DESCRIPTION

TITLE OF THE INVENTION: RF TAG ATTACHMENT TOOL, SUBMERSION DETERMINATION PROGRAM, AND SUBMERSION DETERMINATION SYSTEM

TECHNICAL FIELD

[0001] The present invention relates to an RF tag attachment tool, a submersion determination program, a submersion determination device, and a submersion determination system.

BACKGROUND ART

[0002] Swimming pools are installed in schools, gyms, hotels, and other facilities. As the number of pool users increases, drowning accidents occur every year, making accident prevention measures an urgent issue. In particular, preventive measures are especially necessary for infants, toddlers, and children, who may have limited knowledge regarding water safety. As such measures, conventional methods have relied on deploying lifeguards or human monitoring.

[0003] Since monitoring by lifeguards also has limitations, a submersion determination system has been proposed in which a transmitter is provided on the head of a wearer and submersion of the wearer is detected based on

a sensing signal from a pressure sensor built into the transmitter.

CITATION LIST

PATENT DOCUMENT

[0004] Patent Document 1: JP 62-252219 A

DISCLOSURE OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0005] However, since the pressure sensor described in Patent Document 1 requires a built-in battery, the submersion determination system does not operate when the battery is dead. For this reason, it is necessary to check the built-in battery for each pressure sensor. In addition, water entering the built-in battery causes a malfunction or an accident. Therefore, since the transmitter needs to adopt a waterproof structure, the transmitter consequently becomes heavier and larger.

[0006] In view of these circumstances, the invention is to provide an RF tag attachment tool that is easy to make light or small and a submersion determination program, a submersion determination device, and a submersion determination system that can be applied to such an RF tag attachment tool.

MEANS FOR SOLVING PROBLEM

[0007] The invention is an RF tag attachment tool for attaching, to a determination target, an RF tag that performs wireless communication in a frequency band in which radio waves do not pass through water, the RF tag attachment tool includes: a tag support structure capable of supporting the RF tag; and a mounting structure for mounting the tag support structure on an attachment member for attachment to the determination target, and a gap is formed between an arrangement position of an IC chip built in the RF tag and the determination target.

[0008] It is preferable that the tag support structure includes a first support structure for supporting the RF tag and a second support structure for supporting the first support structure and that, when a portion of the first support structure located in a vicinity of the arrangement position of the IC chip is defined as a chip-vicinity support structure portion, the chip-vicinity support structure portion is spaced apart from the second support structure or the determination target. In addition, it is preferable that, assuming that an end portion on one side relative to the chip-vicinity support structure portion is defined as a one-side support structure end portion and an end portion on the other side relative to the chip-vicinity support structure portion is defined as an other-side

support structure end portion when the first support structure is viewed from a predetermined direction, the chip-vicinity support structure portion is spaced further apart from the second support structure or the determination target than the one-side support structure end portion and the other-side support structure end portion. In addition, it is preferable that the one-side support structure end portion engages with a one-side engagement portion of the second support structure, the other-side support structure end portion engages with an other-side engagement portion of the second support structure, and a length between the one-side engagement portion and the other-side engagement portion is shorter than a length between the one-side support structure end portion and the other-side support structure end portion. In addition, it is preferable that the one-side support structure end portion and the one-side engagement portion are attachable to and detachable from each other by a one-side button mechanism and the other-side support structure end portion and the other-side engagement portion are attachable to and detachable from each other by an other-side button mechanism.

[0009] It is preferable to include an attachment member that supports the tag support structure and is attached to the determination target, and it is preferable that,

assuming that a portion of the tag support structure located in a vicinity of the arrangement position of the IC chip is defined as a chip-vicinity support structure portion, when the attachment member is attached to the determination target, the chip-vicinity support structure portion is spaced apart from the attachment member or the determination target. In addition, it is preferable that, assuming that an end portion on one side relative to the chip-vicinity support structure portion is defined as a one-side support structure end portion and an end portion on the other side relative to the chip-vicinity support structure portion is defined as an other-side support structure end portion when the tag support structure is viewed from a predetermined direction, the one-side support structure end portion engages with a one-side engagement portion of the attachment member, the other-side support structure end portion engages with an other-side engagement portion of the attachment member, and a length between the one-side engagement portion and the other-side engagement portion is shorter than a length between the one-side support structure end portion and the other-side support structure end portion. In addition, it is preferable that the attachment member is formed in an elongated shape, a one-side hole into which the attachment member is insertable is formed in the one-side support structure end

portion, an other-side hole into which the attachment member is insertable is formed in the other-side support structure end portion, and when a position of the attachment member where the one-side hole engages with the attachment member is defined as a one-side engagement position and a position of the attachment member where the other-side hole engages with the attachment member is defined as an other-side engagement position, a length between the one-side engagement position and the other-side engagement position is shorter than a length between the one-side hole and the other-side hole. In addition, it is preferable to include a spacer arranged between the tag support structure and the attachment member, and it is preferable that the attachment member engages with the one-side support structure end portion, the other-side support structure end portion, and the spacer.

[0010] It is preferable that, when a portion of the tag support structure located in a vicinity of the arrangement position of the IC chip is defined as a chip-vicinity support structure portion, the gap is formed in the chip-vicinity support structure portion of the tag support structure.

[0011] It is preferable that, when a portion of the tag support structure located in a vicinity of the arrangement position of the IC chip is defined as a chip-vicinity

support structure portion, the gap is formed by arranging the tag support structure so as to avoid the chip-vicinity support structure portion.

[0012] It is preferable to include the RF tag supported by the tag support structure.

[0013] It is preferable that, when a portion to be brought into contact with the determination target is defined as a contact surface, an orientation of an antenna pattern of the IC chip is oblique with respect to an orientation of the contact surface.

[0014] It is preferable that at least one of following conditions is satisfied: in a first RF tag located upward in an attached state in which the attachment member is attached to the determination target, an upper end of the antenna pattern of the first RF tag is spaced further apart from the contact surface than a lower end of the antenna pattern of the first RF tag; and in a second RF tag located downward in the attached state, a lower end of the antenna pattern of the second RF tag is spaced further apart from the contact surface than an upper end of the antenna pattern of the second RF tag.

[0015] It is preferable to include a hinge structure provided on the tag support structure or the attachment member, and it is preferable that the hinge structure is switchable between a first state in which the antenna

pattern faces in a first direction and a second state in which the antenna pattern faces in a second direction different from the first direction.

[0016] It is preferable that the attachment member includes a first attachment member on which the tag support structure is mounted and a second attachment member connected to the first attachment member and a plurality of the tag support structures are aligned around the determination target by the first attachment member.

[0017] It is preferable that the attachment member is attachable to a head of the determination target.

[0018] A submersion determination program of the invention causes a computer to execute: a signal output step of outputting a predetermined signal to the RF tag attached to the determination target by the RF tag attachment tool according to claim 12; a response signal reception step of receiving a response signal from the RF tag with respect to the predetermined signal; a response signal storage step of storing the response signal in a storage device; a communication state determination step of reading a log of the response signal stored in the storage device and determining whether a status is a communication state in which the response signal from the RF tag is detected under predetermined conditions or a non-communication state in which the response signal from the

RF tag is not detected under the predetermined conditions; and a submersion state determination step of determining that the determination target is submerged when the non-communication state continues for a predetermined period.

[0019] A submersion determination program of the invention causes a computer to execute: a signal output step of outputting a predetermined signal to an RF tag attached to a determination target by an RF tag attachment tool; a response signal reception step of receiving a response signal from the RF tag with respect to the predetermined signal; a response signal storage step of storing the response signal in a storage device; a communication state determination step of reading a log of the response signal stored in the storage device and determining whether a status is a communication state in which the response signal from the RF tag is detected under predetermined conditions or a non-communication state in which the response signal from the RF tag is not detected under the predetermined conditions; and a submersion state determination step of determining that the determination target is submerged when the non-communication state continues for a predetermined period.

[0020] It is preferable that a plurality of the RF tags are mounted on the determination target by the RF tag attachment tool, the storage device is capable of storing

an identifier of the RF tag and an identifier of the RF tag attachment tool or the determination target in association with each other, in the communication state determination step, it is determined whether each of the plurality of RF tags is in the communication state or in the non-communication state, and in the submersion state determination step, when it is determined that all of the RF tags associated with the identifier of the RF tag attachment tool or the determination target are in the non-communication state, it is determined that the determination target is submerged, while when it is determined that at least one or more of the RF tags associated with the identifier of the RF tag attachment tool or the determination target are in the communication state, it is determined that the determination target is not submerged. In addition, it is preferable that, in the submersion state determination step, when it is determined that all of the RF tags associated with the identifier of the RF tag attachment tool or the determination target are in the non-communication state for a first period, it is determined that the RF tag attachment tool or the determination target is in a submerged state, and when it is determined that, for an identifier of the RF tag attachment tool or the determination target determined to be submerged, at least one or more of the RF tags

associated with the identifier are in the communication state for a second period, it is determined that the RF tag attachment tool or the determination target has recovered from submersion, and the second period is shorter than the first period.

[0021] It is preferable to cause the computer to execute: a final survival tag extraction step of, when the RF tag attachment tool or the determination target is determined to be in the submerged state, extracting the RF tag that has entered the non-communication state last among the RF tags associated with the identifier of the RF tag attachment tool or the determination target; a final communication antenna extraction step of extracting the antenna that has last detected the response signal from the RF tag extracted in the final survival tag extraction step; and a submersion occurrence location determination step of determining a candidate for a submersion occurrence location based on an installation location of the antenna extracted in the final communication antenna extraction step.

[0022] It is preferable to cause the computer to execute: a partial submersion step of submerging a predetermined portion of the determination target to which the RF tag attachment tool is attached; and an attachment position registration step of storing the predetermined

portion as an installation location of the RF tag on the determination target in association with an identifier of the RF tag determined to be submerged in the submersion state determination step.

[0023] It is preferable to cause the computer to execute: a partial submersion step of submerging a predetermined portion of determination target to which the RF tag attachment tool is attached; an attachment position determination step of reading, from the storage device, an identifier of the RF tag determined to be submerged in the submersion state determination step and reading the installation location of the RF tag on the determination target associated with the identifier of the RF tag and of determining whether or not the predetermined portion in the partial submersion step matches the installation location of the RF tag; and an attachment position determination result output step of outputting a determination result in the attachment position determination step.

[0024] A submersion determination device of the invention includes: a wireless communication control device that performs wireless communication with an RF tag; and a storage device. The wireless communication control device includes: a signal output unit that outputs a predetermined signal to the RF tag; a response signal reception unit that receives a response signal from the RF tag with respect to

the predetermined signal; a communication state determination unit that determines whether a status is a communication state in which the response signal from the RF tag is detected under predetermined conditions or a non-communication state in which the response signal from the RF tag is not detected under the predetermined conditions; a submersion determination unit that determines that the determination target is submerged when the non-communication state continues for a predetermined period; and an alarm output unit that outputs an alarm when it is determined that the determination target is submerged.

