FORM 2

THE PATENTS ACT, 1970
(39 of 1970)

COMPLETE SPECIFICATION
(See section 10 and rule 13)

1. TITLE OF THE INVENTION

AN AUTONOMOUS SMART NAVIGATIONAL MEDICAL ROBOTIC ECOSYSTEM AND METHOD THEREOF

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3. PREAMBLE TO THE DESCRIPTION

The following specification particularly describes the invention and the manner in which it is to be performed

AN AUTONOMOUS SMART NAVIGATIONAL MEDICAL ROBOTIC ECOSYSTEM AND METHOD THEREOF

FIELD OF INVENTION

The present invention relates to the field of autonomous diagnosis systems, particularly relating to a completely autonomous medical robotic ecosystem capable of medical diagnosis, assessment, health monitoring, and telemedicine. The present invention provides an autonomous smart navigational medical robotic ecosystem that assists people dwelling in rural areas where medical infrastructure is under-developed or is hard to reach.

BACKGROUND OF THE INVENTION

Robotic technology and artificial intelligence are being applied in various ways in the medical field, from medical imaging to surgery, and diagnostics to drug delivery, thereby transforming the healthcare sector. Robots are increasingly being used in telemedicine to provide remote healthcare services to patients in various ways, including enabling healthcare providers to connect remotely with patients, providing virtual consultations and diagnoses, performing medical tests and collection of biological samples from patients, and monitoring the health of patients.

US patent application no. US202117177701A discloses a robot for assisting clinical staff in taking vitals of a patient, the robot comprising a body, a wheelbase supporting the body and allowing the robot to move around, a central processing unit housed in the body and operably connected to the wheelbase, and a plurality of diagnostic devices such as a blood pressure measuring unit, a pulse oximeter, an infrared thermometer, among others, coupled to the body to measure patient vitals and operably connected to the central processing unit. However, the robot disclosed in the cited patent application suffers various technical disadvantages such as (i) it is not fully autonomous and can only be used to assist clinical staff, (ii) cannot work outdoors, and (iii) needs a connection to an electronic system.

Patent document CN202210488310A discloses a medical robot system for health detection comprising a smart medicine box, a blood pressure monitor, a temperature gun, an oximeter, a three-in-one detector, a medical robot, a cloud server, multiple PC terminals and multiple mobile phone terminals. The invention disclosed by the patent document aims to realise intelligent inquiry and diagnosis of personal diseases by providing a simpler and quicker to use system which is intelligent and efficient, improves medical quality, optimises treatment process, reduces medical cost, is higher in interaction performance and has expandability. However, the said robotic system is designed to be stationary and has been aimed to be applicable only in urban areas, mandatorily needing Wi-Fi connection and phone/computer to work.

Patent document EP89304779A discloses an interactive patient assistance system that includes a speech synthesiser and recognition unit coupled to a programmed computer, and a diagnostic testing equipment coupled to the computer along with medication dispensing equipment. The said system is also stationary and only assists a patient in an indoor environment i.e., at home or in a clinic.

The above cited prior art documents, individually and collectively, suffer from various technical disadvantages including not being fully autonomous, lacking in smart navigational capabilities, ability to collect patient vitals but inability to track the vitals over long periods of time continuously, and incapability for use in rural areas with under-developed medical and electronic infrastructure. Therefore, there is a need in the art to provide a completely autonomous medical robotic ecosystem capable of smart navigation which can be used in rural areas where medical infrastructure is under-developed or is hard to reach.

OBJECTIVES OF THE INVENTION

The primary objective of the present invention is to provide a completely autonomous medical robotic ecosystem capable of smart navigation which can be used in rural areas where medical infrastructure is under-developed or is hard to reach.

Another objective of the present invention is to provide a completely autonomous medical robotic ecosystem capable of smart navigation which is completely self-sufficient and needs no additional setting up requirements.

Yet another objective of the present invention is to provide a completely autonomous medical robotic ecosystem capable of smart navigation, with the ability to keep track of the health status of an entire village / rural area and offer medical help to those in need and have negligible access to medical healthcare.

Yet another objective of the present invention is to provide a completely autonomous medical robotic ecosystem capable of supporting preventive healthcare by regularly monitoring health metrics and providing early warnings for potential health risks, thereby aiding in early disease detection including lifestyle related health issues, and prevention through continuous health monitoring and advanced diagnostic tools.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 represents the back view of the robot (1) of the autonomous smart navigational medical robotic ecosystem provided by the present invention, after it is semi-expanded.

Figure 2 represents the back view of the robot (1) of the autonomous smart navigational medical robotic ecosystem provided by the present invention.

Figure 3 represents the bottom view of the robot (1) of the autonomous smart navigational medical robotic ecosystem provided by the present invention.

Figure 4 represents the front view of the robot (1) of the autonomous smart navigational medical robotic ecosystem provided by the present invention.

Figure 5 represents the left view of the robot (1) of the autonomous smart navigational medical robotic ecosystem provided by the present invention, after it is fully expanded.

Figure 6 represents the top right view of the specimen storage space (35) of the robot (1) of the autonomous smart navigational medical robotic ecosystem provided by the present invention, when it is opened.

Figure 7 represents the right view of the front side of the robot (1) of the autonomous smart navigational medical robotic ecosystem provided by the present invention.

Figure 8 represents the side transparent view of the smart base (23) of the robot (1) of the autonomous smart navigational medical robotic ecosystem provided by the present invention.

