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(54) Title: DEVICE AND METHOD FOR SIMULATING A DROWNING SCENARIO

(57) Abstract: The present invention provides devices, which devices are manikins, and methods for simulating a drowning scenario, in particular to aid in locating of missing persons in waterways.



Device and Method for Simulating a Drowning Scenario

The present invention is concerned with devices and methods for simulating a drowning scenario, in particular to aid in locating of missing persons in waterways.

Drowning is believed to account for a similar number of deaths annually in England and Wales as
5 house fires, between about 200 and 300.

Although work and research has been undertaken over the years to understand and simulate drowning scenarios, in different types of environments, more work is still needed to fully understand what may happen in the different scenarios, and especially to understand the movement of a drowned cadaver over subsequent hours and days after drowning to aid discovery.

10 There is especially a need for enhanced tools and methods to aid the locating of missing persons in waterways

The aim of the present invention is thus to provide improved methods and devices for simulating drowning scenarios, and especially to aid in the locating of missing persons in waterways.

Thus, in a first aspect, the present invention provides a manikin suitable for use in simulating a
15 drowning scenario, wherein the manikin is of dimensions representing a human of specific age, sex, weight and build, comprising jointed limbs, wherein the density of the manikin as a whole and the density of each limb and the torso of the manikin is equivalent to the density of the human, comprising means to track the movement of the manikin in a body of water, and a means for simulating abdominal bloat, which means comprise an inflatable bladder in combination with a gas
20 canister to inflate the bladder.

A manikin is generally known in the art as a jointed model of a human. Manikins are generally hollow, though may include within the hollow structure aspects of the internal workings of a human,

such as a CPR model comprises synthetic lungs. Such manikins can be manufactured from plastic or rubber, such as a vinyl plastic or silicone rubber.

The manikin in particular comprises a means for simulating abdominal bloat, which is the release of gases throughout a cadaver as it decomposes. The majority of the gases from decomposition tend to collect in the abdominal region which leads to a swelling or bloating. The Applicant has recognised that such phenomena would clearly affect the motion of a cadaver in a body of water, and in particular would be the means by which a sunken cadaver would eventually float to the surface. A manikin including such a means would thus be highly advantageous for simulating a drowning scenario, especially for a body that may have been in the water for some time. The means for simulating abdominal bloat is an inflatable bladder in combination with a gas canister, and most likely a controller, to control the inflation, which may be programmable or programmed to inflate after a predetermined period of time, or which may also be programmed to inflate the bladder slowly, to best mimic abdominal bloat.

The manikin of the first aspect is designed to mimic the behaviour of a drowned human or cadaver in a body of water, but especially in an environmental body of water having a flow, such as in a river or in a sea.

The invention of the first aspect potentially provides numerous possible manikins, suitable for use in a search for a missing person, with the dimensions and density of the manikin being selected based on those characteristics of a particular missing person. The manikin is thus capable of mimicking any particular type of person, be that a child or adult or varying proportions, build and weight. Such a manikin could be deployed within hours following a missing person being reported. The manikin has been designed such that it can follow a similar drift pattern to a missing person in the body of water/waterway, which could lead to a potential search location being identified, saving time and resources.

Data for the density of the separate limbs and torso of typical/average humans of a specific age range, sex and build may be sourced from public domain information.

In one embodiment the density of the limbs and torso, and complete manikin, may be provided through filling a hollow manikin shell with an epoxy resin/glass sphere mix of differing ratios

- 5 depending on the densities required for the manikin. The calculation of overall weight and density of the manikin may also need to take into account the weight/density of the means to track the movement of the manikin in a body of water, and the position of said means within the manikin.

The means to track the movement of the manikin in a body of water may comprise a global positioning system, an acoustic positioning system, or an inertial measurement system.

- 10 An inertial measurement system may be used to provide rotational velocity and linear acceleration data from the manikin, which could potentially record any rotations or collisions the manikin may experience in the body of water, whilst also providing information as to the distance/path travelled which would in particular be useful if the nature of the subsurface currents in a body of water were unknown.

- 15 A global positioning system could be used to track the trajectory of the manikin, however since GPS signals provide little to no penetration through water, an alternative system may also be required, such as an acoustic positioning system, or a sonar based system.

