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(54) Title: MOTORIZED DEVICE EQUIPPED WITH SENSORS FOR COVERED GROUND PRODUCTION SYSTEMS

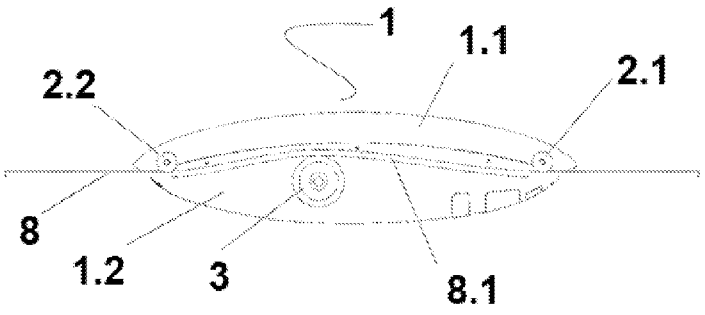

Fig 2

(57) Abstract: The subject matter of this patent application pertains to a device equipped with sensors and motorization for the collection of data, images, or other information in covered ground production systems. Specifically, the subject of this patent application is a device containing a series of sensors, positioned a few meters above the ground, suitable for adapting to any type of crop under cover.

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Title: Motorized device equipped with sensors for covered ground production systems

DESCRIPTION

The subject matter of this patent application pertains to a device equipped with sensors and motorization for the collection of data, images, or other information in covered ground production systems.

Specifically, the subject of this patent application is a device containing a series of sensors, positioned a few meters above the ground, suitable for adapting to any type of crop under cover.

Scope of Application

The subject matter of this patent application finds application in the field of device production.

As is known, the agricultural sector continues to play a significant role in our country's economy, thanks to its strong territorial diversification and the wide variety and quality of productions. Over the last century, agriculture has had to adapt to the increasing market demand, driven by population growth and the improved living standards of a portion of the world's population. In response to this exponential growth, farmers worldwide have devised increasingly sophisticated methods over the years to enhance soil productivity and expand cultivated areas. According to the American Geophysical Union (AGU), by 2050, farmers will be required to double production capacity to meet demand. However, this demand must be reconciled with the current population's preference for consuming foods derived from pesticide-free and/or herbicide-free crops.

To overcome the challenges posed by population growth, the accelerating urbanization that results in reduced manpower in rural areas, the high competitiveness of high-quality products, and the vulnerability of human labor to health risks, scientific advances in various fields are transforming the way agricultural activities are managed, making facilities more efficient and

productive. In particular, technological developments in the reference sector aim to achieve better utilization of soil and water, reduce environmental impact significantly by cutting greenhouse gas emissions, and increase the production of renewable energy to promote its consumption.

In recent times, it has become increasingly necessary to implement solutions that allow for the development of renewable energy by utilizing agricultural lands for energy production without compromising agricultural activities.

State of the Art

The term "agrovoltaic" or "agro-photovoltaic" refers to the combination of the agricultural and photovoltaic sectors. Agrovoltaic involves the production of renewable energy through solar panels without compromising agricultural and/or livestock activities. Simultaneously, the presence of solar panels covering the ground allows for an increase in agricultural yield through shading caused by the panels themselves.

An additional solution is the implementation of agroforestry projects, which involve the heterogeneous combination of trees, shrubs, crops, and livestock. This represents an ecological alternative to monoculture agriculture and ensures greater CO2 absorption.

However, the need to achieve low environmental impact energy production, increase agricultural production without pesticides and/or herbicides, and counteract ongoing climate change poses a series of technological limitations. These limitations are primarily due to the fact that the soil may be covered throughout the year – without bare soil - the land will be covered with solar panels or mixed trees and the need to cover the crops with hail protection elements will arise, crops with protection elements against hail, such as nets, awnings, or similar, and with thermal blankets to combat spring frosts.

Conventionally, indeed, the practice of using monitoring devices for the conditions of the crop or livestock process is well-

known. These devices are typically sensors equipped with suitable algorithms for on-site parameter detection. These parameters are then compared with satellite-detected data, and subsequent laboratory analysis provides useful information for the farmer.