Figure 9 represents the side view of the robot (1) of the autonomous smart navigational medical robotic ecosystem provided by the present invention when it is in contact with its smart base (23).

Figure 10 represents the top left view of the specimen storage space (35) of the robot (1) of the autonomous smart navigational medical robotic ecosystem provided by the present invention, when it is closed.

Figure 11 represents the top view of the specimen storage space (35) of the robot (1) of the autonomous smart navigational medical robotic ecosystem provided by the present invention, when it is opened.

Figure 12 represents the top view of the robot (1) of the autonomous smart navigational medical robotic ecosystem provided by the present invention, when it is in contact with its smart base (23).

Figure 13 represents the top view of the smart base (23) of the robot (1) of the autonomous smart navigational medical robotic ecosystem provided by the present invention.

Figure 14 represents the transparent view of the initial stage of the robot (1) of the autonomous smart navigational medical robotic ecosystem provided by the present invention and its smart base (23) when they are exchanging items.

Figure 15 represents the transparent view of the robot (1) of the autonomous smart navigational medical robotic ecosystem provided by the present invention and its smart base (23) when it's in the process of exchange of materials.

REFERENCE NUMERALS FOR THE FIGURES

1 – Robot of the autonomous smart navigational medical robotic ecosystem provided by the present invention;

2 – lights;

3 – Blood pressure sensor;

4 – Pulse oximeter sensor;

5 – Infra Red (IR) thermometer (to be pulled out and attached to a string);

6 – Breathing Rate Sensor (Spirometer);

7 – Ultrasonic sensor to determine height;

8 – Weighing scale;

9 – Time Of Flight (TOF) camera;

10 – Stereo camera;

11 – Red-Green-Blue (RGB) Cameras;

12 – 360 Light detection and ranging (LIDAR);

13 – Touch-screen display;

14 –Speaker;

15 – Microphone;

16 – Caterpillar tracks;

17 – Plurality of batteries;

18 – Charge port for the robot to be charged in the charging station;

19 – Waste disposal space (where the patient can place their waste such as sanitary napkins, medicine packaging waste etc.);

20 – Solar panels to power the charging station;

21 – Charging port which the robot (1) will connect to charge its batteries (17);

22 – Place where smart base (23) transfers the waste and drone will collect the waste;

23 – The “smart base” where medical products, samples and waste is exchanged between drone, charging station and the robot (1);

24 – Place where the drone will drop medical products for refill;

25 – Place where smart base (23) transfers the samples and where the drone will collect the samples;

26 – Vacuum sucker to transfer the waste from the robot to (22);

27 – Connector of robot (1) and (28);

28 – Passage for medicine to be transferred from (24) to robot (1);

29 – The Global navigation satellite system (GNSS) Real-time kinematic positioning (RTK) base;

30 – Height extender of the height measuring device of the robot (1);

31 – Specimen deposit space;

32 – Test tube holder;

33 –The tray that is going to be dispensed where patients can put their blood samples;

34 – The urine sample holders;

35 – Specimen storage space;

36 – Specimen deposit unit;

37 – Dispenser unit;

38 – Door of the vending machine dispenser unit (37), opened to refill things in the charging station;

39 – Dispensing columns;

40 – Compartment where the patient will collect the item dispensed from the dispenser unit (37);

41 – Scissor lift mechanism to pull specimen storage space (35) and dispenser unit (37);

42 – Blood pressure arm cuff slit;

43 – Door of the specimen deposit space (31), opened to transfer things to the charging station;

44 – Rail that is used to control the weighing scale (8) moving in one direction out of the robot (1);

45 – The lid that opens the dispensing columns (39);

46 – The lid that opens the specimen deposit unit (36);

47 – Sample tray from (36) transferred from the robot (1) to (25)

SUMMARY OF THE INVENTION

The instant invention relates to an autonomous smart navigational medical robotic ecosystem comprising of:

(i) a plurality of robots to collect patient vitals and biological samples from patients, each robot (1) encompassing a plurality of lights (2), a plurality of sensors including a blood pressure sensor (3), pulse oximeter sensor (4), temperature sensor (5), breathing rate sensor (6), ultrasonic sensor (7); a weighing scale (8); a plurality of cameras including time of flight cameras (9), stereo cameras (10), Red-Green-Blue (RGB) cameras (11); a LIDAR (12); a touch-screen display (13); a speaker (14); a microphone (15); a microcontroller; an inertial measurement unit (IMU); a Global navigation satellite system (GNSS) chip; caterpillar tracks (16); a plurality of batteries (17); a charging port (18), and a waste disposal space (19);

(ii) a charging station with a power source, the said charging station encompassing solar panels (20) to charge the robot (1) through a charging port (21) which the robot (1) will connect to charge its batteries (17), a site (22) wherein the waste from the robot (1) is transferred for collection, a smart base (23) comprising a refrigeration unit to store the biological samples collected by the robot (1) and the medicines and pharmaceuticals to be dispensed to patients wherein the said medicines and pharmaceuticals are stored at a site (24) and the said biological samples are stored at a site (25), a vacuum sucker (26) to transfer the waste from the robot (1) to the said site (22), a connecter (27) to connect the robot (1) to a passage (28) wherein medicine is transferred from the site (24) to robot (1), and a Global navigation satellite system (GNSS) Real-time kinematic positioning (RTK) base (29);

(iii) a centre comprising of at least a laboratory to process the biological samples collected by the robot (1) and a dispensary;

(iv) at least one drone for transportation of the biological samples stored in the refrigeration unit of the smart base (23) to the laboratory at the centre as well as carry medicine and pharmaceuticals from the dispensary at the centre to the charging station; and,