In one embodiment the manikin comprises an acoustic positioning system, or similar system capable of achieving tracking in water, or underwater. In another embodiment the manikin further

- 20 comprises a global positioning system and/or an inertial measurement system, thus potentially providing the means for recording as much data relating to the movement of the manikin with the body of water as possible: the acoustic positioning system providing data for when submerged, the global positioning system for when the manikin has surfaced, and the inertial measurement system for recording specific aspects/features of the journey.

The global positioning system on the manikin should be situated such that when the manikin is at the surface the global positioning system is out of the water. The global positioning system(s) could for example be located in the head or lower back regions, which are locations likely to be above the water line.

- 5 The manikin of the first aspect may also comprise a means to resurface the manikin, for use such as when a trial has been completed, to allow the recovery of the manikin without having to use a dive team. The means to resurface the manikin could be an inflation system. This could comprise a combination of a life jacket fitted to the manikin with a gas canister, such as a carbon dioxide gas canister, to inflate the life jacket.
- 10 The manikin of the first aspect may also comprise means to visually record the journey of the manikin, such as with one or more camera(s) to record footage or stills of the journey. The means to visually record may be capable of being controlled remotely, and/or the footage/stills may be capable of being remotely viewed to further aid in the tracking of the manikin.

The present invention shall now be described with respect to the following non-limiting example:

15 Example

A manikin has been created that includes a unique combination of technologies that is of a similar density to that of an average UK male, and is capable of following drift patterns in waterways as a cadaver would. In addition the manikin is trackable when it is both submerged and surfaced, it is capable of providing information as to the path it has taken, and once a trial is finished it will be

- 20 retrievable without the use of a dive team.

The resting place of the manikin could be used to define an area of interest in Police missing person Searches.

The aim was to produce a manikin with a suitable density which could be deployed in the hours/days following a missing person being reported. The manikin would then follow a similar drift pattern to the missing person in the waterway which would lead the Police to a potential search location, saving time and Police resources.

- 5 The manikin comprises an inertial measurement unit (IMU), an acoustic positioning system (APS), two GPS devices, an inflation system to recover the manikin, an abdominal bloat simulant, and a waterproof camera.

All the above features are embedded within a manikin that has been adapted to mirror the density of a young White North European Male, as this is believed to be the most likely subset of the
10 population to go missing.

Manikin

The manikin itself has two primary functions. The first is to provide the form of a person so that the manikin will behave appropriately in a river environment. The second is to act as a framework for the subsystems to be mounted to and protected by.

- 15 Several solutions were considered including a silicone manikin however a Simulaids 'Adult CPR Water Rescue Manikin' made from a vinyl polymer was selected as the hollow shell of choice. To provide a manikin of the correct body weight with limbs of the correct densities an epoxy resin was decided upon as the most suitable solution, missing with glass spheres to provide the desired densities. The desired density for this manikin was calculated to be approximately 1049 kg/m³.

20 Limbs

The limbs were detached from the Simulaids manikin by cutting the cables in the torso of the body. The cables were then shortened and secured to the hips and shoulders individually using a washer

and collet. This removed the excess cable in the centre of the body providing more space for mounting the subsystems within.

The limbs, once removed from the cables, had their volumes measured (both that of the outer shell of material and that of the whole shape assuming it was a solid). From this the density of the filler
5 material was determined using an appropriately written programme. An epoxy resin was used to fill the limbs with glass spheres added to the mixture where necessary to achieve the density required.

Head

A similar process was used when filling the head however a windpipe simulant was set into the epoxy. This windpipe simulant is connected to lungs that were placed within the chest of the
10 manikin. The lungs had their one way valve removed so that fluids could move freely into and from them. In addition a small section in the top of the head was segregated from the epoxy using a clear acrylic insert. This left a hollow region within which a GPS could be placed. To access this hollow region a slot was cut in the top of the head.

Torso

15 To allow easier access to the torso the front portion of the chest was cut away with holes drilled around the perimeter to allow bolts and wing nuts to be used to secure the section back to the body. The bolts themselves were secured to the torso through the use of tabs protruding from the cavity and washers were glued to the cut away section to prevent damage.

