Claims

1. A safety sensing method for a person in an industrial environment, the method comprising:

providing a personnel locator device for location on a person and a reference system comprising a plurality of nodes located at predetermined locations in the industrial environment;

transmitting radio ranging signals between the nodes and the personnel locator device;

deriving measurements of times of flight of the radio ranging signals between the nodes and the personnel locator device;

calculating the location of the personnel locator device within the industrial environment based on the measurements of the times of flight of the radio ranging signals between the nodes and the personnel locator device and reference information representing the predetermined locations of the nodes; and

determining if the calculated location of the personnel locator device is within one or more danger zones in the industrial environment and outputting a warning signal in response thereto,

wherein:

the reference information is communicated to the personnel locator device; and the steps of deriving measurements of the times of flight of the radio ranging signals in respect of respective nodes and calculating the location of the personnel locator device within the industrial environment are performed in the personnel locator device.

2. A safety sensing method according to claim 1, wherein the step of determining if the calculated location of the person is within one or more danger zones is performed in the personnel locator device.

3. A safety sensing method according to claim 2, wherein the warning signal is communicated from the personnel locator device to the reference system.

4. A safety sensing method according to claim 1, wherein the step of determining if the calculated location of the person is within one or more danger zones is performed in the reference system.

5. A safety sensing method according to claim 4, wherein the warning signal is communicated from the reference system to the personnel locator device.

6. A safety sensing method according to any one of claims 3 to 5, wherein the reference system provides an audible or visible alert to a user in response to the warning signal.

7. A safety sensing method according to any one of claims 3 to 6, wherein the reference system causes operation of equipment within the industrial environment to cease in response to the warning signal.

8. A safety sensing method according to any one of claims 2, 3 or 5, wherein the personnel locator device provides an audible or visible alert in response to the warning signal.

9. A safety sensing method according to any one of the preceding claims, wherein the reference information is communicated to the personnel locator device as part of the radio ranging signals.

10. A safety sensing method according to any one of the preceding claims, further comprising transmitting zonal information representing the one or more danger zones to the personnel locator device over a radio communication system.

11. A safety sensing method according to claim 10, wherein the radio communication system over which the zonal information is transmitted to the personnel locator device is separate from the radio ranging signals.

12. A safety sensing method according to any one of the preceding claims, wherein a danger zone is associated with a piece of equipment located in the industrial environment.

13. A safety sensing method according to claim 12, further comprising:

providing an equipment locator device for location on the piece of equipment;

transmitting radio ranging signals between the nodes and the equipment locator device;

deriving measurements of times of flight of the radio ranging signals between the nodes and the equipment locator device; and

calculating the location of the equipment locator device within the industrial environment based on the measurements of the times of flight of the radio ranging signals between the nodes and the equipment locator device and the reference information, and

wherein the danger zone associated with the piece of equipment is defined with respect to the calculated location of the equipment locator device.

14. A safety sensing method according to claim 13, further comprising

before calculating the location of the equipment locator device, transmitting zonal information representing the shape of the danger zone associated with the piece of equipment to the personnel locator device over a radio communication system, and

after calculating the location of the equipment locator device, transmitting the calculated location of the equipment locator device to the personnel locator device over the radio communication system.

15. A safety sensing method according to claim 12 or 13, wherein the method further comprises receiving control information associated with the piece of equipment, and the danger zone associated with the piece of equipment is dependent on the control information associated with the piece of equipment.

16. A safety sensing method according to any one of the preceding claims, further comprising

providing an equipment locator device for location on a piece of equipment;

transmitting radio ranging signals between the equipment locator device and the personnel locator device;

deriving measurements of times of flight of the radio ranging signals between the equipment locator device and the personnel locator device; and

determining if the personnel locator device is located within a danger zone defined with respect to the location of equipment locator device based on the measurements of times of flight of the radio ranging signals between the equipment locator device and the

personnel locator device.

17. A safety sensing method according to any one of the preceding claims, wherein

the step of transmitting radio ranging signals between the nodes and the personnel locator device comprises transmitting outbound signals from the personnel locator device to the nodes and transmitting return signals from the nodes to the personnel locator device in response to the outbound signal; and

the derived measurements are measurements of the total time of flight of the outbound signal and the return signal.

18. A safety sensing method according to any one of claims 1 to 16, wherein

the step of transmitting radio ranging signals between the nodes and the personnel locator device comprises transmitting an inbound signals from the nodes to the personnel locator device;

the derived measurements are measurements of the times of flight of the inbound signals.

19. A safety sensing method according to any one of the preceding claims, wherein the radio ranging signals are ultra-wideband signals.

20. A safety sensing method according to any one of the preceding claims, wherein the radio ranging signals are transmitted from different devices and nodes in time slots allocated to respective devices and nodes.

21. A safety sensing method according to any one of the preceding claims, wherein the step of calculating the location of the personnel locator device within the industrial environment comprises calculating the location that minimises an error between the measurements of times of flight.

22. A safety sensing method according to any one of the preceding claims, wherein the personnel locator device comprises an inertial measurement unit and the step of calculating the location of the personnel locator device within the industrial environment takes account of the output of the inertial measurement unit.

23. A safety sensing method according to any one of the preceding claims, wherein

the nodes are arranged to detect the angle of arrival of the radio ranging signals, and

the step of calculating the location of the personnel locator device within the industrial environment takes account of the detected angle.

24. A safety sensing method according to any one of the preceding claims, wherein the method further comprises determining if the calculated location of personnel locator device falls within one or more safe zones within the industrial environment represented by the zonal information and ceasing performance of the method in response thereto.

25. A safety sensing system for a person in an industrial environment, the system comprising a personnel locator device for location on a person and a plurality of nodes located at predetermined locations in the industrial environment, the system being arranged to:

transmit radio ranging signals between the nodes and the personnel locator device;

derive measurements of times of flight of the radio ranging signals;

calculate the location of the personnel locator device within the industrial environment based on the measurements of the times of flight of the radio ranging signals and reference information representing the predetermined locations of the nodes; and

determine if the calculated location of personnel locator device falls within one or more danger zones in the industrial environment represented by zonal information and output a warning signal in response thereto,

wherein the system is further arranged to:

communicate the reference information to the personnel locator device; and perform the steps of deriving measurements of the times of flight of the radio ranging signals in respect of respective nodes and calculating the location of the personnel locator device within the industrial environment in the personnel locator device.

26. A personnel locator device for use in a safety sensing system comprising a plurality of nodes located at predetermined locations in the industrial environment, the personnel locator device being for location on a person and being arranged to:

receive radio ranging signals from the nodes;

derive measurements of times of flight of the radio ranging signals transmitted between the nodes and the personnel locator device; and

calculate the location of the personnel locator device within the industrial environment based on the measurements of the times of flight of the radio ranging signals and reference information representing the predetermined locations of the nodes.