[0025] A submersion determination system of the invention includes: the RF tag attachment tool described above; the submersion determination device described above; and an antenna that enables wireless communication between the RF tag attachment tool and the submersion determination device.

EFFECT OF THE INVENTION

[0026] According to the invention, it is possible to provide an RF tag attachment tool that is easy to make light or small and a submersion determination program, a submersion determination device, and a submersion determination system that can be applied to such an RF tag attachment tool.

BRIEF DESCRIPTION OF DRAWINGS

[0027] Fig. 1 is an explanatory diagram showing an overview of a submersion determination system;

(A) in Fig. 2 is an explanatory diagram showing an overview when an RF tag attachment tool is attached to the head of a swimmer, and (B) in Fig. 2 is a bottom view showing an overview of the RF tag attachment tool;

Fig. 3 is an exploded perspective view showing an overview of a tag package;

Fig. 4 is a perspective view showing an overview of a tag package;

Fig. 5 is an exploded view showing an overview of a tag package;

Fig. 6 is an enlarged view of main parts showing an overview of a tag package attached to a swimming cap;

Fig. 7A is a plan view showing an overview of an RF tag attachment tool (modification example);

Fig. 7B is a plan view showing an overview of an RF tag attachment tool (modification example);

Fig. 8A is an exploded view showing an overview of an RF tag attachment tool (modification example);

Fig. 8B is an enlarged view of main parts showing an overview of an RF tag attachment tool (modification example);

Fig. 8C is a plan view showing an overview of an RF

tag attachment tool (modification example);

Fig. 8D is an enlarged view of main parts showing an overview of an RF tag attachment tool (modification example);

Fig. 8E is a plan view showing an overview of an RF tag attachment tool (modification example);

Fig. 8F is a plan view showing an overview of an RF tag attachment tool (modification example);

Fig. 8G is an enlarged view of main parts showing an overview of an RF tag attachment tool (modification example);

Fig. 8H is a plan view showing an overview of an RF tag attachment tool (modification example);

Fig. 8I is a plan view showing an overview of a tag support plate (modification example);

Fig. 9 is a hardware configuration diagram of a submersion determination device;

Fig. 10 is a functional block diagram of the submersion determination device;

Fig. 11 is a chart showing an overview of a communication state step and the submersion state determination step;

Fig. 12 is a flowchart showing an overview of a submersion determination method;

(A) in Fig. 13 is an explanatory diagram showing an

overview of a tag DB, and (B) in Fig. 13 is an explanatory diagram showing an overview of an antenna DB;

Fig. 14A is an explanatory diagram showing an overview of a transmission log;

Fig. 14B is an explanatory diagram showing an overview of a reception log;

Fig. 15 is an explanatory diagram showing an overview of a communication state determination log;

Fig. 16 is an explanatory diagram showing an overview of a submersion state determination log;

Fig. 17 is a flowchart showing an overview of an attachment position determination method;

Fig. 18 is a bottom view showing an overview of an RF tag attachment tool (modification example);

Fig. 19 is a perspective view showing an overview of an RF tag attachment tool (modification example);

Fig. 20 is an enlarged view of main parts showing an overview of an RF tag attachment tool (modification example) when attached to the head of a swimmer;

Fig. 21 is an enlarged view of main parts of an RF tag attachment tool (modification example) when attached to the head of a swimmer;

Fig. 22 is a plan view showing an overview of an RF tag attachment tool (modification example);

Fig. 23A is a perspective view showing an overview of

a tag package (modification example);

Fig. 23B is a plan view showing an overview of a tag package (modification example);

Fig. 23C is a side view showing an overview of a tag package (modification example);

Fig. 23D is a front view showing an overview of a tag package (modification example);

Fig. 23E is a cross-sectional view taken along the line XXIIIe-XXIIIe', showing an overview of a tag package (modification example);

Fig. 23F is a cross-sectional view taken along the line XXIIIf-XXIIIf', showing an overview of a tag package (modification example);

Fig. 23G is a cross-sectional view taken along the line XXIIIf-XXIIIf', showing an overview of a tag package (modification example) provided in the front part;

Fig. 23H is a cross-sectional view taken along the line XXIIIf-XXIIIf', showing an overview of a tag package (modification example) provided in the rear part;

Fig. 24A is an explanatory diagram showing an overview of a determination target to which an RF tag attachment tool (modification example) is attached;

Fig. 24B is an explanatory diagram showing an overview of a determination target to which an RF tag attachment tool (modification example) is attached;

Fig. 24C is an explanatory diagram showing an overview of the orientation of an antenna pattern housed in a tag package located on the front side of the head;

Fig. 24D is an explanatory diagram showing an overview of the orientation of an antenna pattern housed in a tag package located on the back side of the head;

Fig. 25A is a cross-sectional view showing an overview of a tag package (modification example);

Fig. 25B is a cross-sectional view showing an overview of a tag package (modification example);

Fig. 26A is an explanatory diagram showing an overview of a determination target to which an RF tag attachment tool (modification example) is attached; and

Fig. 26B is a plan view showing an overview of an RF tag attachment tool (modification example).

BEST MODE(S) FOR CARRYING OUT THE INVENTION

[0028] As shown in Fig. 1, a submersion determination system 2 includes an RF tag attachment tool 100, antennas AT1 to AT4, a receiver RV capable of performing wireless communication with an RF tag provided on the RF tag attachment tool 100 through the antennas AT1 to AT4, and a submersion determination device 10 connected to the receiver RV.

[0029] The antennas AT1 to AT4 are provided on the

poolside so as to surround a pool PL. When the pool PL has a rectangular shape in a plan view, it is preferable that the antennas AT1 to AT4 are arranged along the four sides (Fig. 1). The receivable ranges ATX1 to ATX4 of the respective antennas AT1 to AT4 preferably cover the range where the determination target is present (for example, the entire pool PL), and the receivable ranges ATX1 to ATX4 of the respective antennas AT1 to AT4 preferably overlap each other.

[0030] Each of the antennas AT1 to AT4 is connected to the receiver RV. Based on a control signal from the submersion determination device 10, the receiver RV transmits a predetermined signal to the RF tag through the antennas AT1 to AT4 at predetermined intervals by superimposing the signal on a radio wave or a magnetic field. In addition, the receiver RV receives a response signal from the RF tag, which has been received through the antennas AT1 to AT4. In addition, for the response signal from the RF tag that has been received through the antennas AT1 to AT4, the receiver RV adds an identifier (for example, AT1, AT2, and the like) of the antenna that has received the response signal, and outputs it to the submersion determination device 10.

[0031] As shown in Fig. 2, the RF tag attachment tool 100 is for attaching an RF tag TG (Fig. 3) to the head HTX

of a determination target HT (for example, a swimmer), and includes a swimming cap CAP (attachment member) to be worn on the determination target HT, a tag support structure TSC, and a mounting structure for mounting the tag support structure TSC on the swimming cap CAP. In addition, the tag support structure TSC includes a tag package 120 (first support structure) with the built-in RF tag TG and a support member 110 (second support structure) that is mounted on the swimming cap CAP and supports the tag package 120.

[0032] Hereinafter, for convenience of explanation, an arbitrary direction in the horizontal plane is referred to as an X direction, a direction perpendicular to the X direction among arbitrary directions in the horizontal plane is referred to as a Y direction, and a direction perpendicular to the horizontal plane is referred to as a Z direction.

[0033] As shown in Figs. 3 and 4, the tag package 120 houses the RF tag TG, and includes the RF tag TG, a tag support 122 capable of supporting the RF tag TG, and a tag cover 125 arranged on the tag support 122 to cover the RF tag TG.

[0034] The RF tag TG is a medium for reading and writing data in a built-in memory in a non-contact manner using radio waves (electromagnetic waves). There are three types

of RF tags TG that can be applied: a passive type without a built-in power supply, an active type with a built-in power supply, and a semi-active type that normally operates as a passive type and, only when prompted by a reader or a writer, uses a built-in power supply to transmit radio waves. Any of these types can be applied, but the passive type is preferable among them. The passive RF tag TG includes an insulating film FL formed of synthetic resin, an IC chip CP arranged on the insulating film FL, two electrode patterns PT arranged on the insulating film FL and connected to electrodes of the IC chip CP, and an antenna pattern AP arranged on the insulating film FL and provided from the two electrode patterns PT. The insulating film FL is formed in a rectangular shape with sides in a longitudinal direction (X direction) and a transverse direction (Y direction).

[0035] When the antenna pattern AP receives radio waves or a magnetic field, an induced electromotive force is generated in the IC chip CP, which activates an built-in program of the IC chip CP. As a result, various kinds of information (such as an identifier of an RF tag) stored in the IC chip CP or information as calculation results is transmitted from the antenna pattern AP by carrying a predetermined signal on the radio waves or magnetic field. The predetermined signal transmitted from the RF tag TG is

read by the receiver RV through the antenna AT. In addition, the receiver RV transmits the read signal to the submersion determination device 10 as a response signal.

[0036] When specializing in submersion detection, the frequency band of the radio waves used for wireless communication between the RF tag TG and the antenna AT is preferably a frequency band in which radio waves do not penetrate water. As the frequency band in which radio waves do not penetrate, for example, 300 kHz or higher is preferable. As specific examples applicable to the wireless communication between the RF tag TG and the antenna AT, the HF band (high frequency band: 13.56 MHz), the UHF band (ultra-high frequency band: 860 MHz or more and 920 MHz or less), and the SHF band (microwave band: 2.45 GHz) can be used. In addition, when communication distance or downsizing of antennas, receivers, and the like is taken into consideration, UHF (ultra-high frequency) is preferable.

[0037] The tag support 122 is formed in a plate shape, and is formed in a rectangular shape having sides in a longitudinal direction (X direction) and a transverse direction (Y direction). The tag cover 125 is also formed in a plate shape, and is formed in a rectangular shape having sides in the longitudinal direction (X direction) and the transverse direction (Y direction). It is

preferable that the dimensions of the tag cover 125 in the X and Y directions are smaller than those of the tag support 122. The tag package 120 of the RF tag TG is obtained by placing the tag cover 125 from the top surface onto the tag support 122 having the RF tag TG arranged on its top surface and sealing a gap between the tag support 122 and the tag cover 125. For this reason, the tag package 120 has a waterproof structure. In addition, it is preferable that the tag support 122 and the tag cover 125 are formed of synthetic resin and have flexibility. The insulating film FL also has flexibility. For this reason, it is preferable that the tag package 120 as a whole has flexibility.

[0038] It is preferable that the tag package 120 includes a positioning mechanism capable of positioning the RF tag TG at a predetermined position. The positioning mechanism is preferably a recessed portion or a plurality of protrusions provided on the tag support 122 or the tag cover 125. It is preferable that the recessed portion has a size sufficient to house the RF tag TG. In addition, the plurality of protrusions may be arranged around the arrangement position of the RF tag TG so as to be able to engage with the sides of the RF tag TG.