Conventionally, the monitoring activity supporting farmers is carried out through a Decision Support System (DSS), specifically designed for the agricultural sector and integrated with collected satellite data.

The conditions resulting from ground coverings such as trees, panels, or anti-hail and anti-freeze structures do not allow direct access to the soil for satellite data acquisition. For example, in the case of table grape cultivation, a fruit typically produced using production systems covered with plastic sheets to limit moisture dispersion and protect plants from pests and adverse weather conditions, the described monitoring systems, i.e., those integrating satellite data, are not feasible.

The document IN202211071339 (Holder: Lovely Professional University) describes the implementation of a system comprising a suspended cable housed inside a greenhouse and a sensor slidably associated with said suspended cable. This sensor is capable of acquiring data within the greenhouse. The purpose of the invention described in the aforementioned document is to replace manual data collection by operators with a sensor that can traverse the space inside a greenhouse.

The aforementioned document does not explicitly specify additional characteristics of the sensor, particularly regarding the modes of movement along the suspended cable. Additionally, information is lacking concerning the implementation methods by which data collected by the sensor can be integrated with satellite-acquired data.

In the state of the art, devices appropriately designed to be slidably associated with one or more cables are known.

For instance, the document US9154673 describes a camera transport device along a suspension line. It includes a carriage module, a motorized transport module, a pan/tilt module comprising a pan group and a tilt group, and at least one gear train configured to drive the rotation of the pan group and the pivot of the tilt group. In some additional examples, the camera transport device selectively includes either an open configuration carriage or a closed configuration carriage to engage with the suspension line.

The document NO345714 describes the creation of a device for monitoring power lines. The device is externally equipped with rotating means to allow it to be hung on an electrical network cable and then slid along it.

The document CN212363276 details the creation of a device slidably associated with at least three suspended cables inside a greenhouse. The device is substantially composed of a frame to which means for sliding and means for detecting environmental parameters inside the greenhouse are associated.

However, the solutions known in the state of the art, partially expressed in the aforementioned documents, do not allow for the creation of a device for monitoring environmental conditions in agricultural cultivation contexts that enables both the functionality of sliding along a cable and simultaneously preserves the means of monitoring, sliding, and data collection from alterations resulting from the environmental conditions themselves.

The purpose of the invention described in this patent application is therefore to create a device that enables monitoring of environmental conditions in agricultural cultivation contexts, overcoming the disadvantages of the described prior art.

In particular, the purpose of the invention described in this patent application is to create a device that allows for data detection with direct access to the soil for their acquisition,

even in contexts such as, for example but not limited to, crops equipped with coverings, and the integration of said data with satellite data.

These and additional purposes will be achieved by the device as claimed and described below.

Description of the Figures

The device subject to this patent application is depicted, for illustrative purposes and not limited to, in the attached Figures, where:

Fig 1 – exploded view of the device subject to this patent application;

Fig 2 – side view of the device subject to this patent application;

Fig 3 – view of the inner surface of the lower end of the device subject to this patent application;

Fig 4 – view of the outer surface of the lower end of the device subject to this patent application;

Fig 5 – detailed view of the device subject to this patent application.

Detailed Description

With reference to Figures 1, 2, 4, 5, the device subject to this patent application is indicated by the number (1).

Referring to Fig 1, the device (1) subject to this patent application consists of a box-shaped body comprising an upper shell (1.1) and a lower shell (1.2). The upper shell (1.1) is reversibly associated with the lower shell (1.2) through generic association devices, for example, but not limited to, association devices of the screw type.

The device (1) subject to this patent application includes at least two small wheels (2.1, 2.2) inside it, said at least two small wheels (2.1, 2.2) being of the wheeled type with an axle, and at least one central wheel (3). The central wheel (3) is associated with an electric motor (4).

In a preferred, but not exclusive, embodiment, the integral housing of the central wheel (3) with the electric motor (4) to the lower shell (1.2) of the device (1) is achieved through a bracket body (5.1, 5.2).