(v) an electronic device that stores the data received from the various components of the autonomous smart navigational medical robotic ecosystem and processes it into patient records containing specific attributes such as patient profile including patient's name, age, gender, occupation, blood type, weight, height, calculated BMI, blood analysis, heart rate, blood oxygen level, body temperature, breathing rate, blood pressure;

wherein:

(a) the robot (1) is designed to include an extendable rod (30) mounted with ultrasonic sensor (7) attached at the top to measure the height of the patient; an insulated compartment having a specimen deposit space (31) encompassing a plurality of test tubes arranged in a row in a test tube holder (32), the said test tubes respectively containing test tubes for blood sample (33) and urine sample holders (34), and a specimen storage space (35) to store the collected blood and urine samples from the patients whereby together with the specimen deposit space (31), makes a specimen deposit unit (36); a dispenser unit (37) with a door (38) encompassing dispensing columns (39) through which medicine, the test tubes for blood sample (33), and pharmaceuticals will be dispensed to the patient; and a compartment (40) where the patient collects the dispensed medicines and pharmaceuticals;

(b) the medical products, blood and urine samples, and waste are exchanged between drone, charging station and the robot (1) at the smart base (23);

(c) the refrigeration unit in the smart base (23) comprises a conveyor belt and horizontal magnetized scissor lifts (41), which will push the test tube holder (32) with the test tubes (33) and the urine sample holder (34), pharmaceutical products and medicines to the respective position;

(d) the charging station is equipped with transceivers to communicate with the centre and drone the said transceivers working on WiFi/ Cellular Data when available and on backup satellite communication systems otherwise;

(e) the centre is equipped with transceivers to receive and transmit data including information regarding patient information, drone pick-ups and deliveries, emergencies, medicine requirements and dispensing, to the robot (1) and the charging station.

The instant invention further relates to a method of providing medical assistance to a target area using the said autonomous smart navigational medical robotic ecosystem, wherein:

(i) all points of importance within the ecosystem including the various households, charging station, important landmarks, and road system, are mapped into a cartesian plane and this information along with the Real-Time Kinetic (RTK) enabled Global Navigation Satellite System (GNSS) coordinates of each of the points of importance is stored in the microcontroller of the robot (1) which is then transmitted to the electronic device for storage of navigational data as a failsafe to create a GNSS map comprising cartesian coordinates and GNSS coordinates;

(ii) the road system is then manually defined upon deployment of a human as traversable roads and will be temporarily taped with a black / magnetic tape which the robot (1) can follow and mark as parts of the road system on the cartesian plane as well as GNSS map using cartesian coordinates and GNSS coordinates;

(iii) the robot (1) initially navigates between the households of the target area and the charging station in coordination with the microcontroller whereby the position of the robot (1) is estimated by using the orientation of the robot (1) from the inertial measurement unit (IMU) of the robot (1) to calculate distance from origin and its position in the cartesian plane and compares it to the current GNSS location for added accuracy;

(iv) once the robot (1) completes creating the GNSS map in coordination with the microcontroller, the robot (1) is aware of all the traversable roads and will start using the shortest path from its position to the destination with the help of its microcontroller;

(v) in case of obstacles in traversing the roads, the robot (1), with the help of its cameras (9, 10, 11), Inertial Measurement Unit, and LIDAR (12) first tries to navigate around the obstacle, and in the event that it is unsuccessful, finds an alternative route using the GNSS map while coordinating with the microcontroller;

(vi) the robot (1) identifies the household to enter based on the GNSS and cartesian coordinates of the robot (1) and the household and enters the household accordingly;

(vii) upon entering the household, the robot (1) demonstrates video-cum-audio instructions to be followed by the patient on its touch-screen display (13);

(viii) the robot (1) then takes the various vitals of the patient including blood pressure, blood oxygen levels, body temperature, height, weight, breathing rate, and transmits the said readings to the microcontroller which then transmits it to the electronic device for processing;

(ix) the robot (1) then collects blood samples from the patient whereby the test tubes for blood sample (33) are first dispensed to the patient through the dispensing columns (39), the blood sample is then extracted by the patient by following the instructions presented to the patient by the robot (1) following which the patient places the filled test tubes (33) in the specimen deposit space (31), the collected blood samples are thereafter inserted into the test tube holder (32) and then stored in the specimen storage space (35);

(x) the robot (1) then optionally collects urine samples from the patient whereby the urine sample holders (34) are first dispensed to the patient through the dispensing columns (39), the urine sample is then collected by the patient following which the patient places the filled urine sample holders (34) in the specimen deposit space (31) and the collected samples are inserted into the test tube holder (32) and subsequently stored in the specimen storage space (35);

(xi) the robot (1) then navigates to the charging station and dispenses the blood and urine samples collected from the patient by transferring the specimen deposit unit (36) into the refrigeration unit of the smart base (23) wherein the horizontal magnetized scissor lifts (41) and the conveyor belt then push the test tubes (33) and the urine sample holders (34) to the respective position;

(xii) the drone then arrives for collection of the specimen samples and transports the same to the laboratory at the centre;

(xiii) the specimen samples are then tested at the laboratory and the results are transmitted to the electronic device and studied by a doctor, along-with the medical information received from the robot (1), who then prescribes appropriate medication which is collected by the drone from the dispensary at the centre and transported to the charging station;

(xiv) the robot (1) collects the medicine from the charging station and transports it to the patient’s household and dispenses the same to the patient through the compartment (40) along with instructions for use.