[0039] As shown in Fig. 2, the swimming cap CAP includes an edge portion CAP1 (attachment body), which forms an

opening into which the determination target HT can be inserted, and an extended portion CAP2, which extends from one side of the edge portion CAP1. The extended portion CAP2 is formed in a hemispherical shape. The edge portion CAP1 has elasticity, and is formed in an annular shape. For this reason, when a radially outward force is applied to the edge portion CAP1, the edge portion CAP1 is deformed so as to extend radially outward. The head HTX of the determination target HT is inserted into the edge portion CAP1 in a state of being expanded by the outward force, and the head HTX is made to reach the extended portion CAP2 as it is. Then, when the outward force is released, the edge portion CAP1 tightly fits against the head portion HTX of the determination target HT by the restoring force of the edge portion CAP1. As a result, the swimming cap CAP is attached to the head HTX of the determination target HT without a gap.

[0040] As a material for forming the edge portion CAP1, an elastic material such as rubber or an elastic fabric such as a knit is preferable. As a material for forming the extended portion CAP2, a material similar to that of the edge portion CAP1 or a material with good drainage such as a mesh is preferable.

[0041] As shown in Fig. 5, the support member 110 is formed in a plate shape, and is formed in a rectangular

shape having sides in a longitudinal direction (X direction) and a transverse direction (Y direction). The support member 110 is formed of synthetic resin and has flexibility. A button B1 (mounting structure) is provided on a bottom surface 110U of the support member 110. On the other hand, two buttons B2 (mounting structures) that are attachable to and detachable from the button B1 are provided on the outer surface of the edge portion CAP1 of the swimming cap CAP1 so as to be spaced apart from each other by a predetermined distance. By the button B1 and the button B2, the support member 110 is mounted on the edge portion CAP1 so as to be attachable to and detachable from the edge portion CAP1. Here, in the swimming cap CAP, a position where the button B2 on one side is provided is referred to as a one-side engagement portion CAP1L, and a position where the button B2 on the other side is provided is referred to as an other-side engagement portion CAP1R.

[0042] On a top surface 110T of the support member 110, a female button 110A (one-side button structure) is provided at a one-side end portion (one-side engagement portion) in the X direction, and a female button 110B (other-side button structure) is provided at an other-side end portion (other-side engagement portion) in the X direction. In addition, on a bottom surface 122K of the tag support 122, a male button 122A (one-side button

structure) is provided at a one-side end portion 122L (one-side support structure end portion) in the X direction, and a male button 122B (other-side button structure) is provided at an other-side end portion 122R (other-side support structure end portion) of the tag support 122 in the X direction. The female button 110A can be attached to and detached from the male button 122A, and the female button 110B can be attached to and detached from the male button 122B.

[0043] A distance L1 in the X direction between the two female buttons 110A and 110B in the support member 110 in a flat state is shorter than a distance L2 in the X direction between the two male buttons 122A and 122B provided on the tag support 122. When the female button 110A is attached to the male button 122A and the female button 110B is attached to the male button 122B, the support member 110 is curved so as to protrude outward along the head HTX as shown in Fig. 6, and the tag support 122 mounted on the support member 110 is curved so as to protrude outward (toward the top surface 122T side). For this reason, an intermediate portion 122C in the X direction, which is located between the one-side end portion 122L in the X direction and the other-side end portion 122R in the X direction of the tag support 122, moves further away from the head HTX of the determination target HT than both the

end portions 122L and 122R. As a result, the RF tag TG supported by the tag support 122 is also curved so as to protrude upward similarly to the tag support 122, and accordingly, moves away from the head HTX of the determination target HT. For this reason, the male buttons 122A and 122B provided at both end portions of the tag support 122 in the X direction, the support member 110, and the female buttons 110A and 110B provided at both end portions of the support member 110 in the X direction function as a separation support structure.

[0044] When the swimming cap CAP is worn on the head HTX of the determination target HT (Fig. 2), the RF tag TG moves away from the head HTX of the determination target HT by the separation support structure, so that wireless communication by the RF tag TG becomes possible without being affected by moisture contained in the head or hair or moisture attached thereto.

[0045] In addition, when a portion of the tag support 122 located in the vicinity of the arrangement position of the IC chip CP is defined as a chip-vicinity support portion 122CX (chip-vicinity support structure portion) (Figs. 3, 5, and 6), in the tag support 122 when the swimming cap CAP is worn on the determination target HT, the chip-vicinity support portion 122CX has a shape moving further away from the head HTX of the determination target

HT than the one-side end portion 122L and the other-side end portion 122R. As a result, the IC chip CP built in the RF tag TG moves away from the head HTX of the determination target HT, and a gap XX (Figs. 3 and 6) is formed between the IC chip CP and the swimming cap CAP. Here, the gap is a space where there is no object (solid or liquid) forming an RF tag attachment tool, that is, a space where there is an atmospheric gas such as air. For this reason, an induced electromotive force is easily generated in the IC chip CP without being affected by moisture contained in the head or hair or moisture attached thereto.

[0046] When the swimming cap CAP is worn on the determination target HT, it is preferable that the tag packages 120 mounted on the swimming cap CAP are arranged so as to be lined up around the head HTX at predetermined pitches therebetween, such as a face (forehead or the like), a left side of the head, a back side of the head, and a right side of the head (Fig. 2). Specifically, as a desirable installation location of the tag package 120, it is preferable to be the face (forehead or the like) of the determination target HT wearing the swimming cap CAP, in order to easily detect the submersion of a mouth or a nose.

[0047] When mounting a plurality of tag packages 120 on the swimming cap CAP, as another layout example, these may be arranged not only on the face (forehead or the like) but

also on the top of the head, the right side of the head, and the left side of the head, as shown in Fig. 7A. In addition, as shown in Fig. 7B, when mounting a plurality of tag packages 120 on the swimming cap CAP, the tag packages 120 may be provided in a vertical direction.

[0048] In addition, another member may be present between the swimming cap CAP and an intermediate portion of the tag support 122 in the X direction (support intermediate portion). However, considering that the dielectric constant of air is relatively lower than those of other materials, it is preferable that another member is not present. That is, it is preferable that the support of the tag package 120 with respect to the swimming cap CAP is realized by both end portions of the tag support 122 in the X direction and the support member 110.

[0049] In addition, although the support member 110 can be attached to and detached from the swimming cap CAP by using the button B1 and the like provided at both end portions in the X direction of the bottom surface 110U of the support member 110 itself, the support member 110 may be fixed to the swimming cap CAP by sewing, adhering, or the like to the swimming cap CAP. In addition, although the tag package 120 may be directly mounted on the swimming cap CAP, when the rigidity of the extended portion CAP2 is relatively small, it is better to attach the tag package

120 through the support member 110 having rigidity greater than that of the extended portion CAP2.

[0050] Thus, since the RF tag attachment tool 100 uses wireless communication using an RF tag, downsizing becomes easy. In addition, even when the determination target HT has a high dielectric constant such as a human or an animal or when the RF tag attachment tool 100 is used in an environment in which water or the like easily adheres thereto, the RF tag attachment tool 100 includes a separation support structure that keeps the RF tag away from the determination target HT in the attached state, so that it is less likely to be adversely affected on wireless communication. In addition, since the separation support structure is a simple structure, downsizing is easy, and it is also possible to stabilize quality or suppress manufacturing costs.

[0051] In addition, the support member 110 may be omitted, and the tag support 122 may be directly mounted on the swimming cap CAP. In this case, as shown in Fig. 8A, it is preferable that a distance L1' between the two buttons B2 in the X direction is shorter than a distance L2 between the male buttons 122A and 122B in the X direction and that the two buttons B2 provided on the outer surface of the edge portion CAP1 of the swimming cap CAP are attachable to and detachable from the male buttons 122A and

122B provided on the tag support 122, respectively. That is, the two buttons B2 and the male buttons 122A and 122B function as a mounting structure.

[0052] In addition, in the above embodiment, when the swimming cap CAP is worn on the determination target HT, in the tag support structure TSC (tag support 122) that directly supports the RF tag TG, the chip-vicinity support portion 122CX moves further away from the swimming cap CAP or the determination target HT than other portions of the tag support 122. However, the invention is not limited thereto. For example, as shown in Fig. 8B, the shape deformation of the support member 110 may be performed along with the shape deformation of the tag support 122. The shape deformation of the support member 110 means that a center portion of the support member 110 in the X direction is deformed so as to have a shape moving further away from the swimming cap CAP or the determination target HT than both end portions of the support member 110 in the X direction.

[0053] In addition, in the above embodiment, the tag support 122 or the support member 110 that supports the entire RF tag TG from the lower side is used as the tag support structure TSC, but, the invention is not limited thereto. As shown in Figs. 8C to 8G, the tag support structure TSC arranged so as to avoid the arrangement

position of the IC chip CP in the RF tag TG may be used. For example, as shown in Figs. 8C to 8D, a support plate 510 may be used as the tag support structure TSC. The support plate 510 is provided on the swimming cap CAP and supports the tag support 122. The support plate 510 includes a one-side support end portion 510L that is attachable to and detachable from a button provided on the one-side engagement portion CAP1L and an other-side support end portion 510R that is attachable to and detachable from a button provided on the other-side engagement portion CAP1R. At the one-side support end portion 510L and the other-side end portion 122R, female buttons 510A and 510B that are attachable to and detachable from male buttons 122A and 122B provided at both end portions of the tag support 122 in the X direction are provided, respectively. In a plan view seen from the Z direction (Fig. 8C), the one-side support end portion 510L and the other-side support end portion 510R are arranged at positions avoiding the arrangement position of the IC chip CP. For this reason, the gap XX (Fig. 8D) is formed between the swimming cap CAP and the IC chip CP of the RF tag TG. In addition, in a plan view (Fig. 6D), the position where the support plate 510 is provided is arranged so as to avoid the tag cover 125 or the RF tag TG in a plan view seen from the Z direction (Fig. 8C), but the invention is not limited

thereto. The position where the support plate 510 is provided may overlap the tag cover 125 or the RF tag TG as long as the position is a position avoiding the IC chip CP in a plan view seen from the Z direction (Fig. 8C).

[0054] Similarly, as shown in Fig. 8E, a support plate 610 may be used as the tag support structure TSC. The support plate 610 is provided on the swimming cap CAP and supports the tag support 122. The support plate 610 includes a one-side engagement portion 610U that supports a one-side support end portion 122U in the Y direction of the tag support 122 and an other-side engagement portion 610D that supports an other-side support end portion 122D in the Y direction of the tag support 122. In a plan view seen from the Z direction (Fig. 8E), the one-side engagement portion 610U and the other-side engagement portion 610D are arranged at positions avoiding the IC chip CP. For this reason, a gap is formed between the swimming cap CAP and the IC chip CP of the RF tag TG.