Referring to Fig 3 and Fig 4, according to the invention described in this patent application, the lower shell (2.1) internally accommodates at least one sensor (1.2.6, Fig 4). This at least one sensor (1.2.6) is preferably, but not exclusively, at least one of humidity sensor, temperature sensor, NIR sensor for calculating plant vegetation indices, IR sensor for night vision. It also houses at least one hyperspectral camera (1.1.2), at least one printed circuit board (1.2.2) with memory for managing acquired data, the motor (4), at least two electric power devices (1.2.3), preferably but not exclusively of the battery type, at least two charging pins (1.2.4), a housing for accommodating a dispenser device (6), and at least one GNSS antenna (1.2.5).

With reference to Fig 4, the external lower surface of the lower shell (1.2) includes a pass-through opening to which a transparent covering element (7) is associated. This pass-through opening is positioned corresponding to at least one sensor (1.2.6) and at least one hyperspectral camera (1.1.2).

In a preferred but not exclusive embodiment, the covering (7) is made of plastic material.

Referring to Fig 1 and Fig 2, according to the invention described in this patent application, the at least one first small wheel (2.1) and the at least one second small wheel (2.2) are positioned at the lateral ends of the upper and lower shells (1.1, 1.2).

In particular, and with reference to Fig 2, the at least one first small wheel (2.1) and the at least one second small wheel (2.2) are interposed between the upper shell (1.1) and the lower shell (1.2) of the device (1).

With reference to Figures 2, 3, 4, and 5, a portion (8.1) of the at least one cable (8) is contained within the device (1). This at least one cable (8) is slidably inserted into the device (1) through pass-through openings (10, Fig 3) obtained at the lateral ends of the lower shell (1.2) or the upper shell (1.1) or on both shells (1.1, 1.2).

In particular, the portion (8.1) of at least one cable (8) is slidably associated with at least one first small wheel (2.1), the central wheel (3), and at least one second small wheel (2.2).

In a preferred but not exclusive embodiment, at least one cable (8) is made of metal.

As previously stated, the portion (8.1) of at least one cable (8) is placed under mechanical tension inside the device (1).

In a preferred embodiment, the tension of the portion (8.1) of at least one cable (8) is achieved by associating the free lateral ends of at least one cable (8) with at least one rigid element anchored to the ground.

In a preferred embodiment, preferred but not exclusive embodiment,, at least one rigid element anchored to the ground is part of the elements constituting the tensile flat cable tensile structure consisting of poles, cables, and nets. This tensile structure is parallel to the ground plane on which it is built and is typically used in the cultivation of table grapes.

Regardless of the preferred embodiments mentioned above, as previously described, the device (1) slides along at least one cable (8) through the action of the motor (4) on the central wheel (3) to which the portion (8.1) of at least one cable (8) is associated.

In a preferred embodiment, preferred but not exclusive embodiment, the motor (4) is a 6V DC electric motor capable of allowing linear sliding movement.

In a preferred embodiment, preferred but not exclusive embodiment, at least one first small wheel (2.1) and at least

one second small wheel (2.2) have a concave profile, allowing the central maintenance of the portion (8.1) of at least one cable (8) during the sliding phase.

In a preferred but not exclusive embodiment, the central wheel (3) is made of rubber.

In a further preferred embodiment, preferred but not exclusive embodiment, the central wheel (3) and the motor (4) are associated with a bracket assembly (5.1, 5.2) where the lower portion (5.2) includes elastic elements such as springs (not visible in the attached figures). This allows the force of the tension in the portion (8.1) of at least one cable (8) to be distributed onto the elastic elements rather than on the structure of the lower shell (1.2), relieving the tension on the springs and not on the shell.

As previously explained and referring to Fig 5, the central wheel (3), due to the presence of the elastic elements, exerts a force (f1) on the cable portion (8.1). This force is in the opposite direction to the force (f2) exerted by at least one first small wheel (2.1) and at least one second small wheel (2.2) on the cable portion (8.1), ensuring a stable grip between the central wheel (3) and the cable portion (8.1).

As previously explained, given the elements central wheel (3), motor (4), and any elastic elements positioned inside the lower shell (1.1), the weight of the device (1) is substantially concentrated in the lower portion, thus preventing its overturning during the sliding phase or rotation around the axis of the at least one cable (8).