DETAILED DESCRIPTION OF THE INVENTION

Throughout this specification, the use of the word “comprise” and variations such as “comprises” and “comprising” may imply the inclusion of an element or elements not specifically recited.

The present specification discloses an autonomous smart navigational medical robotic ecosystem capable of medical diagnosis, assessment, health monitoring, and telemedicine. The said system includes a set of devices, components, capabilities and processes that assists people dwelling in rural areas where medical infrastructure is under-developed or is hard to reach.

The autonomous smart navigational medical robotic ecosystem works on the principle of integration of various pre-existing medical technology in the market while staying mobile.

The first important device and component of the said ecosystem is the plurality of robots to collect patient vitals and biological samples from patients, each robot (1) encompassing a a plurality of lights (2), a plurality of sensors including a blood pressure sensor (3), pulse oximeter sensor (4), temperature sensor (5), breathing rate sensor (6), ultrasonic sensor (7); a weighing scale (8); a plurality of cameras including time of flight cameras (9), stereo cameras (10), Red-Green-Blue (RGB) cameras (11); a LIDAR (12); a touch-screen display (13); a speaker (14); a microphone (15); a microcontroller; an inertial measurement unit (IMU); a Global navigation satellite system (GNSS) chip; caterpillar tracks (16); a plurality of batteries (17); a charging port (18), and a waste disposal space (19). Each robot (1) is designed to include an extendable rod (30) mounted with ultrasonic sensor (7) attached at the top to measure the height of the patient; a test tube holder (32); an insulated compartment having a specimen deposit space (31) encompassing a plurality of test tubes arranged in a row in a test tube holder (32), the said test tubes respectively containing test tubes for blood sample (33) and urine sample (34) and a specimen storage space (35) to store the collected blood and urine samples from the patients whereby together with the specimen deposit space (31), makes a specimen deposit unit (36) through which medicine, the test tubes for blood sample (33), and pharmaceuticals will be dispensed to the patient; and a compartment (40) where the patient collects the dispensed medicines and pharmaceuticals.

The plurality of lights (2) helps the robot (1) navigate at night if needed and are also installed for security purposes at night.

Example 1:

The instructions on how the robot (1) takes the patient vitals will be displayed on the display (13) through an informative demonstration. In a specific embodiment of the invention, the said display (13) is a touch-screen, the breathing rate sensor (6) is a Spirometer, and the blood samples are collected by a Tasso kit (33).

In an embodiment of the present invention, the robot (1) of the autonomous smart navigational medical robotic ecosystem collects patient vitals and biological samples from patients in the following manner:

(i) The blood pressure sensor (3) works by the cuff of the sensor being extended when required through a slit (42) in the robot (1) and can be worn around the arm of the patient and inflated for tightness, the required data after measurements will then be transferred to the microcontroller for further processing via bluetooth/wire.

(ii) The pulse oximeter (4) will have a slot with an indentation on the surface of the robot (1), where the index finger of the patient can be inserted and then again the sensor will transfer required data to the microcontroller via wire/bluetooth.

(iii) Body temperature is measured by clinical grade medical thermometers (5) measuring the temperature at the forehead, the touch-screen display (13) will guide patients to properly centre themselves towards the thermometer (5), sufficiently close to the sensor. Data is then transferred to the microcontroller.

(iv) Height can be measured using an extendable rod (30) that is fitted with ultrasonic sensors (7) at the top, which can measure the perpendicular height from the ground. When the rod (30) is extended till the patient’s head and then placed at that spot the height will be recorded.

(v) Weight will be measured by extending a weighing scale (8) from the bottom of the robot (1). BMI can be calculated and recorded.

(vi) Breathing rate will be analysed using a smart spirometer (6) that will be dispensed along with a disposable turbine and cardboard mouthpiece. There will be an instruction video playing on the touch-screen display (13) on how to carry out the simple procedure of fitting the turbine and mouthpiece. The information from the spirometer will be wirelessly relayed to the microcontroller.

(vii) Blood samples will be collected by dispensing the contents of a Tasso kit (33). An instruction audio-cum-video will once again play and once the blood has been collected through the specimen deposit space (31), it can be inserted into the robot's (1) test tube holder (32) and into the insulated compartment.

(viii) Similarly, urine samples may be collected whereby an instruction audio-cum-video will play and once the urine has been collected through the specimen deposit space (31), it can be inserted into the robot's (1) test tube holder (32) and into the insulated compartment.

All the data that will be transferred to the microcontroller will be adequately organised in local databases within the robot (1) and transferred to the electronic device where the government can access it.

The plurality of robots will carry out various medical assessments and tasks. This information can be used for further tracking of the medical history of that particular village. One robot (1) may be in charge of one village or a cluster if located within close proximity.

The second important component of the ecosystem is the charging station with a power source, the said charging station encompassing solar panels (20) to charge the robot (1) through a charging port (21) which the robot (1) will connect to charge its batteries (17), a site (22) wherein the waste from the robot (1) is transferred for collection, a smart base (23) comprising a refrigeration unit to store the biological samples collected by the robot (1) and the medicines and pharmaceuticals to be dispensed to patients wherein the said medicines and pharmaceuticals are stored at a site (24) and the said biological samples are stored at a site (25), a vacuum sucker (26) to transfer the waste from the robot (1) to the said site (22), a connecter (27) to connect the robot (1) to a passage (28) wherein medicine is transferred from the site (24) to robot (1), and a Global navigation satellite system (GNSS) Real-time kinematic positioning (RTK) base (29).