[0055] In addition, the one-side support end portion 510L and the other-side support end portion 510R may be used in combination with the one-side engagement portion 610U and the other-side engagement portion 610D.

[0056] In addition, in order to prevent foreign matter from entering a gap between the swimming cap CAP and the IC chip CP of the RF tag TG, a foreign matter entry prevention

member 525 may be provided for an opening 510X (Fig. 8D) formed by the tag support 122, the one-side support end portion 510L, and the other-side support end portion 510R (Figs. 8F to 8G). The foreign matter entry prevention member 525 may have a plate shape, or may have a net shape as long as it can prevent the target foreign matter from entering.

[0057] In the above embodiment, the tag support structure TSC is arranged at a position avoiding the IC chip CP in a plan view seen from the Z direction, but the invention is not limited thereto. For example, as shown in Figs. 8H to 8I, a support plate 710 that supports the entire bottom surface of the tag support 122 and has a through-hole 710X formed as a gap may be used. The formation position of the through-hole 710X is preferably arranged so as to overlap the IC chip CP. The support plate 710 having the through-hole 710X formed at such a position also functions as a foreign matter entry prevention member for the through-hole 710X, that is, the gap. In addition, a blind hole may be formed in the support plate 710 instead of the through-hole 710X as long as it does not depart from the spirit of the invention.

[0058] In addition, as shown in Figs. 8C to 8I, when using the tag support structure TSC arranged so as to avoid the arrangement position of the IC chip CP in the RF tag

TG, a length L1 between the one-side engagement portion CAP1L and the other-side engagement portion CAP1R may be shorter than the distance L2 between the male buttons 122A and 122B in the X direction, similarly to Figs. 5 and 6.

[0059] As shown in Fig. 9, the submersion determination device 10 includes a CPU 11 (wireless communication control device), a RAM 12, a ROM 13, an external storage device 14 (storage device), an input device 15, an output device 16, an input/output interface 18, and a bus 19.

[0060] The CPU 11 is a so-called central processing unit, and executes various programs to realize various services of the submersion determination device 10. The RAM 12 is a so-called RAM (random access memory), and is used as a work area of the CPU 11. The ROM13 is a so-called ROM (read only memory), and stores a basic OS or various programs (for example, a submersion determination program) executed by the CPU 11.

[0061] The external storage device 14 is constructed with various DBs (databases) and stores calculation results of various programs, and examples thereof include a built-in storage device (for example, a hard disk drive) and a detachable storage device (for example, a memory card or the like). In addition, the external storage device 14 may be connected through a communication line, such as a NAS (network attached storage).

[0062] The input device 15 is an input key, a keyboard, or a mouse, and inputs various kinds of information. The output device 16 is a display, and displays various operating states.

[0063] The input/output interface 18 enables communication over a communication line. The bus 19 serves as a wiring that integrally connects the CPU 11, the RAM 12, the ROM 13, the input device 15, the output device 16, the input/output interface 18, and the like to perform communication.

[0064] When the basic OS or various programs stored in the ROM 13 are executed by the CPU 11, as shown in Fig. 10, the CPU 11 includes a receiver control unit 11RT that performs predetermined control on the receiver RV, a communication state determination unit 11EX that determines a state of wireless communication between the receiver RV and the RF tag TG, a submersion state determination unit 11EY that determines that a determination target is submerged when predetermined conditions are satisfied, an alarm output unit 11AL that outputs an alarm when it is determined that the determination target is submerged, and a control unit 11CR that controls each unit.

[0065] The receiver control unit 11RT transmits a predetermined signal (such as a polling signal) to the RF tag. The polling signal includes a request signal for

predetermined processing on the RF tag and the like. In addition, the receiver control unit 11RT may store various kinds of information (such as a request signal for predetermined processing for the RF tag) included in the polling signal in the external storage device 14.

[0066] In addition, the receiver control unit 11RT reads the signals received by the respective antennas AT1 to AT4 and determines whether or not these are response signals from the RF tag. In addition, when it is determined that the signals are response signals from the RF tag, the receiver control unit 11RT reads identifiers of the respective antennas AT1 to AT4 that have received the response signals, reception times of the response signals received by the respective antennas AT1 to AT4, signal strengths of the response signals regarding the respective antennas AT1 to AT4, an identifier of the RF tag or a status (a normal state or an abnormal state) of the RF tag included in the response signal, and the like. In addition, regarding the response signals for the respective antennas AT1 to AT4, the receiver control unit 11RT may compare the signal strengths and rank the strengths of the respective response signals. In addition, the receiver control unit 11RT stores the identifiers of the respective antennas AT1 to AT4 that have received the response signals, the reception times of the response signals, the

signal strengths of the response signals, the order of the strengths of the response signals based on the comparison between the signal strengths, the identifier of the RF tag or the status (a normal state or an abnormal state) of the RF tag included in the response signal, and the like, in the external storage device 14 in association with an identifier of itself (receiver).

[0067] The communication state determination unit 11EX determines whether or not a response signal of the RF tag has been detected within a predetermined period for all RF tags to be determined. Then, when a response signal of the RF tag has been detected within a predetermined period, the communication state determination unit 11EX determines that the RF tag is in a communication state, whereas when no response signal of the RF tag has been detected within a predetermined period, the communication state determination unit 11EX determines that the RF tag is in a non-communication state. In addition, the communication state determination unit 11EX stores the determination result of the communication state or the determination time in the external storage device 14 in association with the identifier of each RF tag.

[0068] The submersion state determination unit 11EY reads the determination result by the communication state determination unit 11EX from the external storage device 14

at predetermined intervals (for example, 0.5 to 2 seconds), and determines whether or not a swimmer wearing the RF tag is submerged based on the determination result. Regarding a method for determining whether or not the swimmer is submerged, for all RF tags (TG1 to TG4 in the diagram) worn by the swimmer through the RF tag attachment tool, when at least one RF tag is in a communication state, the swimmer is determined as "not submerged", whereas when all the RF tags are in a non-communication state, the swimmer is determined as "submerged". In addition, the submersion state determination unit 11EY stores the submersion determination result ("not submerged" or "submerged") in the external storage device 14 in association with the identifier of the swimmer who is a determination target.

[0069] Incidentally, in submersion monitoring in a pool, all RF tags may be submerged under a normal state, that is, under a situation in which a wearer of the RF tag attachment tool is swimming. For this reason, when it is determined that the swimmer is submerged based on the detection that "all RF tags associated with the identifier of the swimmer to be determined are in a non-communication state", "switching between the communication state and the non-communication state" frequently occurs despite the normal swimming state, and as a result, a submersion determination result important for a lifeguard cannot be

displayed. In this case, when "all RF tags associated with the identifier of the swimmer to be determined are in a non-communication state" is maintained for a first period T1, it is preferable that the submersion state determination unit 11EY determines that the swimmer is "submerged" (Fig. 11).

[0070] In addition, regarding the RF tag associated with the identifier of the swimmer determined as "submerged" in the submersion determination, when transitioning from "a state in which all RF tags are in a non-communication state" to "a state in which at least one RF tag is in a normal state", the submersion state determination unit 11EY may determine that the swimmer "has recovered from the submersion state" based on the transition. However, "switching between the submersion state and the state recovered from submersion" frequently occurs, and as a result, the submersion determination result important for the lifeguard cannot be displayed in some cases. In this case, when a state switched from "the state in which all RF tags are in a non-communication state" to "the state in which at least one RF tag is in a normal state" is maintained for a second period T2, the submersion state determination unit 11EY determines that the swimmer "has recovered from submersion", and stores "recovered from submersion" as a submersion determination result in the

external storage device 14 in association with the identifier of the swimmer who is a determination target. By setting the second period T2, it is possible to determine whether the recovery from submersion is temporary or continuous.

[0071] Here, it is preferable that the first period T1 is shorter than the second period T2. This is because if the second period is shorter than the first period, it may be actually determined that the swimmer has recovered from submersion despite a state in which the swimmer has not recovered from submersion. Therefore, it becomes possible to detect "transition from the communication state to the non-communication state", which is important in terms of ensuring safety.

[0072] In addition, when the state is maintained during a third period after "the state in which all RF tags are in a non-communication state" is determined, switching to "the state recovered from submersion" may be restricted.

[0073] When there is the identifier of the swimmer determined to be submerged, the alarm output unit 11AL displays a name of the swimmer associated with the identifier of the swimmer on a warning screen of the output device 16, sounds a buzzer BZ connected to the alarm output unit 11AL, or turns on or blinks an alarm lamp LD connected to the alarm output unit 11AL.

[0074] Next, a submersion determination method (Fig. 12) in the submersion determination system 2 (Fig. 12) will be described.

[0075] In a submersion determination method S500, an attachment step S510, a transmission and reception step S520, a communication state determination step S540, a submersion state determination step S550, and an alarm output step S560 are performed.

[0076] As a preliminary stage of the attachment step S510, the identifier and the name of the swimmer to be determined are stored in a tag DB ((A) in Fig. 13) of the external storage device 14 in a state associated with the identifier of the RF tag. In addition, it is preferable that, in the tag DB, the attachment position of the RF tag is associated with the identifier of the RF tag.

[0077] In the attachment step S510, an administrator or a lifeguard attaches the RF tag attachment tool 100 to the swimmer. For example, four RF tags are attached to the RF tag attachment tool 100 worn by the swimmer (name: Ichiro Yamada, ID: USR001), and the identifier and the attachment position of each RF tag "face (forehead): TAG001," "back side of the head: TAG002", "left side of the head: TAG003", and "right side of the head: TAG004" are associated with the identifier "USR001" of the swimmer and stored in the tag DB ((A) in Fig. 13) constructed in the external storage

device 14. In addition, in an antenna DB ((B) in Fig. 13) constructed in the external storage device 14, an installation location of the antenna and the like are associated with the identifiers (AT1 to AT4) of the antennas.

[0078] In the transmission and reception step S520, a signal output step and a response signal reception step are performed. When there are a plurality of antennas, the signal output step and the response signal reception step for the first antenna AT1 are performed, and then the signal output step and the response signal reception step for the second antenna AT2 are performed. Similarly, the signal output step and the response signal reception step are performed for the third antenna AT3 and the fourth antenna AT4. In this manner, the processing for all antennas is defined as one set, and this set is repeatedly performed.

[0079] In the signal output step, under the control of the receiver control unit 11RT, a polling signal is transmitted from the receiver RV to the RF tag TG. A transmission log at this time is shown in Fig. 14A. The RF tag TG that has received the polling signal reads various kinds of information included in the polling signal, adds the identifier of its own RF tag together with a predetermined processing result for the request included in

the polling signal, and transmits these as a response signal.