With reference to the above, within the monitoring site, the device (1) is associated with at least one cable (8). The movement of the device (1) within the site is achieved by sliding the device (1) along the cable (8).

Through generic sensing devices housed internally in the device (1), it is possible to collect necessary data such as, for example but not limited to, temperature, internal humidity, data

for calculating the plant's Vegetation Index (NDVI) and Crop Water Stress Index (CWSI), image acquisition. These data are subsequently sent and analyzed by the Decision Support System (DSS).

In a preferred but not exclusive embodiment, the presence of cameras installed on the sensors allows for fruit scanning and comparison between the acquired images and an image database containing pictures of agricultural products affected by diseases or attacked by pests, enabling the identification or spread of specific pests or diseases. Additionally, prediction algorithms can calculate the final yield of the production system, providing a concrete contractual advantage at the time of product sale.

The additional acquisition of satellite data, in addition to on-site data, is enabled by at least one first GNSS antenna (1.2.5) housed in the lower shell (1.2) and at least one second GNSS antenna housed in the upper shell (1.1). These first (1.2.5) and second GNSS antennas are installed in a mirror configuration, with one directed upwards for direct signals and one downwards for reflected signals. This particular technique allows obtaining data in uncovered points of the production system.

According to the description provided earlier, the device (1) subject to this patent application utilizes the Global Navigation Satellite System Reflectometry (GNSS-R) to study the soil surface and vegetation cover. Specifically, thanks to the acquired data, it is possible to indirectly measure the soil moisture content, Leaf Area Index (LAI), and total nitrogen concentration (NTC). These data are integrated with those acquired by the hyperspectral camera installed in the lower part of device. The hyperspectral camera will analyze the amount of organic carbon in the soil (SOM - Soil Organic Matter).

In a preferred, but not exclusive, embodiment, the device (1) created as described includes a dispenser device (6) designed for the dissemination of elements for plant treatment.

Specifically, the dispenser (6) is reversibly associated with the lower shell's body (1.2) to allow for easy removal, replacement, or reloading without having to disassociate the device (1) from at least one cable (8).

It is indeed known that grape cultivation in covered systems is susceptible to diseases and the constant presence of grapevine moths or Lobesia botrana. Through the dispenser (6) housed on the device's (1) body, the dispersion of pheromones is possible, helping to limit damage. According to the subject matter of this patent application, it is thus possible to uniformly spread the treatment substance throughout the entire system.

Moreover, due to the presence of infrared cameras and sensors, the device (1) can also perform a night surveillance function by sending a signal and a communication in case of perimeter violation. Thanks to infrared cameras positioned opposite to the clusters, the device (1) described in this patent application can analyze the captured images using an on-board Computer Vision algorithm, said algorithm being explicitly excluded from this patent application.

The aforementioned implementation thus allows the device (1) subject to the patent application to function as an alarm system that limits or completely prevents unauthorized intrusion.

As previously explained, the use of the device (1) constructed as described enables the improvement of economic crop management, water resource management, optimization and reduction of pesticide use, assessment of an estimated field yield, and recording of all operations performed in the field to comply with quality control protocols, all within covered production systems not reachable by satellite data.

CLAIMS

1. A sensorized device said device being used in covered terrain comprising an electric motor (4) and at least one sensor for detecting images and parameters, said device (1) comprising means for sliding along a cable (8), said cable (8) being positioned above at least a portion of the soil, said device (1) comprising a hollow box body consisting of an upper shell (1.1) and a lower shell (1.2) said upper schell (1.1) being reversibly associated with the lower shell (1.2) and at least one first wheel (2.1) and at least one second wheel (2.2), at least one central wheel (3), said central wheel (3) being associated with the electric motor (4), the upper body (1.2) housing ad least one GNSS antenna and one first wheel (2.1) is positioned at the lateral end of the upper and lower shells (1.1,1.2) and the second wheel (2.2) is positioned at the opposite lateral end of the upper and lower shells (1.1,1.2) said device characterized in that:
the at least one first wheel (2.1) and the at least one second wheel (2.2) are contained in the the hollow box body,
the at least one central wheel (3) is associated with the lower shell (1.2) of the device (1) by a bracket body (5.1.5. 2),
the cable (8) is slidably inserted in the device (1) by means of through openings (10) made at the lateral ends of the lower shell (1.2) or of the upper shell (1.1) or on both the shells (1.1.1. 2),
the lower shell (2.1) internally houses at least one sensor (1.2.6), at least one hyperspectral chamber (1.1.2), at least one printed circuit (1.2.2) with memory for the management of the data acquired, the electric motor (4), at least two electrical power devices (1.2.3), at least two refill pins (1.2.4), a seat for housing a dispenser device (6).