Within the chest several supports were removed and replaced by a plastic panel running the length
20 of the back. This both acted as a source of rigidity and as a base onto which the inflation system could be mounted. Clips were mounted to the black plastic base to hold the CO2 canisters and regulator in place.

To separate the lungs from the other components in the chest a natural rubber flap was added.

A plastic divide was added below the chest section to be used as a mounting point for the IMU. Foam was added to create a more stable contact when securing the IMU in place.

The lower back portion contains a small indent which was used to house a mounting bracket for an Underwater Locator Beacon (Acoustic Positioning System).

- 5 In a similar region two large eye bolts were installed, protruding from the lower back. These have a plastic support connecting on the inside of the manikin to prevent tearing under large stresses as these were to be used to attach a tether during testing. The lower support for the eye bolts was also used as a securing point for a GPS contained within a waterproof casing.

Inertial measurement Unit (IMU)

- 10 An IMU was included to provide rotational velocity and linear acceleration data from the manikin. This data will allow the user to see any rotations or collisions the manikin experiences whilst also providing information as to the distance/path travelled which will be useful when the nature of the subsurface currents is unknown.

The components used to create the IMU were an Arduino UNO and mount, prototyping shield, MPU-

- 15 6050 sensor, SD card reader, BOCUBE enclosure, and two PP3 batteries.

The MPU-6050 sensor was soldered to a prototyping shield along with the SD card reader. The Arduino mount was secured within a waterproof BOCUBE (IP68) enclosure which protects the Arduino from both water and impacts. The PP3 batteries were also mounted within the enclosure.

- Following fabrication the IMU prototyping shields were calibrated through the use of a turntable and
20 drop rig. From a repetitive testing regime it was possible to determine the offset, scaling error, and drift error for each sensor.

Acoustic Positioning System (APS)

The APS is used for the tracking of the manikin while it is submerged. With GPS signals providing little to no penetration through water, a system was required to provide information as to where the manikin is. It was decided to place an Underwater Locator Beacon (UBL), which only activates when in contact with water on the manikin, with a hydrophone array mounted for example to a following
5 boat listening for pulses.

There was an RJE UBL-350 on the body emitting a 10ms long 37 kHz pulse with two Aquarian H2A-XLR hydrophones in the array. The hydrophones detect the signal and then through use of an appropriate programme calculate the two possible position solutions. The UBL is located in the lower back region as this is the highest point in the characteristic position of a cadaver in water.
10 Being the highest point, signals emitted from the UBL will experience the minimal amount of reflections from the limbs and torso.

The APS could also be linked to GPS so that the APS could provide real time geo-located data.

GPS

The GPS accompanies the APS by providing location information when the manikin has surfaced. The
15 Tractive GPS XL was chosen as a cost effective and robust GPS with a relatively long battery life and a suitable water resistance. Two GPS devices emit real time data which can be seen live and saved for analysis. The GPS's are located in the head and lower back regions. These locations were chosen as the two most likely areas to be above the water line in a floating cadaver.

The inflation system (discussed below) resurfaces the manikin head first; consequently one GPS is in
20 the top of the head. The second is in the lower back as again this is the highest region in the characteristic position of a floating cadaver, and thus is most likely to be above the waterline.

While the GPS devices are water resistant to IPX7 rating, waterproof cases have been employed to provide further protection.

Inflation System

The purpose of the inflation system is to resurface the manikin once a trial is finished and to prevent the need for dive teams to be used for retrieval. Several solutions were proposed including using a ballast system or a CO₂ canister to inflate the stomach (linked to the bloat section). The final design
5 uses a CO₂ canister connected to a regulator which in turn is connected to a solenoid valve. The solenoid valve is normally closed however once the timer is reached the solenoid valve is opened allowing gas to travel into a lifejacket on the outside of the body.

The solenoid valve and micro Arduino are contained within a waterproof enclosure. The waterproof enclosure has two aluminium pieces within it to act as a heat sink to dissipate the heat generated by
10 holding the solenoid valve on for extended periods of time. To prevent overheating the solenoid valve is closed after the lifejacket is inflated.