[0080] In the response signal reception step, under the control of the receiver control unit 11RT, it is determined whether or not the signal received through the antenna within a predetermined period is a response signal of the RF tag corresponding to the polling signal. Then, when it is determined that the signal is the response signal of the RF tag, the identifier of the antenna that has received the response signal, the identifier of the receiver that has received the response signal, and the reception time of the response signal at the receiver are associated with the identifier of the RF tag TG and a recording time, and these are stored as a reception log (Fig. 14B) in the external storage device 14. Here, the recording time is a time at the time of recording in the reception log. On the other hand, when the response signal of the RF tag cannot be detected within the predetermined period, "no reception" instead of the reception time of the response signal at the receiver may be associated with the identifier of the antenna, the identifier of the receiver, and the recording time, and these may be stored as a reception log (Fig. 14B) in the external storage device 14.

[0081] In the communication state determination step S540, the communication state determination unit 11EX reads

the reception log (Fig. 14B) from the external storage device 14, and determines whether or not a response signal of the RF tag has been detected within the same set in the transmission and reception step S520 for the RF tag to be determined. When the response signal reception time is recorded in any of the antennas within the same set, it is determined that the RF tag was in a communication state, whereas when there is no record in the reception log (Fig. 14B) for all antennas within the same set or when "no reception" is recorded in the response signal reception time, the RF tag is determined to be in a non-communication state. In addition, the communication state determination unit 11EX associates a wireless communication status (a communication state or a non-communication state) along with a time when the determination was performed (determination time) with the identifier of the RF tag TG that is a determination target, and stores these as a communication state determination log (Fig. 15) in the external storage device 14.

[0082] In the submersion state determination step S550, the submersion state determination unit 11EY reads the communication state determination log (Fig. 15), and performs submersion state determination for each identifier of the swimmer to be determined at predetermined intervals. In the submersion state determination, for all RF tags (TG1

to TG4 in the figure) worn by the swimmer through the RF tag attachment tool, when at least one RF tag is in a communication state, the swimmer is determined as "not submerged". On the other hand, when all the RF tags are in a non-communication state, the swimmer is determined as "submerged".

[0083] For example, when the identifier of the swimmer is "USR001" and the determination time is "10:00:01" and "10:00:02," the four RF tags (identifiers: TAG001 to TAG004) are each in a communication state. Therefore, the submersion determination result is OK (a state of not being submerged). In addition, when the determination time is "10:00:10" and "10:00:11," three RF tags (identifiers: TAG002 to TAG004) are in a non-communication state, but one RF tag (identifier: TAG001) is in a communication state. Therefore, the submersion determination result is OK (a state of not being submerged). In addition, when the determination time is "10:00:12," four RF tags (identifiers: TAG001 to TAG004) are in a non-communication state, but the first period T1 has not passed from the non-communication state of the four RF tags. Therefore, the submersion determination result is OK (a state of not being submerged). However, when the determination time is "10:00:13," the four RF tags (identifiers: TAG001 to TAG004) are in a non-communication state and the first

period T1 has passed from the non-communication state of the four RF tags. Therefore, the submersion determination result is NG (submersion state).

[0084] In addition, the submersion state determination unit 11EY associates the determination result of the submersion state ("not submerged", "submerged", or "recovered from submersion") with the identifier of the RF tag attachment tool that is a determination target, and stores these as a submersion state determination log (Fig. 16) in the external storage device 14.

[0085] In the alarm output step S560, when there is an identifier determined as "submerged" among the identifiers of the swimmers to be determined in the submersion state determination step S550, the alarm output unit 11AL displays the swimmer name associated with the identifier of the swimmer on the warning screen of the output device 16, sounds the buzzer BZ, or turns on or blinks the alarm lamp LD. Therefore, it is possible to notify the administrator or the lifeguard of a risk of a submersion accident occurring and prompt them to check whether or not submersion is actually occurring and perform necessary rescue.

[0086] Thus, according to the submersion determination system 2, it is possible to easily check whether or not the swimmer is submerged. In addition, since a tag attachment

tool that is easy to make light or small can be applied to the submersion determination system 2, it is possible to suppress the adverse effect of wireless communication due to a high dielectric material as much as possible. In addition, since a plurality of RF tags are provided for one tag attachment tool or a plurality of antennas are provided in the submersion determination system 2, it is possible to suppress the occurrence of a situation in which the RF tag is in a non-communication state depending on the orientation of the tag attachment tool despite “not submerged”.

[0087] The submersion determination system of the invention is not limited to the above-described embodiment. Hereinafter, modification examples of the above embodiment will be described, but the same parts, steps, and the like as those in the above embodiment are denoted by the same reference numerals, detailed descriptions thereof will be omitted, and only parts different from the above embodiment will be described.

[0088] In the submersion determination system 2 described above, when detecting submersion, only the presence or absence of submersion has been detected, but a location where the submersion is occurring may be detected. For example, in the submersion state determination step S550, when there is an identifier determined as "submerged"

among the identifiers of the swimmers to be determined, a last surviving tag extraction step and a last communication antenna extraction step may be performed.

[0089] In the last surviving tag extraction step, the reception log (Fig. 14B) stored in the external storage device 14 is read, and among the RF tags associated with the identifier of the swimmer determined to be in a submersion state, an RF tag that has transitioned to a non-communication state last (in Fig. 16, an "RF tag with the identifier 'TAG001' at 10:00:11" regarding the swimmer identifier USR001) is extracted.

[0090] In the last communication antenna extraction step, the identifier of the antenna that has last detected the response signal from the RF tag extracted in the last surviving tag detection step is extracted. Here, by referring to the reception log of Fig. 14B based on the RF tag extracted in the last surviving tag detection step (the "RF tag with the identifier 'TAG001' at 10:00:11"), it is possible to extract the identifier of the antenna that has last detected the response signal from the RF tag.

[0091] Then, in the alarm output step S560, the antenna DB ((B) in Fig. 13) stored in the external storage device 14 may be read, and the installation location of the antenna determined as a "candidate for the submersion occurrence location" may be displayed on the warning screen

of the output device 16. Alternatively, the alarm lamp LD or the buzzer BZ may be individually installed for the antennas AT1 to AT4, and the administrator or the lifeguard may be notified of the "candidate for the submersion occurrence location" by operating the alarm lamp LD or the buzzer BZ corresponding to the applicable antennas AT1 to AT4.

[0092] In addition, when a plurality of antennas are extracted in the last communication antenna extraction step, the signal strengths of the response signals received by the antennas may be compared, and the installation location of the antenna that has received the response signal with the largest signal strength may be determined as the "candidate for the submersion occurrence location," or the installation location of the antenna that has received the response signal with the first largest signal strength may be determined as a "first candidate for the submersion occurrence location" and the installation location of the antenna that has received the response signal with the second largest signal strength may be determined as a "second candidate for the submersion occurrence location".

[0093] Next, an attachment position determination method will be described.

[0094] An attachment position determination method 501S

(Fig. 17) includes an attachment step S510, a partial submersion step S515, a transmission and reception step S520, a communication state determination step S540, an attachment position determination step S555, and an alarm output step S560.

[0095] In the partial submersion step S515, the administrator or the lifeguard instructs the swimmer to submerge only a predetermined part (for example, the face or the forehead) so that the RF tag installed on the part is in a non-communication state. In this state, by performing the transmission and reception step S520 and the communication state determination step S540, the RF tag attached to the part intended by the administrator or the lifeguard is determined as being in a non-communication state. Then, in the attachment position determination step S555, by comparing the part intended by the administrator or the lifeguard with the attachment position of the RF tag determined to be in a non-communication state, it is possible to check whether or not the RF tag is attached in an orientation intended by the administrator or the lifeguard.

[0096] In addition, as the "predetermined part" in the partial submersion step S515, one stored in advance in the tag DB (Fig. 13A) of the external storage device 14 may be used, or one that is input each time to the submersion

determination device 10 by an operation of the administrator or the lifeguard using the input device 15 may be used.

[0097] Alternatively, an attachment position registration step may be performed instead of the attachment position determination step S555. In the attachment position registration step, when the part intended by the administrator or the lifeguard is compared with the attachment position of the RF tag determined to be in a non-communication state and both are different, the "attachment position of the RF tag determined to be in a non-communication state" in the tag DB (Fig. 13A) of the external storage device 14 may be updated to the "part intended by the administrator or the lifeguard".

[0098] In the above embodiment, it has been described that the identifier of the RF tag and the identifier of the swimmer are stored in association with each other in the tag DB (Fig. 13A), but the invention is not limited thereto, and the identifier of the RF tag and the identifier of the swimmer may be associated with each other in the RF tag. In this case, request processing for associating the identifier of the swimmer with the identifier of the RF tag in the IC chip may be performed on the RF tag TG in advance by the receiver control unit 11RT.

[0099] The RF tags that are submersion determination

targets in the invention may be all of those for which the identifier of the attachment body to be used or the swimmer is stored in advance in the tag DB ((A) in Fig. 13) of the external storage device 14, or may be limited to those that have communicated from an antenna installed at the entrance/exit of a place where the submersion determination process is performed.

[0100] In addition, after an "event requiring submersion determination", such as swimming in a pool, has ended, the transmission and reception step S520 is performed for all the antennas, and the communication state determination step S540 is performed on the communication results of the transmission and reception step S520. Therefore, when an RF tag in a communication state is detected, it is also possible to determine that an attachment body or an RF tag has been left behind in the pool where the swimming has ended.

[0101] In the above embodiment, one receiver is used, but a plurality of receivers may be used. In addition, when there are a plurality of RF tags associated with the same determination target or when there are a plurality of antennas or receivers used in the system, operating states of the RF tags, the antennas, or the receivers may be stored in the external storage device 14 such as a reception log. The control unit can specify a

malfunctioning or unstable one among the RF tags, the antennas, and the receivers, by reading the reception log or the like, and replace the devices.

[0102] In the transmission and reception step of the above embodiment, after transmitting a polling signal receivable by the RF tag to be determined using one antenna, a response signal from the RF tag is received using the antenna, and this series of transmission and reception is performed sequentially for all antennas, but the invention is not limited thereto. After transmitting the polling signal receivable by the RF tag to be determined through all antennas, the response signal from the RF tag may be received through all antennas.

[0103] In the above embodiment, the location where the pool for submersion determination is performed can be any of the following: a school, a gym, a hotel, etc., and it can be either an indoor or outdoor pool.

[0104] In the above embodiment, as the RF tag attachment tool of the invention, a case has been described in which the attachment member is the swimming cap CAP, but the invention is not limited thereto.

[0105] As shown in Figs. 18 to 20, the RF tag attachment tool 100 (RF tag attachment tool) includes the tag package 120 and an annular rubber band 200 (attachment member) attached to the determination target HT. The tag packages

120 are provided so as to be arranged at predetermined pitches on the annular rubber band 200. In addition, in the illustrated form, four tag packages 120 are provided on the annular rubber band 200.