Example 2:

In an embodiment of the present invention, the charging station is an enclosed physical infrastructure that not only acts as the charging unit for the robot (1), but also as intermediary between the centres and robot (1). The said charging station is equipped with solar panels (20) and collects electricity to charge the robots and the refrigeration in the station and will be possibly connected to the electricity grid if available.

The charging station will further be equipped with batteries for running during the night.

The charging station is equipped with a refrigerator for the storage of blood and urine samples and pharmaceuticals (medicine).

The refrigeration unit in the smart base (23) comprises a conveyor belt and horizontal magnetized scissor lifts (41), which will push the test tube holder (32) with the test tubes (33) and urine samples (34), pharmaceutical products and medicines to the respective position.

The charging station is equipped with transceivers to communicate with the centre and drone, the said transceivers working on WiFi/ Cellular Data when available and on backup satellite communication systems otherwise.

<u>Example 3</u>:

Process of transfer of urine and blood samples from robot (1) to the charging station:

(i) The robot (1) will be equipped with a container (Cuboid) where the blood and urine samples will be stored, this container will be cooled and insulated. This insulated compartment comprises of the specimen deposit space (31) and a specimen storage space (35).

(ii) The charging station will be equipped with a refrigerated container in its smart base (23) which will store the blood and urine samples from the robot (1) awaiting collection from the drone, wherein the said medicines and pharmaceuticals are stored at a site (24) and the said biological samples are stored at a site (25).

(iii) When the robot (1) reaches the refrigerated container, it will reveal the inside of the container through a slider door (38) which moves horizontally (the front side of the cuboid is removed).

(iv) The robot (1) will have rows of containers within the container. One for blood samples, one for urine samples and two for pharmaceuticals and medicine and two for waste (might need more depending on the conditions).

(v) When the robot (1) puts something in the refrigeration unit, the robot (1) will be present near the entrance of the refrigeration unit and it will transfer the rows of samples using a magnetised scissor lift (41).

(vi) The refrigeration unit will have a conveyor belt which will push the container to the respective position.

(vii) When the drone arrives for collection, the container will open a compartment from the top from which the drone can pick up the biological samples (25) and waste (22) as well as a separate container to drop pharmaceutical products into (24).

The third component of the ecosystem is the centre comprising of at least a laboratory to process the biological samples collected by the robot (1) and a dispensary. The centre is equipped with transceivers to receive and transmit data including information regarding patient information, drone pick-ups and deliveries, emergencies, medicine requirements and dispensing, to the robot (1) and the charging station.

Drones will connect the centres to the robots (1). The centres will be equipped with laboratories and storage for pharmaceuticals. These centres will carry out various activities like, analysing blood and urine samples, keeping track of public health records of the villages, providing drugs and pharmaceutical products.

In a specific embodiment of the present invention, existing nearby hospitals can be converted into centres for the robots. One centre can be in charge of multiple villages and possibly drones if necessary.

The fourth and most important component and device of the ecosystem are the drones. At least one drone is used for transportation of the biological samples stored in the refrigeration unit of the smart base (23) to the laboratory at the centre as well as to carry medicine and pharmaceuticals from the dispensary at the centre to the charging station.

Drones play a major role in the ecosystem. Drones will be used to transport the blood, waste and urine samples from the charging stations to the laboratories. These laboratories will collect samples from multiple villages. One drone can serve many villages for transporting blood and urine samples.

Also, in addition to transporting blood, waste and urine samples, the drones can carry medicine to the charging station, where the robot will collect it and distribute it to the ones in need. Medicines will only be dispensed after the doctor has diagnosed a patient after seeing his tests done by the robot.

Waste refers to the disposables that are dispensed to patients, which then the patients put in the robot for disposal, for example, sanitary napkins, tissues, medicine packaging, mouthpiece of the spirometer, etc.

Another important component of the ecosystem is the electronic device that stores the data received from the various components of the autonomous smart navigational medical robotic ecosystem and processes it into patient records containing specific attributes such as patient profile, weight, height, blood analysis, heart rate, blood oxygen level, body temperature.

Example 4:

In an embodiment of the present invention, the electronic device is a computer that maintains a database and helps in the communication of the various components of the autonomous smart navigational medical robotic ecosystem wherein the database is going to be holding all of the patient’s data taken from the robot (1) including weight, height, blood analysis, heart rate, temperature, etc. The way the robot (1) is going to be communicating with the database will be in one of two scenarios:

1. Using mobile coverage, since the majority of the villages in India have mobile coverage, the robot and the charging station will be equipped with mobile data modules to be connected to the internet. All information regarding patient information, drone pick-ups and deliveries, emergencies, medicine requirements and dispensing will be communicated to the centres via mobile coverage.

2. In case the village has a lack of mobile coverage, the charging station will be equipped with satellite transceivers to communicate with the drones and the centres. The robot (1) will transfer all information to the centre via short range WiFi/Bluetooth. The robot (1) also has LoRa transceivers, which can be used for emergency SOS from robot (1) to base (23). The SOS will be transmitted from base (23) to centre for further action. The centres will be equipped with satellite transceivers to receive and transmit data to the charging station directly and the charging station communicates with the robot (1).

All communication with the drone will be done using a mix of mobile coverage/WiFi and LoRa. The centre will be the intermediary between the charging station and the drone. So all information whether automatically transmitted or manually filtered data will be going through the centre.

The instant invention further relates to a method of providing medical assistance to a target area using the said autonomous smart navigational medical robotic ecosystem. The most important technological advancement provided by the instant invention is the smart navigational ability of the fully autonomous medical robot (1).