Currently the timer is set before use however alternative embodiments could link the APS to the inflation system. This would create a failsafe system with a hydrophone, as part of the inflation system, used to detect the 37 kHz pulses from the beacon. If the beacon was to fail and the pulses
15 could no longer be heard then the inflation system would resurface the manikin. The inclusion of a hydrophone on the inflation system would also allow a 'stop' signal to be received by the system to resurface the manikin. This could be activated if the trial was to finish before the timer limit was reached.

Abdominal Bloat System

20 When a cadaver decomposes, gases are released throughout the body. The majority of the gases from decomposition collect in the abdominal region which leads to a swelling or 'bloating'. This increases the volume of the cadaver and resultantly lowers the density. This effect is often so pronounced that it causes the cadaver to become positively buoyant and surface after previously being on the waterway's bed.

An abdominal bloat system could inflate slowly over a period of time similar to that in which bloat can materialise on a cadaver. This however is a complex mechanism which can be difficult to model, as it depends on a number of factors such as water temperature, trauma to the cadaver, and food eaten prior to death. The variation in time can be from several days to several weeks.

- 5 In the manikin, an inflatable bladder was provided with a maximum volume of 6.5L. This was arranged to be inflated to different volumes, and at different speeds, through use of a CO₂ canister.

Other designs of manikin could consolidate the bloat simulant and inflation system into one device serving both purposes. For example, a ballast system with an expandable chamber to simulate bloat and resurface the manikin could be utilised or just a CO₂ canister to inflate the stomach instead of a
10 lifejacket.

Waterproof Camera

To provide a view of the manikin's surroundings five Victure Action Cameras were be placed in various locations around the body. Each camera has a field of view of 170° and is positioned as follows: upper thigh outer face (left and right), torso (front and rear), and head (front). The cameras
15 were secured through the use of altered commercially available mounts.

The manikin will often be used in environments with a high density of suspended sediment lowering visibility. Diving lights were tested to see if this would improve visibility however a greater range was achieved by using the cameras without a light source.

Some thought has been given to seeing live footage from these cameras. With transferring data
20 through water using conventional methods, for example WIFI, not feasible and a wired solution likely to become tangled, wirelessly acoustic communications would appear to be a good option.

Claims

1. A manikin suitable for use in simulating a drowning scenario, wherein the manikin is of dimensions representing a human of specific age, sex, weight and build, comprising jointed limbs, wherein the density of the manikin as a whole, and the density of each limb and the torso of the manikin, is equivalent to the density of the human, comprising means to track the movement of the manikin in a body of water, and a means for simulating abdominal bloat, which means comprise an inflatable bladder in combination with a gas canister to inflate the bladder.
2. A manikin according to Claim 1, wherein the density of the manikin as a whole, and each limb and the torso, is provided through the manikin, limbs and torso being filled with an epoxy resin/glass sphere mix of differing ratios depending on the densities required for the manikin.
3. A manikin according to Claim 1 or Claim 2, wherein the means to track the movement of the manikin in a body of water comprises an acoustic positioning system.
4. A manikin according to Claims 1 to 3, wherein the means to track the movement of the manikin in a body of water comprises an inertial measurement system.
5. A manikin according to Claims 1 to 4, wherein the means to track the movement of the manikin in a body of water comprises a global positioning system.
6. A manikin according to Claims 1 to 5, further comprising a means to resurface the manikin said means comprising a life jacket fitted to the manikin and a gas canister to inflate the life jacket.
7. Use of a manikin according to Claims 1 to 6 in simulating a drowning scenario.

INTERNATIONAL SEARCH REPORT

International application No

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A. CLASSIFICATION OF SUBJECT MATTER

INV. G09B19/00 G09B23/30
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G09B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 397 401 A1 (SAVE DUMMY S L [ES]) 21 December 2011 (2011-12-21) figures 1-3 paragraph [0018] paragraph [0019] paragraph [0020] paragraph [0040] paragraph [0041] claims 1-3,12	1-7
X	US 5 913 708 A (GROSS FLORA GEANE [US]) 22 June 1999 (1999-06-22) figures 6,14,20-22	1
A		2-7



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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