[0106] The cross-sectional shape of the annular rubber band 200 is preferably rectangular (Fig. 19). In addition, a thermosetting elastomer (so-called rubber) is used as a material for forming the annular rubber band 200. Since the annular rubber band 200 is elastic, when an outward force is applied, the annular rubber band 200 deforms so as to extend outward. For this reason, the head HTX of the determination target HT is inserted into the annular rubber band 200 in a state in which the annular rubber band 200 is expanded by the outward force. Then, when the outward force is released, the annular rubber band 200 tightly fits around the head HTX (such as the forehead) of the determination target HT due to the restoring force of the annular rubber band 200. As a result, the annular rubber band 200 is attached to the head HTX of the determination target HT.

[0107] An insertion hole 200X into which the annular rubber band 200 can be inserted is formed at both ends of the tag support 122 in the X direction. The shape of the insertion hole 200X is preferably rectangular. The annular rubber band 200 is inserted into the insertion hole 200X

(one-side hole) at one end portion (one-side support structure end portion) of the tag support 122 in the X direction, from the outside toward the inside as viewed from the head HTX of the determination target HT. In addition, the annular rubber band 200 is arranged along the inner surface of the tag support 122. Thereafter, the annular rubber band 200 is passed from the inside toward the outside through the insertion hole 200X (other-side hole) at the other end portion (other-side support structure end portion) of the tag support 122 in the X direction. In this manner, the tag support 122 is mounted on the annular rubber band 200. Therefore, the insertion hole 200X (one-side hole) and the insertion hole 200X (other-side hole) function as a mounting structure. At this time, since the tag support 122 is located outside the annular rubber band 200, the tag support 122 is spaced apart from the head HTX of the determination target HT.

[0108] In addition, due to friction with the annular rubber band 200, both end portions of the tag support 122 in the X direction engage with the annular rubber band 200 at predetermined positions. Here, a position on the annular rubber band 200 that engages with one insertion hole 200X is defined as a one-side engagement position P1, and a position that engages with the other insertion hole 200X is defined as an other-side engagement position P2.

It is preferable that an X-direction distance L3 between the two insertion holes 200X provided in the flat tag support 122 is greater than a distance L4 between the one-side engagement position P1 and the other-side engagement position P2 when the tag support 122 is attached to the head HTX of the determination target HT. As a result, the tag support 122 mounted on the annular rubber band 200 is curved so as to protrude outward (Fig. 20). For this reason, the intermediate portion 122C between the one-side end portion 122L and the other-side end portion 122R of the tag support 122 is spaced further apart from the head HTX of the determination target HT than the one-side end portion 122L or the other-side end portion 122R. That is, the annular rubber band 200 and the insertion hole 200X function as a separation support structure.

[0109] As shown in Fig. 21, a spacer 201, which serves as the tag support structure TSC, may be provided between the tag support 122 and the annular rubber band 200. A top surface 201T of the spacer 201 is fixed to a central portion in the X direction of the bottom surface 122K (the surface on a side opposite to the tag cover 125) of the tag support 122. The spacer 201 is formed in a block shape, and has a through-hole 201X into which the annular rubber band 200 can be inserted. The annular rubber band 200 passes through the insertion hole 200X at one end portion

of the tag support 122 in the X direction, the through-hole 201X of the spacer 201, and then the insertion hole 200X at the other end portion of the tag support 122 in the X direction in this order. As a result, it is possible to prevent the tag support 122 from approaching the head HTX of the determination target HT due to the external force.

[0110] In addition, the spacer 201 arranged between the tag support 122 and the annular rubber band 200 is provided between the IC chip CP built in the RF tag TG and the annular rubber band 200. However, the invention is not limited thereto, and the spacer 201 may be provided at a position avoiding the IC chip CP in a plan view as viewed from the Z direction. In addition, when the spacer 201 is provided at a position overlapping the IC chip CP in a plan view (Fig. 21), a through-hole 201Z extending in the Z direction may be formed in a portion of the spacer 201 between the IC chip CP and the annular rubber band 200. Since the formation of the through-hole creates a gap between the IC chip CP and the annular rubber band 200, induced electromotive force is more likely to be generated in the IC chip CP without being affected by moisture contained in the head or hair or moisture attached thereto. In addition, the spacer 201 having a through-hole formed at such a position also functions as a foreign matter entry prevention member for the through-hole, that is, the gap.

[0111] In the above embodiment, a rectangular tag support 122 is used. However, the invention is not limited thereto, and a cross-shaped tag support may be used as shown in Fig. 22. The cross-shaped tag support 122 shown in Fig. 22 includes an X-direction extending portion 122X extending in the X direction and a Y-direction extending portion 122Y extending in the Y direction, but the RF tag TG may be arranged on the tag support 122 such that its longitudinal direction matches the X direction, or may be arranged on the tag support 122 such that its longitudinal direction matches the Y direction. In addition, instead of the insertion hole 200X (Figs. 18 to 21), an insertion hole 200Y (one-side hole) formed on one side in the Y direction of the Y-direction extending portion 122Y and an insertion hole 200Y (other-side hole) formed on the other side in the Y direction of the Y-direction extending portion 122Y may be provided. The annular rubber band 200 can be inserted into these insertion holes 200Y.

[0112] As a modification example of the RF tag attachment tool 100 shown in Figs. 18 to 21, a tag package 120 (first support structure) shown in Figs. 23A to 23E, an annular rubber band 200, and a support member 110 (second support structure) that supports the tag package 120 may be provided.

[0113] The tag package 120 shown in Figs. 23A to 23E is

formed in a rectangular shape having sides in the longitudinal direction (X direction) and the transverse direction (Y direction) in a plan view seen from the Z direction (Figs. 23A to 23B). In addition, in a front view seen from the Y direction (Fig. 23D), the tag package 120 is formed in an arc shape such that its intermediate portion protrudes upward relative to both end portions thereof.

[0114] The tag package 120 includes the tag support 122 capable of supporting the RF tag TG and the tag cover 125 arranged on the tag support 122 to cover the RF tag TG. The tag support 122 includes a housing space in which the RF tag TG can be housed, and the tag cover 125 can be attached to and detached from the tag support 122 so as to be switchable between an open state in which an opening of the housing space is open to the external space (Fig. 23E) and a closed state retracted from the open state (Fig. 23D).

[0115] The tag support 122 and the tag cover 125 are each formed in a plate shape. Similar to the tag package 120, the tag support 122 and the tag cover 125 are formed in a rectangular shape having sides in the longitudinal direction (X direction) and the transverse direction (Y direction) in a plan view seen from the Z direction (Figs. 23A to 23B), and are formed in an arc shape such that its

intermediate portion protrudes upward relative to both end portions thereof in a front view seen from the Y direction (Figs. 23D to 23E).

[0116] The support member 110 includes a one-side support portion 110L (one-side support structure end portion) provided at the one-side end portion 122L (one-side support structure end portion) of the tag support 122 in the X direction and an other-side support portion 110R (other-side support structure end portion) provided at the other-side end portion 122R (other-side support structure end portion) of the tag support 122 in the X direction. Here, it is preferable that the one-side support portion 110L and the other-side support portion 110R are arranged so as to avoid the chip-vicinity support portion 122CX.

[0117] The one-side support portion 110L includes an upper portion 110LT connected to the one-side end portion 122L of the tag support 122 in the X direction and a lower portion 110LU arranged below the upper portion 110LT. The lower portion 110LU is provided so as to protrude downward relative to the one-side end portion 122L, and is formed with an insertion hole 200X on one side (one-side hole) into which the annular rubber band 200 can be inserted. Similarly, the other-side support portion 110R includes an upper portion 110RT connected to the other-side end portion 122R of the tag support 122 in the X direction and a lower

portion 110RU arranged below the upper portion 110RT. The lower portion 110RU is provided so as to protrude downward relative to the other-side end portion 122R, and is formed with an insertion hole 200X on the other side (other-side hole) into which the annular rubber band 200 can be inserted.

[0118] For this reason, the four tag packages 120 are connected to each other by inserting the annular rubber band 200 into the insertion hole 200X on one side and the insertion hole 200X on the other side that are formed at both end portions of the support member 110 in the X direction. Therefore, the insertion hole 200X on one side (one-side hole) and the insertion hole 200X on the other side (other-side hole) function as a mounting structure. In a state in which the RF tag attachment tool 100 is attached to the head HTX of the determination target HT, the four tag packages 120 are arranged around the head HTX. Then, the chip-vicinity support portion 122CX moves away from the annular rubber band 200 or the head HTX of the determination target HT, and as a result, the gap XX is formed.

[0119] Incidentally, when a short-haired person wears the RF tag attachment tool 100 including the annular rubber band 200, it is possible to wear the RF tag attachment tool 100 in the orientation shown in Fig. 24A. On the other

hand, when a long-haired person wears the annular rubber band 200, due to the presence of hair HT10 tied at the back of the head, it is conceivable to wear the RF tag attachment tool 100 so as to avoid the hair HT10 (Fig. 24B). In this case, the antenna pattern AP (Fig. 3) of the RF tag arranged in front of the determination target HT faces diagonally upward instead of directly in front of the determination target HT. Thus, the attached state of the RF tag attachment tool 100 may depend on the individual circumstances of the determination target HT. Therefore, when there are a plurality of determination targets HT, the orientation of the antenna pattern AP is not uniformly fixed, and as a result, there is a possibility that the quality of communication between the RF tag TG attached to each determination target HT and the receiver RV may decrease.

[0120] Therefore, the RF tag attachment tool may include an antenna adjustment mechanism that can adjust the orientation of the antenna pattern AP.

[0121] The RF tag attachment tool 100 shown in Figs. 25A to 25B includes the tag package 120, the annular rubber band 200 (attachment member) attached to the determination target HT, and an antenna adjustment mechanism 280 (hinge structure).

[0122] The antenna adjustment mechanism 280 is for

attaching the tag package 120 to the annular rubber band 200, and includes a first hinge plate 281 that supports the tag support 122 of the tag package 120, a second hinge plate 282 that is mounted on the annular rubber band 200, and a rotation mechanism 283 that connects the first hinge plate 281 and the second hinge plate 282 to each other. The second hinge plate 282 is provided so as to be attachable to and detachable from the annular rubber band 200 by a button (not shown).

[0123] The rotation mechanism 283 allows the first hinge plate 281 to rotate relative to the second hinge plate 282 around a rotation axis AX extending in the X direction. By making the first hinge plate 281 rotatable relative to the second hinge plate 282, the first hinge plate 281 can be switched between a prone state in which the first hinge plate overlaps the second hinge plate 282 (Fig. 25A) and an upright state in which the first hinge plate stands upright relative to the second hinge plate 282 (Fig. 25B).

[0124] Therefore, even if the attachment position on the determination target HT is not as intended, the orientation of the antenna pattern AP becomes as intended, so that a decrease in the quality of communication with the receiver RV can be suppressed.

