

**VIGILANCE MONITORING SYSTEM****CROSS REFERENCE TO RELATED APPLICATIONS**

This patent application for U.S. Letters Patent relates to and incorporates by reference the contents of International application No. PCT/AU99/01166 and this application for U.S. Letters Patent hereby claims priority under 35 U.S.C. Section 365 to Jan. 27, 1999, the priority date of said International application.

The present invention relates to a vigilance monitoring system. In particular the invention relates to a system for monitoring, recording and/or analysing vigilance, alertness or wakefulness and/or a stressed state of an operator of equipment or machinery in a variety of situations including situations wherein the degree of vigilance of the operator has implications for the safety or well being of the operator or other persons. A typical application may include monitoring the driver of a vehicle or pilot of an aircraft, although the invention also has applications in areas involving related occupations such as train drivers and operators of equipment such as cranes and industrial machinery in general, and where lack of operator vigilance can give rise to harmful social or economic consequences.

The system of the present invention will be described herein with reference to monitoring a driver of a vehicle nevertheless it is not thereby limited to such applications. For example, other applications may include monitoring routine, acute or sub-acute physiological parameters of a person or subject in a home, work, clinic or hospital environment. The monitored parameters may include cardiac, respiratory and movement parameters as well as parameters relating to apnea events, subject sleep states or sudden death syndrome on-set.

The monitoring system is designed, inter alia, to provide non-invasive monitoring of a driver's physiological data including movement activity, heart activity, respiration and other physiological functions. The monitored physiological data may undergo specific analysis processing to assist in determining of the driver's state of vigilance. The system is designed to detect various states of the driver's activity and detect certain conditions of driver fatigue or relaxation state that could lead to an unsafe driving condition or conditions.

The system of the present invention includes means for gathering movement data associated with the driver. The movement gathering means may include a plurality of sensors such as touch sensitive mats placed in locations of the vehicle that make contact with the driver, such as the seat, steering wheel, pedal(s), seat belt or the like. Each location may include several sensors or mats to more accurately monitor movements of the driver.

Signals from the various sensors/mats may be processed and analysed by a processing means. The processing means may include a digital computer. The processing means may be programmed to recognize particular movement signatures or patterns of movement, driver posture or profile and to interpret these to indicate that vigilance has deteriorated or is below an acceptable threshold. The processing means may include one or more algorithms.

The sensors or mats may include piezoelectric, electrostatic, piezo ceramic or strain gauge material. The latter may be manufactured by separating two conductive materials such as aluminium foil with an electrolyte material which is capable of passing AC but not DC current. In one form the sensors or mats may include Capacitive Static Discharge (CSD) or Polyvinylidene fluoride (PVDF) mate-

rial. The sensors/mats may be covered with a non-obtrusive, flexible surface which is capable of detecting pressure and/or monitoring electrophysiological activity.

The pressure detecting capability may be used for detecting driver movement. The or each sensor may produce an output signal that represents the magnitude of the pressure or force that is applied to the sensor. The or each pressure signal may thus represent an absolute or quantitative measure of pressure applied to the sensor. The electrophysiological activity may include electrical signals generated by the body of the driver eg. electrical muscle activity and/or pulse activity.

The sensors or mats may be located in various parts of a vehicle. The seat of the driver may be divided into several sections such as upper or back and lower or seat. The upper or back section may include sensors in the top edge, centre and base. The lower or seat section may include sensors in the front edge, centre and rear. The or each sensor may include CSD or PVDF material,

The steering wheel may include a plurality of sensors. The steering wheel may be divided into eight zones such as upper, upper left, upper right, left, right, lower left, lower right and lower. At least one sensor may be associated with each zone. The or each sensor may include CSD or PVDF material.

The floor covering such as carpet may include a plurality of sensors. The floor covering or carpet may be divided into a plurality of zones. At least one sensor may be associated with each zone. The or each sensor may include CSD or PVDF material.

The accelerator, clutch and brake pedals may include a plurality of sensors. Each pedal may be divided into a plurality of zones such as upper, middle and lower. At least one sensor may be associated with each zone. The or each sensor may include CSD, PVDF or other movement sensitive material.

The seat belt may include one or a plurality of sensors. In one form a sensor or sensors may be embedded in the fixed (i.e. non-retractable) section of the seat belt. The or each sensor may include CSD or PVDF material.

In some embodiments a head tilt device incorporating a positional switch or the like may be associated with the drivers cap, glasses or goggles or may be arranged to clip over the drivers ear or glasses. The head tilt device may be adapted to provide a signal or data which alters in accordance with the position of the driver's head. Alternatively a radio tracking device may determine and track a subject's head movements.

In critical applications of vigilance monitoring including applications involving pilots of aircraft, persons responsible for navigating/controlling shipping and drivers of road or rail transport it may be desirable to utilize more comprehensive methods of vigilance monitoring. The latter may include techniques used in conventional sleep monitoring. A head band and/or chin band sensor may be used to monitor EEG, EMG and EOG signals. The head band sensor may include separate left and right frontal zones and left and right eye zones. The sensor may include CSD or PVDF material or other material sensitive to measuring patient skin electrical surface variations and/or impedance.

Various sensors/techniques may be adapted for monitoring eye movement including those based on reflected light, electric skin potential, contact lenses, limbus tracking, video imaging and magnetic induction. The sensors/techniques may include EOG electrodes, infrared detection of eye movements and/or video tracking and processing of eye