In a specific embodiment of the invention, the movement of the robot (1) is carried out using the system of sensors and cameras that we have available using multiple cameras, for various purposes:

- Stereo Cameras (10) for long range 3d recognition and mapping;
- Normal HD colour cameras (11) for path recognition and backup obstacle avoidance using sensor fusion with the 2D LIDAR (12), etc.;
- 2D LIDAR (12) for very long range inexpensive backup to detect obstacles;
- Monochromatic cameras for when amount of exposure is too high or low;
- Depth of field/3D LIDAR (12)/Time of Flight cameras (9) for facial recognition, detailed 3D view of the structures ahead, for object detection and avoidance at night as well as any further mapping needs.

The navigation of the robot (1) around the village will be based on the following principles:

- A basic cartesian plane system

- An RTK Enabled GNSS chip
- A predefined road system
- IMU to measure orientation, velocity, and gravitational forces

The cartesian plane system will be a basic system which has a purpose of providing an estimation of our position, this will be calculated as the distance travelled from the origin by calculating the distance moved and using that and the orientation of the robot to calculate distance from origin and our position in the cartesian plane. The determination of the location of the robot will be done primarily using the GNSS chip, but will be cross-checked with the cartesian coordinate.

We will use the cartesian plane and the GNSS system to mark points of importance, including the charging station, the road system, the houses of all the patients (this will be stored along with information of who all belong to which households), and important landmarks.

The road system will be manually defined upon deployment by a human as traversable roads, it will be temporarily taped with a black/magnetic tape which the robot can follow and mark as parts of the road system on the cartesian plane as well as GNSS map using cartesian coordinates and GNSS coordinates.

Once the robot is aware of all the traversable roads, it will use the shortest path from its position to the destination. In case of issues with the traversable road, the robot (1) will remember it and also find an alternate way using both alternate routes, as well as navigating around obstacles using the camera system, which can detect obstacles, paths, and has a 3D depth scan of the front side.

The RTK enabled GNSS system will provide cm level accuracy, allowing the robot to locate and enter homes with ease.

In a specific embodiment of the present invention, the robot (1) is equipped with caterpillar tracks (16) to allow it to move over rough and muddy terrain.

Example 5:

In an embodiment of the present invention, the robot (1), from the data collected has a detailed view on the particular medical issues faced by every individual, and based on that information can relay the information to the individual and a nearby hospital and conduct virtual doctor consultations where the doctor has access to the robot’s medical capabilities to take various readings.

The robot (1) will also after the consultation with a doctor, dispense the required medications at the specified time limits through an open dispensary part of the robot (1).

The medical history of each individual will be shared with the government, this will help the government track the general well being of the population and also react faster to regional irregularities signalling possible outbreaks of diseases. For example, irregular amounts of fevers, and a high average body temperature can signal an outbreak of the flu.

The robot (1) will have information about the name, age, gender and all valid information of an individual from the first interaction, where his facial identity, household position, and his personal information, along with his past medical information will be recorded and remembered. This will help the robot keep track of all the individuals in the specified area and better diagnose the individual later. Based on the medical risk of each individual which will be calculated based on the irregularities of various medical measurements, the frequency of the medical inspections will also be decided. For example, a person with heart problems will be checked on by the robot far more frequently than a healthy youngster.

In a specific embodiment of the present invention, the robot (1) dispenses required materials through a pop out drawer that will only have the required materials when extended.

What has been described and illustrated herein is a preferred embodiment of the invention along with some of its components. The terms, descriptions and figures used herein are set forth by way of illustration only and are not meant as limitations. Those skilled in the art will recognise that many variations are possible within the spirit and scope of the invention, which is intended to be defined by the following claims (and their equivalents) in which all terms are meant in their broadest reasonable sense unless otherwise indicated. Any headings utilized within the description are for convenience only and have no legal or limiting effect.

Dated this 29th day of July, 2024

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WE CLAIM:

1. An autonomous smart navigational medical robotic ecosystem comprising of:

(i) a plurality of robots to collect patient vitals and biological samples from patients, each robot (1) encompassing a plurality of lights (2), a plurality of sensors including a blood pressure sensor (3), pulse oximeter sensor (4), temperature sensor (5), breathing rate sensor (6), ultrasonic sensor (7); a weighing scale (8); a plurality of cameras including time of flight cameras (9), stereo cameras (10), Red-Green-Blue (RGB) cameras (11); a LIDAR (12); a touch-screen display (13); a speaker (14); a microphone (15); a microcontroller; an inertial measurement unit (IMU); a Global navigation satellite system (GNSS) chip; caterpillar tracks (16); a plurality of batteries (17); a charging port (18), and a waste disposal space (19);

(ii) a charging station with a power source, the said charging station encompassing solar panels (20) to charge the robot (1) through a charging port (21) which the robot (1) will connect to charge its batteries (17), a site (22) wherein the waste from the robot (1) is transferred for collection, a smart base (23) comprising a refrigeration unit to store the biological samples collected by the robot (1) and the medicines and pharmaceuticals to be dispensed to patients wherein the said medicines and pharmaceuticals are stored at a site (24) and the said biological samples are stored at a site (25), a vacuum sucker (26) to transfer the waste from the robot (1) to the said site (22), a connecter (27) to connect the robot (1) to a passage (28) wherein medicine is transferred from the site (24) to robot (1), and a Global navigation satellite system (GNSS) Real-time kinematic positioning (RTK) base (29);