[0125] In addition, in the Y direction, when the rotation axis AX is separated from the IC chip by a

predetermined distance CL1, the gap XX can be formed between the IC chip CP and the swimming cap CAP by rotating the first hinge plate 281 relative to the second hinge plate 282.

[0126] Here, as shown in Fig. 24B, when attaching the RF tag attachment tool 100 including the four tag packages 120 and the annular rubber band 200 connecting the tag packages 120 to each other, the first tag package 120 is located at the front portion of the determination target HT, the second tag package 120 is located at the left side portion of the determination target HT, the third tag package 120 is located at the rear portion of the determination target HT, and the fourth tag package 120 is located at the right side portion of the determination target HT. In this manner, when the RF tag attachment tool 100 is attached to the determination target, if the four tag packages 120 are arranged diagonally with respect to the horizontal plane, the orientation of the antenna pattern AP may be appropriately adjusted for each tag package 120.

[0127] Figs. 24C and 24D are cross-sectional views of an arbitrary tag package 120 when viewed from the X direction. In the tag package 120 located on the upper side in the attached state, that is, in the tag package 120 located at the front portion, it is preferable that the upper end APT of the antenna pattern AP of the RF tag TG is spaced

further apart from the head HTX than the lower end APU of the antenna pattern AP of the RF tag TG (Fig. 24C). In addition, in the tag package 120 located on the lower side in the attached state, that is, in the tag package 120 located at the rear portion, it is preferable that the lower end APU of the antenna pattern AP of the RF tag TG is spaced further apart from the head HTX than the upper end APT of the antenna pattern AP of the RF tag TG (Fig. 24D). In adopting such a structure, among a plurality of antenna adjustment mechanisms 280 mounted on each tag package 120, it is preferable that the rotation axis AX of one antenna adjustment mechanism 280 is located on one side in the width direction of the annular rubber band 200 (upward direction in Fig. 24B) and the rotation axis AX of the other antenna adjustment mechanism 280 is located on the other side in the width direction of the annular rubber band 200 (downward direction in Fig. 24B).

[0128] That is, when a portion of the RF tag attachment tool 100 that comes into contact with the head HTX of the determination target HT is defined as a contact surface, it is preferable that the orientation of the antenna pattern AP of the IC chip CP is oblique with respect to the orientation of the contact surface. In this case, as a portion serving as the contact surface, the tag support structure TSC, the attachment member, and the like are

assumed. In the RF tag attachment tool 100 shown in Figs. 24A to 24B, the portion serving as the contact surface may be the lower surface of the tag support 122 (tag support structure TSC) or the inner side surface of the annular rubber band 200 (attachment member).

[0129] In the above embodiment, a hinge structure is used as the antenna adjustment mechanism 280. However, the invention is not limited thereto, as long as the orientation of the antenna pattern AP can be appropriately adjusted with respect to the determination target, the tag support structure TSC, or the attachment member.

[0130] In addition, in the above embodiment, the antenna adjustment mechanism 280 is provided on the annular rubber band 200. However, the invention is not limited thereto, and the antenna adjustment mechanism 280 may be provided on the swimming cap CAP as shown in Fig. 2 or the like. In this case, the first hinge plate provided so as to support the tag support 122 may be provided so as to support the support member 110.

[0131] In the above embodiment, the antenna adjustment mechanism 280 is used to adjust the angle of the antenna pattern AP so that the orientation of the antenna pattern AP is oblique with respect to the orientation of the contact surface. However, the invention is not limited thereto. For example, the tag support structure TSC may be

used in which the orientation of the antenna pattern AP of the IC chip CP is oblique with respect to the orientation of the contact surface.

[0132] When the RF tag attachment tool 100 shown in Figs. 23A to 23E is attached to the head HTX, the contact surface that comes into contact with the head HTX serves as a bottom surface LX of the lower portion 110LU on one side and a bottom surface RX of the lower portion 110RU on the other side in the support member 110 (Figs. 23D to 23E). That is, the orientation D_{AP} of the antenna pattern AP of the IC chip CP is not parallel but oblique with respect to the orientation D_{LX} of the contact surface (Fig. 23F). In addition, in Fig. 23F, an angle θ1 formed by the orientation D_{AP} of the antenna pattern AP and the orientation D_{LX} of the contact surface is, for example, preferably 1° or more and 30° or less, more preferably 3° or more and 25° or less, and particularly preferably 5° or more and 20° or less. Here, the orientation D_{AP} of the antenna pattern AP refers to a direction extending in a direction perpendicular to the antenna pattern AP, and the orientation D_{LX} of the contact surface refers to a direction extending in a direction perpendicular to the contact surface.

[0133] Here, in the tag package 120 located on the upper side in the attached state, that is, in the tag package 120

located at the front portion, it is preferable that the upper end APT of the antenna pattern AP of the RF tag TG is spaced further apart from the head HTX than the lower end APU of the antenna pattern AP of the RF tag TG (Fig. 23G). In addition, in the tag package 120 located on the lower side in the attached state, that is, in the tag package 120 located at the rear portion, it is preferable that the lower end APU of the antenna pattern AP of the RF tag TG is spaced further apart from the head HTX than the upper end APT of the antenna pattern AP of the RF tag TG (Fig. 23H). In adopting such a structure, among a plurality of antenna adjustment mechanisms 280 mounted on each tag package 120, it is preferable that the rotation axis AX of one antenna adjustment mechanism 280 is located on one side in the width direction of the annular rubber band 200 (upward direction in Fig. 23B) and the rotation axis AX of the other antenna adjustment mechanism 280 is located on the other side in the width direction of the annular rubber band 200 (downward direction in Fig. 23B).

[0134] In addition, the tag support structure TSC in which the orientation of the antenna pattern AP of the IC chip CP is oblique with respect to the orientation of the contact surface can also be applied to other embodiments. In addition, instead of using the tag support structure TSC in which the orientation of the antenna pattern AP of the

IC chip CP is oblique with respect to the orientation of the contact surface, a tag support structure TSC may be used in which the orientation of the antenna pattern AP of the IC chip CP is oblique with respect to the orientation of the surface of the determination target.

[0135] In the above RF tag attachment tool 100 (RF tag attachment tool), the antenna adjustment mechanism 280 is used as an antenna adjustment mechanism, but the invention is not limited thereto. Instead of providing the antenna adjustment mechanism, an annular rubber band 210 (first attachment member) and an annular rubber band 220 (second attachment member) may be provided as attachment members (Figs. 26A to 26B).

[0136] The annular rubber band 210 and the annular rubber band 220 each have the same structure as the annular rubber band 200 described above.

[0137] In the annular rubber band 210, the tag packages 120 are aligned at predetermined intervals along the longitudinal direction thereof. By placing the annular rubber band 210 on the head HTX of the determination target HT, a plurality of tag packages 120 are arranged around the head HTX so as to be aligned at predetermined intervals.

[0138] As for the annular rubber band 220, one end portion 220L of the annular rubber band 220 is connected to one position 210L of the annular rubber band 210, and the

other end portion 220R of the annular rubber band 220 is connected to the other position 210R of the annular rubber band 210. Then, in a state in which the annular rubber band 210 is placed on the head HTX, an intermediate portion 210C of the annular rubber band 220 passes through the vicinity of the back of the head of the determination target HT, so that the RF tag attachment tool 100 (RF tag attachment tool) can be attached to the head HTX. Here, by changing the placement state of the annular rubber band 200 so that the orientation of the antenna pattern AP becomes a desired orientation, the orientation of the antenna pattern AP can be set while maintaining the state of attachment to the determination target HT.

[0139] An attachment member including such an annular rubber band 210 and an annular rubber band 220 can be said to have an orientation adjustment function for the determination target so that the orientation of the antenna pattern AP becomes a desired orientation and an attachment function for attaching the antenna pattern AP having the desired orientation to the determination target. Here, the annular rubber band 210 is responsible for the orientation adjustment function, while the annular rubber band 220 is responsible for the attachment function.

[0140] In the above embodiment, the annular rubber band 200 having a rectangular cross-sectional shape is used.

However, the invention is not limited thereto, and its cross-sectional shape may be other shapes such as a circular shape or an elliptical shape. In addition, in the above embodiment, the annular rubber band 200 is used. However, the invention is not limited thereto, and any attachment body that can be attached by coming into direct contact with the determination target HT may be used. In addition, the location where the attachment body is attached may be the arm, wrist, waist, thigh, ankle, and the like, in addition to the head. In addition, it is preferable that the attachment body is formed of an elastic material, like the annular rubber band 200. Therefore, the material for forming the attachment body may be not only a thermosetting elastomer (so-called rubber) but also a thermoplastic elastomer, a synthetic resin having elasticity, a metal, or other elastic materials. In addition, the shape of the attachment body may be a C-shape such as that of a headband as well as an annular shape such as that of the annular rubber band 200, or may be a linear body (such as a belt or a cable tie) including a locking tool capable of forming a closed curve.

[0141] In the above embodiment, the RF tag attachment tool 100 is attached to the head of the determination target HT. However, the invention is not limited thereto, and the RF tag attachment tool 100 may be attached to an

arm, torso, leg, foot, or the like of the determination target HT.

[0142] In the above embodiment, the submersion determination target is a swimmer. However, the invention is not limited thereto, and the determination target may be an RF tag attachment tool. In this case, in the tag DB (Fig. 13(A)), the identifier of the RF tag attachment tool on which the RF tag is mounted may be associated with the identifier of the RF tag. In addition, in the above embodiment, the submersion determination target is a swimmer in a pool. However, the invention is not limited thereto, and the determination target may be a person bathing in a bath at home, in a public bath, a health spa, a care facility, or the like, or may be a user of a water play area at an amusement park or the like. In addition, the submersion determination target is not limited to humans, and may be animals or objects other than living organisms.

[0143] It goes without saying that the invention is not limited to the above-described embodiments and various changes can be made without departing from the scope of the invention.

EXPLANATIONS OF LETTERS OR NUMERALS

[0144] 2 SUBMERSION DETERMINATION SYSTEM

10 SUBMERSION DETERMINATION DEVICE

100 RF TAG ATTACHMENT TOOL

110, 510, 610, 710 SUPPORT MEMBER

110L ONE-SIDE SUPPORT PORTION

110R OTHER-SIDE SUPPORT PORTION

120 TAG PACKAGE

122 TAG SUPPORT

125 TAG COVER

200 ANNULAR RUBBER BAND

200X INSERTION HOLE

200Y INSERTION HOLE

201 SPACER

210 ANNULAR RUBBER BAND

220 ANNULAR RUBBER BAND

280 ANTENNA ADJUSTMENT MECHANISM

AP ANTENNA PATTERN

APT UPPER END

APU LOWER END

CAP SWIMMING CAP

CAP1L ONE-SIDE ENGAGEMENT PORTION

CAP1R OTHER-SIDE ENGAGEMENT PORTION

CP IC CHIP

D_{AP} ORIENTATION

D_{LX} ORIENTATION

HT DETERMINATION TARGET

TSC TAG SUPPORT STRUCTURE

XX: GAP

CLAIMS

[Claim 1]

An RF tag attachment tool for attaching, to a determination target, an RF tag that performs wireless communication in a frequency band in which radio waves do not pass through water, the RF tag attachment tool comprising:

a tag support structure capable of supporting the RF tag; and

a mounting structure for mounting the tag support structure on an attachment member for attachment to the determination target,

wherein a gap is formed between an arrangement position of an IC chip built in the RF tag and the determination target.