2. Device as per claim 1 characterized in that the at least one sensor (1.2.6) is at least one of a humidity sensor,

temperature sensor, NIR sensor for calculating the plant vegetation indexes, IR sensor for night vision.

3. Device as per claim 1 characterized in that the at least two electrical power supply devices (1.2.3) are alkaline batteries.

4. Device as claimed in the preceding claims, characterized in that the outer lower surface of the lower shell (1.2) comprises a through opening with which a transparent cover element (7) is associated, said through opening being positioned at the at least one sensor (1.2.6) and at least one hyperspectral chamber (1.1.2).

5. Device according to the preceding claims, characterized in that the portion (8.1) of the cable (8) is slidably associated with the at least one first wheel (1.2), to the central wheel (3) and to the at least one second wheel (1.2).

6. Device according to the preceding claims, characterized in that the device (1) slides along the cable (8) by means of the action of the motor (4) on the central wheel (3) to which the portion (8.1) of the cable (8) is associated.

7. Device according to the preceding claims, characterized in that the at least one first wheel (2.1) and the at least one second wheel (2.2) both they have concave profile allowing the central maintaining of the portion (8.1) of the cable (8) during the device (1) sliding movement.

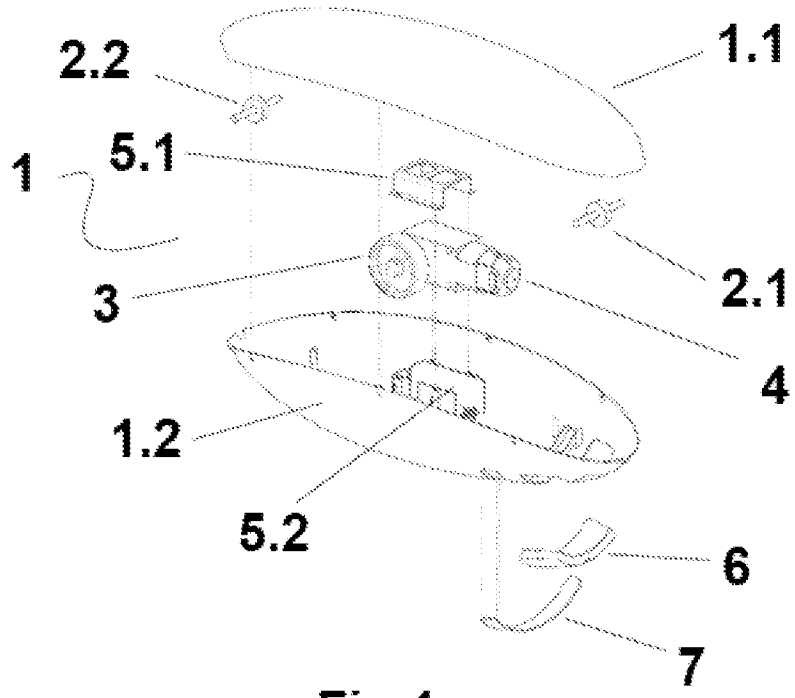

Fig 1

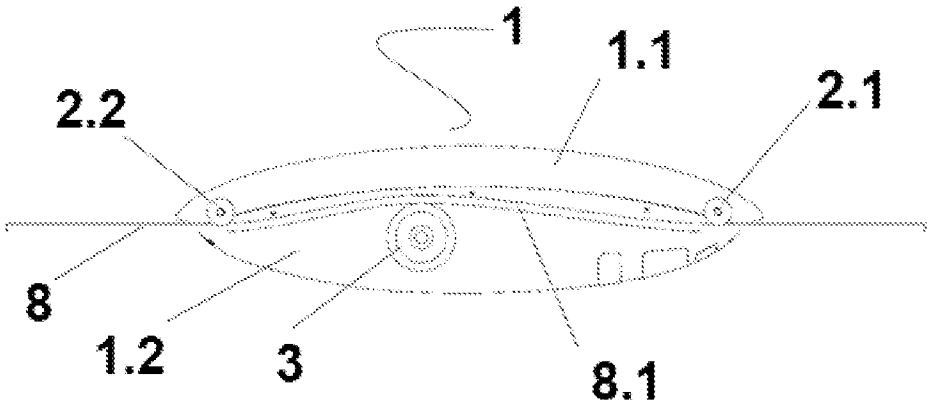

Fig 2

