0, IEC 60079-11, EN 60079-0, EN 50020 and EN 60079-26 in the applicable version in force and as amended from time to time. Additionally the instrument must meet other relevant standards required for its sale and use in industrial installations, such as standards relating to
- 15 radiofrequency emission and electromagnetic interference (e.g. EN6100). These features or a combination thereof may enable the dose meter to be certifiable for use in hazardous areas, for example zone 0, 1 or 2 hazardous areas, in accordance with national and international standards for intrinsically safe equipment for use in potentially explosive atmospheres, such as those described in the ATEX European Union Directives, as amended from time to time.
- 20 The housing is portable, in that it is of suitable size, weight and shape to be carried or worn by the user. Personal dose meters are already widely used and suitable housing sizes will be understood by the skilled person. The housing preferably comprises a clip, strap or other means of attachment to a user's clothing or PPE. Alternatively it may be provided with a case which includes such attachment means. It is preferred that any case, strap, clip etc is
- 25 detachable from the instrument so that contamination hazards may be minimised. The housing may be brightly coloured to increase its visibility or to identify individual instruments within a set of instruments. In a preferred form the housing is provided with a portion which may be detached and reattached. This portion may be identifiable by means of a colour or customisable surface design in order to offer the opportunity to personalise an instrument by
- 30 the selection of a selected combination of the detachable portion and the housing. The detachable portion is advantageously a clip or strap. The use of personalised instruments allows a person to select his/her own instrument from a number of similar instruments which may be assembled in a control area for charging or programming.

- The radiation detector preferably comprises a Geiger-Müller tube, which may be an energy-
- 35 compensated Geiger-Müller tube. In a preferred embodiment of a dose monitor of the invention a single halogen, energy compensated Geiger Müller tube is used which is suitable

for the detection of gamma and X-radiation having energies in the range from 30 keV to 1.4 MeV, more preferably from 50 to 1.25 keV.

The instrument comprises a pulse counter, amplifier and a signal processor, normally comprising pulse shaping and smoothing algorithms, for converting the signals generated by the detector into a visual and/or audible display. The processor comprises a memory which is capable of holding the calibration and display codes. Preferably the instrument also comprises a memory in which the amount of radiation detected may be stored for access by the user or, for example, to enable the maximum dose and cumulative dose functions to be used. The memory may also store information such as date of calibration and/or testing and/or the date when the instrument should next be tested and/or calibrated. The processor is preferably programmed to enable selection of an appropriate calibration and to enable the user to select the display mode required. The instrument may be programmed to display in one or more than one unit, for example Rems (or m Rems) and Sv or μSv and optionally may convert between different units. The instrument is programmed to display the instantaneous dose rate, a cumulative dose and a calculated time remaining until a predetermined cumulative dose has been received, i.e. "time on task" display, and preferably also to provide appropriate audible signals, optionally in the form of alarms or speech warnings, at predetermined values of remaining "time on task". The instrument is preferably adapted to recalculate the "time on task" remaining according to the measured dose rate. In this way the instrument is suitable for monitoring the dosage of radiation received in a particular location or by a person wearing or carrying the instrument. Preferably the instrument is capable of displaying the peak dose rate measured during the period of monitoring. The instrument may be provided with means to indicate when a pre-determined dose or dose rate has been exceeded, e.g. by means of a visual or audible signal.

The instrument is preferably calibrated to display a direct reading of dose rate, e.g. in μSv per hour. Normally the dose rate meter is calibrated using appropriate known sources, for example ^{137}Cs or ^{241}Am .

The instrument may comprise means to determine its location. Suitable means include a GPS system or means to calculate location by reception of signals transmitted from locator beacons or transponder means.

The display is preferably a colour display. The display is an electronic display screen suitable for use in small portable electronic devices. The display preferably utilises a matrix technology allowing addressing of individual pixels in the display in order to provide a more adaptable display of information from the instrument. This type of display allows more information to be presented to the user than many pre-existing displays used in personal dose meters. A preferred type of display comprises an organic LED which is preferably an active-matrix