[Claim 2]

The RF tag attachment tool according to claim 1,

wherein the tag support structure includes a first support structure for supporting the RF tag and a second support structure for supporting the first support structure, and

when a portion of the first support structure located in a vicinity of the arrangement position of the IC chip is defined as a chip-vicinity support structure portion, the

chip-vicinity support structure portion is spaced apart from the second support structure or the determination target.

[Claim 3]

The RF tag attachment tool according to claim 2,

wherein, assuming that an end portion on one side relative to the chip-vicinity support structure portion is defined as a one-side support structure end portion and an end portion on the other side relative to the chip-vicinity support structure portion is defined as an other-side support structure end portion when the first support structure is viewed from a predetermined direction, the chip-vicinity support structure portion is spaced further apart from the second support structure or the determination target than the one-side support structure end portion and the other-side support structure end portion.

[Claim 4]

The RF tag attachment tool according to claim 3,

wherein the one-side support structure end portion engages with a one-side engagement portion of the second support structure,

the other-side support structure end portion engages

with an other-side engagement portion of the second support structure, and

a length between the one-side engagement portion and the other-side engagement portion is shorter than a length between the one-side support structure end portion and the other-side support structure end portion.

[Claim 5]

The RF tag attachment tool according to claim 4,

wherein the one-side support structure end portion and the one-side engagement portion are attachable to and detachable from each other by a one-side button mechanism, and

the other-side support structure end portion and the other-side engagement portion are attachable to and detachable from each other by an other-side button mechanism.

[Claim 6]

The RF tag attachment tool according to claim 1, further comprising:

an attachment member that supports the tag support structure and is attached to the determination target,

wherein, assuming that a portion of the tag support structure located in a vicinity of the arrangement position

of the IC chip is defined as a chip-vicinity support structure portion, when the attachment member is attached to the determination target, the chip-vicinity support structure portion is spaced apart from the attachment member or the determination target.

[Claim 7]

The RF tag attachment tool according to claim 6,

wherein, assuming that an end portion on one side relative to the chip-vicinity support structure portion is defined as a one-side support structure end portion and an end portion on the other side relative to the chip-vicinity support structure portion is defined as an other-side support structure end portion when the tag support structure is viewed from a predetermined direction, the one-side support structure end portion engages with a one-side engagement portion of the attachment member,

the other-side support structure end portion engages with an other-side engagement portion of the attachment member, and

a length between the one-side engagement portion and the other-side engagement portion is shorter than a length between the one-side support structure end portion and the other-side support structure end portion.

[Claim 8]

The RF tag attachment tool according to claim 7,

wherein the attachment member is formed in an elongated shape,

a one-side hole into which the attachment member is insertable is formed in the one-side support structure end portion,

an other-side hole into which the attachment member is insertable is formed in the other-side support structure end portion, and

when a position of the attachment member where the one-side hole engages with the attachment member is defined as a one-side engagement position and a position of the attachment member where the other-side hole engages with the attachment member is defined as an other-side engagement position, a length between the one-side engagement position and the other-side engagement position is shorter than a length between the one-side hole and the other-side hole.

[Claim 9]

The RF tag attachment tool according to claim 7 or 8, further comprising:

a spacer arranged between the tag support structure and the attachment member,

wherein the attachment member engages with the one-side support structure end portion, the other-side support structure end portion, and the spacer.

[Claim 10]

The RF tag attachment tool according to any one of claims 1 to 9,

wherein, when a portion of the tag support structure located in a vicinity of the arrangement position of the IC chip is defined as a chip-vicinity support structure portion, the gap is formed in the chip-vicinity support structure portion of the tag support structure.

[Claim 11]

The RF tag attachment tool according to any one of claims 1 to 9,

wherein, when a portion of the tag support structure located in a vicinity of the arrangement position of the IC chip is defined as a chip-vicinity support structure portion, the gap is formed by arranging the tag support structure so as to avoid the chip-vicinity support structure portion.

[Claim 12]

The RF tag attachment tool according to any one of

claims 1 to 11, further comprising:

the RF tag supported by the tag support structure.

[Claim 13]

The RF tag attachment tool according to any one of claims 1 to 12, when a portion to be brought into contact with the determination target is defined as a contact surface, an orientation of an antenna pattern of the IC chip is oblique with respect to an orientation of the contact surface.

[Claim 14]

The RF tag attachment tool according to any one of claims 1 to 13,

wherein at least one of following conditions is satisfied:

in a first RF tag located upward in an attached state in which the attachment member is attached to the determination target, an upper end of the antenna pattern of the first RF tag is spaced further apart from the contact surface than a lower end of the antenna pattern of the first RF tag; and

in a second RF tag located downward in the attached state, a lower end of the antenna pattern of the second RF tag is spaced further apart from the contact surface than

an upper end of the antenna pattern of the second RF tag.

[Claim 15]

The RF tag attachment tool according to any one of claims 1 to 14, further comprising:

a hinge structure provided on the tag support structure or the attachment member,

wherein the hinge structure is switchable between a first state in which the antenna pattern faces in a first direction and a second state in which the antenna pattern faces in a second direction different from the first direction.

[Claim 16]

The RF tag attachment tool according to any one of claims 1 to 15,

wherein the attachment member includes a first attachment member on which the tag support structure is mounted and a second attachment member connected to the first attachment member, and

a plurality of the tag support structures are aligned around the determination target by the first attachment member.

[Claim 17]

The RF tag attachment tool according to any one of claims 1 to 16,

wherein the attachment member is attachable to a head of the determination target.

[Claim 18]

A submersion determination program causing a computer to execute:

a signal output step of outputting a predetermined signal to the RF tag attached to the determination target by the RF tag attachment tool according to claim 12;

a response signal reception step of receiving a response signal from the RF tag with respect to the predetermined signal;

a response signal storage step of storing the response signal in a storage device;

a communication state determination step of reading a log of the response signal stored in the storage device and determining whether a status is a communication state in which the response signal from the RF tag is detected under predetermined conditions or a non-communication state in which the response signal from the RF tag is not detected under the predetermined conditions; and

a submersion state determination step of determining that the determination target is submerged when the non-

communication state continues for a predetermined period.

[Claim 19]

A submersion determination program causing a computer to execute:

a signal output step of outputting a predetermined signal to an RF tag attached to a determination target by an RF tag attachment tool;

a response signal reception step of receiving a response signal from the RF tag with respect to the predetermined signal;

a response signal storage step of storing the response signal in a storage device;

a communication state determination step of reading a log of the response signal stored in the storage device and determining whether a status is a communication state in which the response signal from the RF tag is detected under predetermined conditions or a non-communication state in which the response signal from the RF tag is not detected under the predetermined conditions; and

a submersion state determination step of determining that the determination target is submerged when the non-communication state continues for a predetermined period.

[Claim 20]

The submersion determination program according to claim 18 or 19,

wherein a plurality of the RF tags are mounted on the determination target by the RF tag attachment tool,

the storage device is capable of storing an identifier of the RF tag and an identifier of the RF tag attachment tool or the determination target in association with each other,

in the communication state determination step, it is determined whether each of the plurality of RF tags is in the communication state or in the non-communication state, and

in the submersion state determination step, when it is determined that all of the RF tags associated with the identifier of the RF tag attachment tool or the determination target are in the non-communication state, it is determined that the determination target is submerged, while when it is determined that at least one or more of the RF tags associated with the identifier of the RF tag attachment tool or the determination target are in the communication state, it is determined that the determination target is not submerged.

[Claim 21]

The submersion determination program according to

claim 20,

wherein, in the submersion state determination step, when it is determined that all of the RF tags associated with the identifier of the RF tag attachment tool or the determination target are in the non-communication state for a first period, it is determined that the RF tag attachment tool or the determination target is in a submersion state, and when it is determined that, for an identifier of the RF tag attachment tool or the determination target determined to be submerged, at least one or more of the RF tags associated with the identifier are in the communication state for a second period, it is determined that the RF tag attachment tool or the determination target has recovered from submersion, and

the second period is shorter than the first period.

[Claim 22]

The submersion determination program according to any one of claims 18 to 21, causing the computer to further execute:

a final survival tag extraction step of, when the RF tag attachment tool or the determination target is determined to be in the submersion state, extracting the RF tag that has entered the non-communication state last among the RF tags associated with the identifier of the RF tag

attachment tool or the determination target;

a final communication antenna extraction step of extracting the antenna that has last detected the response signal from the RF tag extracted in the final survival tag detection step; and

a submersion occurrence location determination step of determining a candidate for a submersion occurrence location based on an installation location of the antenna extracted in the final communication antenna extraction step.

[Claim 23]

The submersion determination program according to any one of claims 18 to 22, causing the computer to further execute:

a partial submersion step of submerging a predetermined portion of the determination target to which the RF tag attachment tool is attached; and

an attachment position registration step of storing the predetermined portion as an installation location of the RF tag on the determination target in association with an identifier of the RF tag determined to be submerged in the submersion state determination step.

[Claim 24]

The submersion determination program according to any one of claims 18 to 23, causing the computer to further execute:

a partial submersion step of submerging a predetermined portion of determination target to which the RF tag attachment tool is attached;

an attachment position determination step of reading, from the storage device, an identifier of the RF tag determined to be submerged in the submersion state determination step and reading the installation location of the RF tag on the determination target associated with the identifier of the RF tag and of determining whether or not the predetermined portion in the partial submersion step matches the installation location of the RF tag; and

an attachment position determination result output step of outputting a determination result in the attachment position determination step.

[Claim 25]

A submersion determination device, comprising:

a wireless communication control device that performs wireless communication with an RF tag; and

a storage device,

wherein the wireless communication control device includes:

a signal output unit that outputs a predetermined signal to the RF tag;

a response signal reception unit that receives a response signal from the RF tag with respect to the predetermined signal;

a communication state determination unit that determines whether a status is a communication state in which the response signal from the RF tag is detected under predetermined conditions or a non-communication state in which the response signal from the RF tag is not detected under the predetermined conditions;

a submersion determination unit that determines that the determination target is submerged when the non-communication state continues for a predetermined period; and

an alarm output unit that outputs an alarm when it is determined that the determination target is submerged.

[Claim 26]

A submersion determination system, comprising:

the RF tag attachment tool according to any one of claims 1 to 17;

the submersion determination device according to claim 25; and

an antenna that enables wireless communication between

the RF tag attachment tool and the submersion determination device.