(iii) a centre comprising of at least a laboratory to process the biological samples collected by the robot (1) and a dispensary;

(iv) at least one drone for transportation of the biological samples stored in the refrigeration unit of the smart base (23) to the laboratory at the centre as well as carry medicine and pharmaceuticals from the dispensary at the centre to the charging station; and,

(v) an electronic device that stores the data received from the various components of the autonomous smart navigational medical robotic ecosystem and processes it into patient records containing specific attributes such as patient profile including patient's name, age, gender, occupation, blood type, weight, height, calculated BMI, blood analysis, heart rate, blood oxygen level, body temperature, breathing rate, blood pressure;

wherein:

(a) the robot (1) is designed to include an extendable rod (30) mounted with ultrasonic sensor (7) attached at the top to measure the height of the patient; an insulated compartment having a specimen deposit space (31) encompassing a plurality of test tubes arranged in a row in a test tube holder (32), the said test tubes respectively containing test tubes for blood sample (33) and urine sample holders (34), and a specimen storage space (35) to store the collected blood and urine samples from the patients whereby together with the specimen deposit space (31), makes a specimen deposit unit (36); a dispenser unit (37) with a door (38) encompassing dispensing columns (39) through which medicine, the test tubes for blood sample (33), and pharmaceuticals will be dispensed to the patient; and a compartment (40) where the patient collects the dispensed medicines and pharmaceuticals;

(b) the medical products, blood and urine samples, and waste are exchanged between drone, charging station and the robot (1) at the smart base (23);

(c) the refrigeration unit in the smart base (23) comprises a conveyor belt and horizontal magnetized scissor lifts (41), which will push the test tube holder (32) with the test tubes (33) and the urine sample holder (34), pharmaceutical products and medicines to the respective position;

(d) the charging station is equipped with transceivers to communicate with the centre and drone the said transceivers working on WiFi/ Cellular Data when available and on backup satellite communication systems otherwise;

(e) the centre is equipped with transceivers to receive and transmit data including information regarding patient information, drone pick-ups and deliveries, emergencies, medicine requirements and dispensing, to the robot (1) and the charging station.

2. The autonomous smart navigational medical robotic ecosystem as claimed in Claim 1, wherein the power source for the charging station is solar panels (20).

3. The autonomous smart navigational medical robotic ecosystem as claimed in Claims 1 and 2, wherein the power source for the charging station also includes batteries.

4. The autonomous smart navigational medical robotic ecosystem as claimed in Claim 1, wherein the weighing scale (8) is slidably fixed to the bottom of the robot (1).

5. The autonomous smart navigational medical robotic ecosystem as claimed in Claim 1, wherein the breathing rate sensor (6) is a smart spirometer.

6. A method of providing medical assistance to a target area using the autonomous smart navigational medical robotic ecosystem, wherein:

(i) all points of importance within the ecosystem including the various households, charging station, important landmarks, and road system, are mapped into a cartesian plane and this information along with the Real-Time Kinetic (RTK) enabled Global Navigation Satellite System (GNSS) coordinates of each of the points of importance is stored in the microcontroller of the robot (1) which is then transmitted to the electronic device for storage of navigational data as a failsafe to create a GNSS map comprising cartesian coordinates and GNSS coordinates;

(ii) the road system is then manually defined upon deployment of a human as traversable roads and will be temporarily taped with a black / magnetic tape which the robot (1) can follow and mark as parts of the road system on the cartesian plane as well as GNSS map using cartesian coordinates and GNSS coordinates;

(iii) the robot (1) initially navigates between the households of the target area and the charging station in coordination with the microcontroller whereby the position of the robot (1) is estimated by using the orientation of the robot (1) from the inertial measurement unit (IMU) of the robot (1) to calculate distance from origin and its position in the cartesian plane and compares it to the current GNSS location for added accuracy;

(iv) once the robot (1) completes creating the GNSS map in coordination with the microcontroller, the robot (1) is aware of all the traversable roads and will start using the shortest path from its position to the destination with the help of its microcontroller;

(v) in case of obstacles in traversing the roads, the robot (1), with the help of its cameras (9, 10, 11), Inertial Measurement Unit, and LIDAR (12) first tries to navigate around the obstacle, and in the event that it is unsuccessful, finds an alternative route using the GNSS map while coordinating with the microcontroller;

(vi) the robot (1) identifies the household to enter based on the GNSS and cartesian coordinates of the robot (1) and the household and enters the household accordingly;

(vii) upon entering the household, the robot (1) demonstrates video-cum-audio instructions to be followed by the patient on its touch-screen display (13);

(viii) the robot (1) then takes the various vitals of the patient including blood pressure, blood oxygen levels, body temperature, height, weight, breathing rate, and transmits the said readings to the microcontroller which then transmits it to the electronic device for processing;

(ix) the robot (1) then collects blood samples from the patient whereby the test tubes for blood sample (33) are first dispensed to the patient through the dispensing columns (39), the blood sample is then extracted by the patient by following the instructions presented to the patient by the robot (1) following which the patient places the filled test tubes (33) in the specimen deposit space (31), the collected blood samples are thereafter inserted into the test tube holder (32) and then stored in the specimen storage space (35);

(x) the robot (1) then optionally collects urine samples from the patient whereby the urine sample holders (34) are first dispensed to the patient through the dispensing columns (39), the urine sample is then collected by the patient following which the patient places the filled urine sample holders (34) in the specimen deposit space (31) and the collected samples are inserted into the test tube holder (32) and subsequently stored in the specimen storage space (35);