- organic LED (AMOLED). Alternatively, a passive-matrix OLED (PMOLED) may be used. A significant benefit of OLED displays over traditional liquid crystal displays (LCDs) is that OLEDs do not require a backlight to function. Thus they draw far less power and, when powered from a battery, can operate longer on the same charge. An OLED display can be
- 5 made lighter and thinner than an LCD panel. Another benefit of an OLED display, particularly an AMOLED display, is that the screen may be programmed to provide a wide variety of information. For example, the screen may provide a menu system, a means to select the operating mode or settings of the instrument and/or a page-based information function. These features of an OLED display enable the user to operate the instrument relatively easily.
- 10 The display is of a suitable size, for example being a rectangle having sides of approximately 30 – 50 mm. A suitable standard size which is available is a 47 mm display, i.e. a rectangle having a diagonal length of 47 mm. The display may be programmed to show the instantaneous dose rate, a cumulative dose, a calculated time remaining until a predetermined cumulative dose has been received, i.e. “time on task” display or the cumulative dose for a
- 15 particular task. Information relating to the task may be preset or reset by the operator. The display may include alphanumeric indicators. It is preferred that the display can be programmed to show graphical information, for example to display a graphical indicator to show the proportion of a pre-determined dose which has been measured by the instrument within a time period. This may be shown, for example by the proportion of a shape which is
- 20 filled with a particular colour to represent dose received or by indicating on a graphical scale the amount of dose received. Preferably such graphical indicators are shown in addition to a numerical indication of dose rate and/or dose. The display may also be programmed to show date, time, personnel name or number. The display is also capable of showing the amount of power remaining in the power source. In a preferred embodiment, the display may be
- 25 programmed to rotate the displayed information by a predetermined amount, preferably through 180 degrees, so that it may be viewed by the user from above when required, for example when the instrument is attached to the user’s clothing.

- The display is positioned to be visible from at least one surface of the instrument. It is common for personal dose meters to be shaped as a rectangular parallelepiped, usually
- 30 having rounded corners and resembling a relatively thin tablet so that the instrument can be carried in or clipped to a pocket or lapel worn by the user. The display area of such instruments often occupies a relatively narrow side of the housing which is positioned in such use to face upwards so that the user can look down at the display without moving the instrument. In the present invention the display may be present on such an upper side and/or
- 35 on a larger face of the housing which is designed to face forwardly when worn clipped to a pocket. The display may therefore occupy more than one face of the housing, for example by wrapping around the shape of the housing. Alternatively two or more displays may be

provided, each being positioned to be visible at a different face of the instrument housing. As a further alternative, a colour matrix display may be positioned at a first part of the housing and a second type of display may be positioned to be visible at a second part of the housing. The second type of display may take to form of one or more lights (e.g. LEDs) or a conventional LCD type of display. Warning lights, alerting the user and other personnel to a particular occurrence are preferably visible from more than one surface of the housing. At least one display is positioned to be visible at an upper surface of the housing, when the instrument is attached to apparel worn by a user.

The display is preferably protected by and visible through a transparent or translucent portion of the instrument housing. The transparent / translucent material forming the housing is resistant to electrostatic discharge. The surface of the display, or of the translucent portion of the housing covering the display, is preferably formed from a static dissipative material, either through being coated with a static dissipative material or through being formed from a material which is inherently static dissipative.

The display preferably incorporates an audible signal to indicate various occurrences to the user. Such occurrences include the measurement of a predetermined cumulative dose, for example a percentage of a dose selected to be a maximum desirable for a particular individual at a particular time; the measurement of a dose rate which is higher than a predetermined dose rate; a fault in the instrument, loss of communication signal, low power remaining in the power source, calibration and/or testing due etc. The audible signal may comprise a siren, alarm, and/or speech. For example the instrument may be programmed to give non-final warnings in speech mode whilst urgent warnings may be signalled by means of an alarm.

The instrument housing comprises a user interface enabling the user to switch the power on or off, and select the display mode. The interface preferably provides one or more pressure activated buttons or switches located on one or more interface panels, the switches preferably being sealed within the housing. When more than one calibration is available, the interface comprises means to select the desired calibration. When more than one mode, e.g. continuous cumulative monitoring or instantaneous monitoring is provided, the interface provides means for the user to select the desired mode. Optionally separate buttons are provided to select the calibration, mode, peak dose etc. It is preferred that the display functions are selected by the user from a programmed menu system displayed on the display. The interface may also provide means for the user to operate an audible indication means and/or a light.

The power supply preferably comprises a battery, housed within a sealed compartment within the instrument housing. The battery is preferably a rechargeable battery. The instrument preferably includes means to signal when the battery power falls below a threshold in order to

warn the user. The instrument may comprise means to indicate the estimated power remaining in the battery. The instrument is preferably provided with means to recharge a rechargeable battery. Connectors may be provided on the housing to engage with reciprocal connectors on a recharger. The connectors may be provided within an array of connectors so
5 that a number of instruments may be recharged simultaneously.