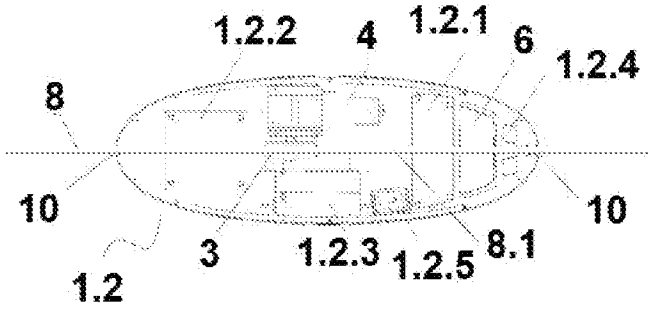

Fig 3

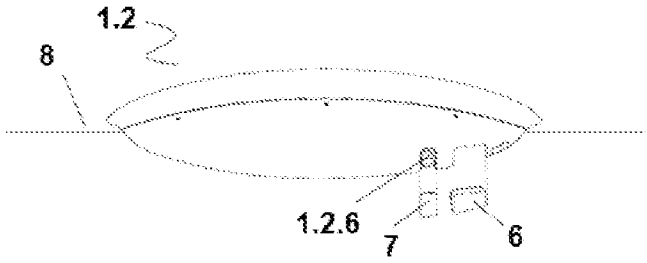

Fig 4

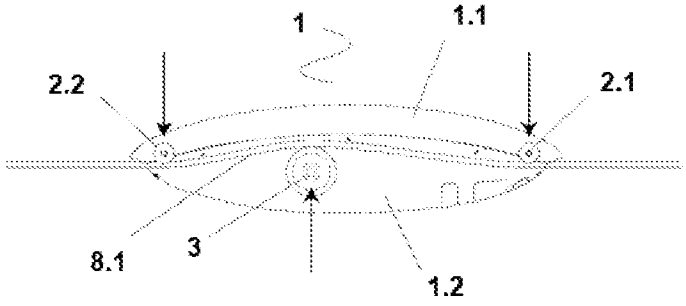

Fig 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2024/050025

A. CLASSIFICATION OF SUBJECT MATTER
INV. A01G25/16 A01B79/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A01G A01B A01D G01V G01T

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 9 154 673 B2 (STONE KENNETH [US]) 6 October 2015 (2015-10-06) cited in the application column 3, line 43 - column 14, line 8; figures 1-19C	1-7
A	NO 345 714 B1 (COMROD AS [NO]) 28 June 2021 (2021-06-28) cited in the application page 11, line 9 - page 21, line 11; figures 1-17	1-7
A	CN 212 363 276 U (ORDOS CITY MENGKANGYUAN BIOTECHNOLOGY RES CO LTD) 15 January 2021 (2021-01-15) cited in the application the whole document	1-7

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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

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Date of the actual completion of the international search	Date of mailing of the international search report
13 June 2024	27/06/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Vehrer, Zsolt

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IT2024/050025

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 9154673 B2	06-10-2015	NONE	
NO 345714 B1	28-06-2021	AU 2020391306 A1	26-05-2022
		CA 3157253 A1	03-06-2021
		EP 4066337 A1	05-10-2022
		NO 20191411 A1	28-05-2021
		US 2022385047 A1	01-12-2022
		WO 2021107784 A1	03-06-2021
CN 212363276 U	15-01-2021	NONE	