The instrument may be provided with means to communicate with another similar instrument or with a data or control processor. The communication means preferably include wireless transmission means but may also include wired connection means. Physical connection means may be provided in a power recharging module so that the instrument is in
10 communication with a control system during recharging. In this manner, information concerning the time of recharging, the measured dose and dose rates, calibration and test dates etc may be passed from the instrument to the control system. Information concerning predetermined maximum dose and dose rate, user identity etc may be passed from the control system to the instrument. In a particular embodiment, the instrument is capable of intermittent
15 or continuous communication with a control system during use. The communication is preferably two-way. In this way information concerning the radiation dose, dose rate measured by the instrument, its power status and/or location can be communicated to the control system and continuously monitored and recorded by the control system. A back up alarm may be operable by the control system in the event it detects any of the alarm events,
20 such as the dose or dose rate exceeding a predetermined value. Information concerning the allowable maximum dose, dose rate, can be communicated to the instrument by the control system. In a particular embodiment, the instrument may be adapted to communicate using radio signals using a pre-existing radio transmitter-receiver communications system. As a particular example, it is preferred that the instrument may be adapted to communicate using a
25 communications system which is used by emergency services personnel. This offers the opportunity for a control system, for example an emergency services control system, to monitor radiation doses encountered by personnel using the instrument in noisy or dangerous environments, where the operator may be unable to see or hear alarms or signals emitted or displayed by the instrument. In such a case an alarm condition may be relayed to the user
30 using an alternative communications device such as a radio transmitter-receiver unit.

Fig 1 is a schematic view from the front of a dose meter instrument according to the invention.

One embodiment of an instrument according to the invention is described in Fig 1, which is a schematic view from the front of a dose meter instrument 10. The dose meter comprises a moulded plastic housing 12 measuring approximately 80mm long by about 60mm wide by
35 about 10 mm thick. An active matrix organic LED display 14 is mounted on the front face of the housing. The display shows information about the measured radiation dose and time remaining before a pre-determined dose will be achieved at the current dose rate. A "window"

16 of material which minimises attenuation of radiation is located in the region where a Geiger-Müller tube is contained in the housing for measuring radiation received by the instrument. Operable button 18 is used to select the function and display operations of the instrument using a menu system displayed on the display. A speaker 20 is present to generate audible
5 signals and alarms and LED lights 22, visible from several directions are also provided to signal warning states.

Claims

1. A dose meter instrument (10), capable of measuring and displaying a dose rate and/or total dose of ionising radiation, comprising a portable housing (12), a radiation detector, a power source, a signal processor and a display (14), said radiation detector, power source, signal processor and display being housed within said housing, characterised in that said display comprises a pixel-addressable display.
2. An instrument according to claim 1, wherein the radiation detector comprises a Geiger Müller tube.
3. An instrument according to claim 1 or claim 2, wherein said display comprises an organic LED.
4. An instrument according to claim 3, wherein said display comprises an active-matrix organic LED (AMOLED).
5. An instrument according to claim 3, wherein said display comprises an passive-matrix organic LED (PMOLED).
6. An instrument according to any one of the preceding claims, wherein said display comprises a multicolour display.
7. An instrument according to any one of the preceding claims, calibrated to display a direct reading of dose rate.
8. An instrument according to any one of the preceding claims, adapted to display a cumulative dose measured over a selected period of time.
9. An instrument according to any one of the preceding claims comprising an audible indication means (20).
10. An instrument according to claim 9, wherein said audible indication means includes a speech warning and wherein the instrument is programmed to play said speech warning when a predetermined proportion of a predetermined total dose has been measured.
11. An instrument according to any one of the preceding claims further comprising an LED light (22).

12. An instrument according to any one of the preceding claims wherein the power, processor and display circuits are not capable of igniting potentially explosive atmospheres, the power supply is potted and the housing is sealed to prevent the ingress of liquid.

13. An instrument according to any one of the preceding claims which is suitable for use in hazardous areas, zones 0, 1 and 2.

14. An instrument according to any one of the preceding claims, wherein the display is protected by and visible through a transparent or translucent portion of the instrument housing, which portion is resistant to electrostatic discharge.

15. An instrument according to any one of the preceding claims, wherein the surface of the display is formed from a material which is static dissipative.