(xi) the robot (1) then navigates to the charging station and dispenses the blood and urine samples collected from the patient by transferring the specimen deposit unit (36) into the refrigeration unit of the smart base (23) wherein the horizontal magnetized scissor lifts (41) and the conveyor belt then push the test tubes (33) and the urine sample holders (34) to the respective position;

(xii) the drone then arrives for collection of the specimen samples and transports the same to the laboratory at the centre;

(xiii) the specimen samples are then tested at the laboratory and the results are transmitted to the electronic device and studied by a doctor, along-with the medical information received from the robot (1), who then prescribes appropriate medication which is collected by the drone from the dispensary at the centre and transported to the charging station;

(xiv) the robot (1) collects the medicine from the charging station and transports it to the patient’s household and dispenses the same to the patient through the compartment (40) along with instructions for use.

Dated this 27th day of July, 2024

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ABSTRACT

AN AUTONOMOUS SMART NAVIGATIONAL MEDICAL ROBOTIC ECOSYSTEM AND METHOD THEREOF

The present invention provides an autonomous smart navigational medical robotic ecosystem capable of medical diagnosis, assessment, health monitoring, and telemedicine, in rural areas where medical infrastructure is under-developed or is hard to reach. The autonomous smart navigational medical robotic ecosystem disclosed herein comprises a plurality of robots to collect patient vitals and biological samples from patients, a charging station, a centre, at least one drone for transportation of the biological samples and carry medicine and pharmaceuticals; and, an electronic device that stores the data received from the various components of the autonomous smart navigational medical robotic ecosystem. A method of providing medical assistance to a target area using the autonomous smart navigational medical robotic ecosystem is also disclosed.

(Figure to be published along with the abstract: Figure 14)

Dated this 27th day of July, 2024

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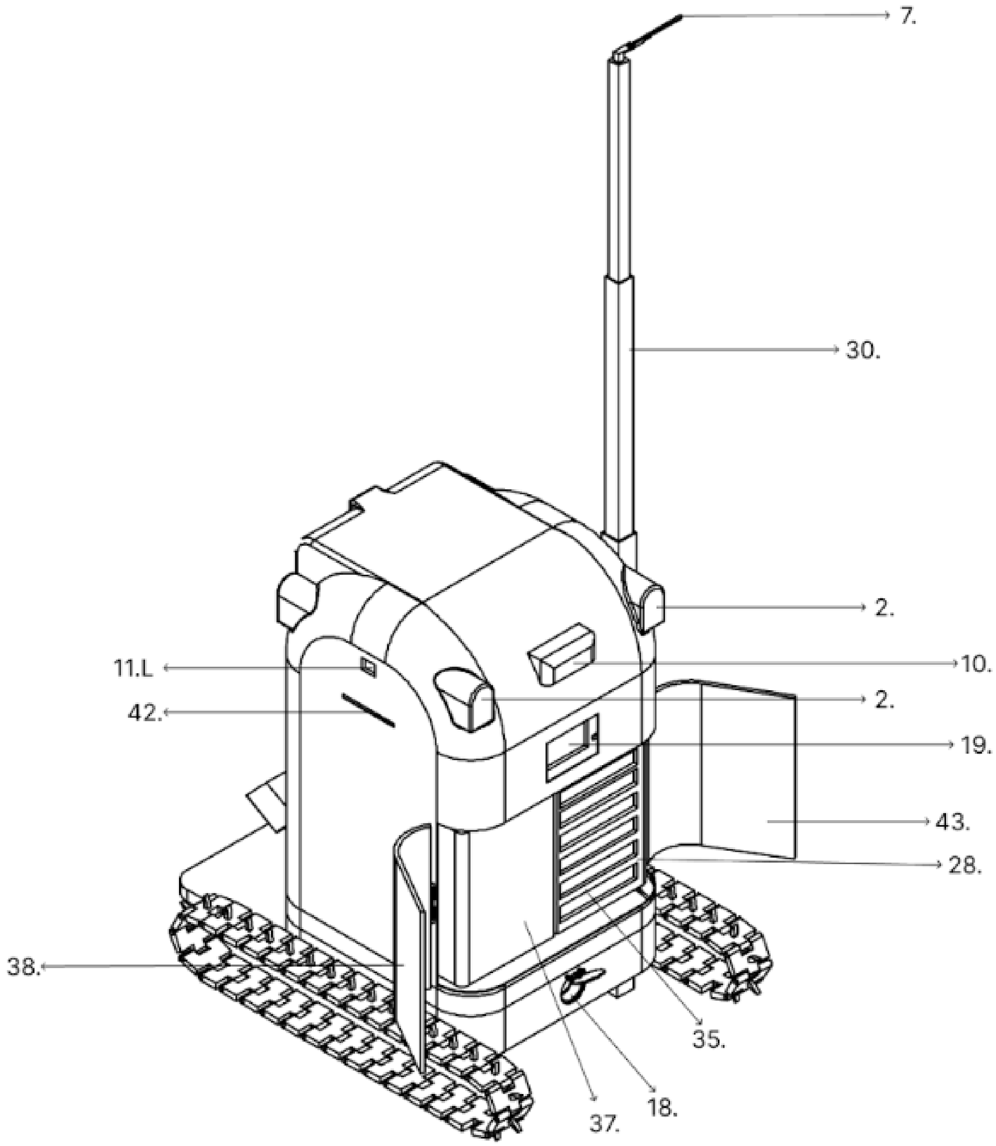

Figure 1

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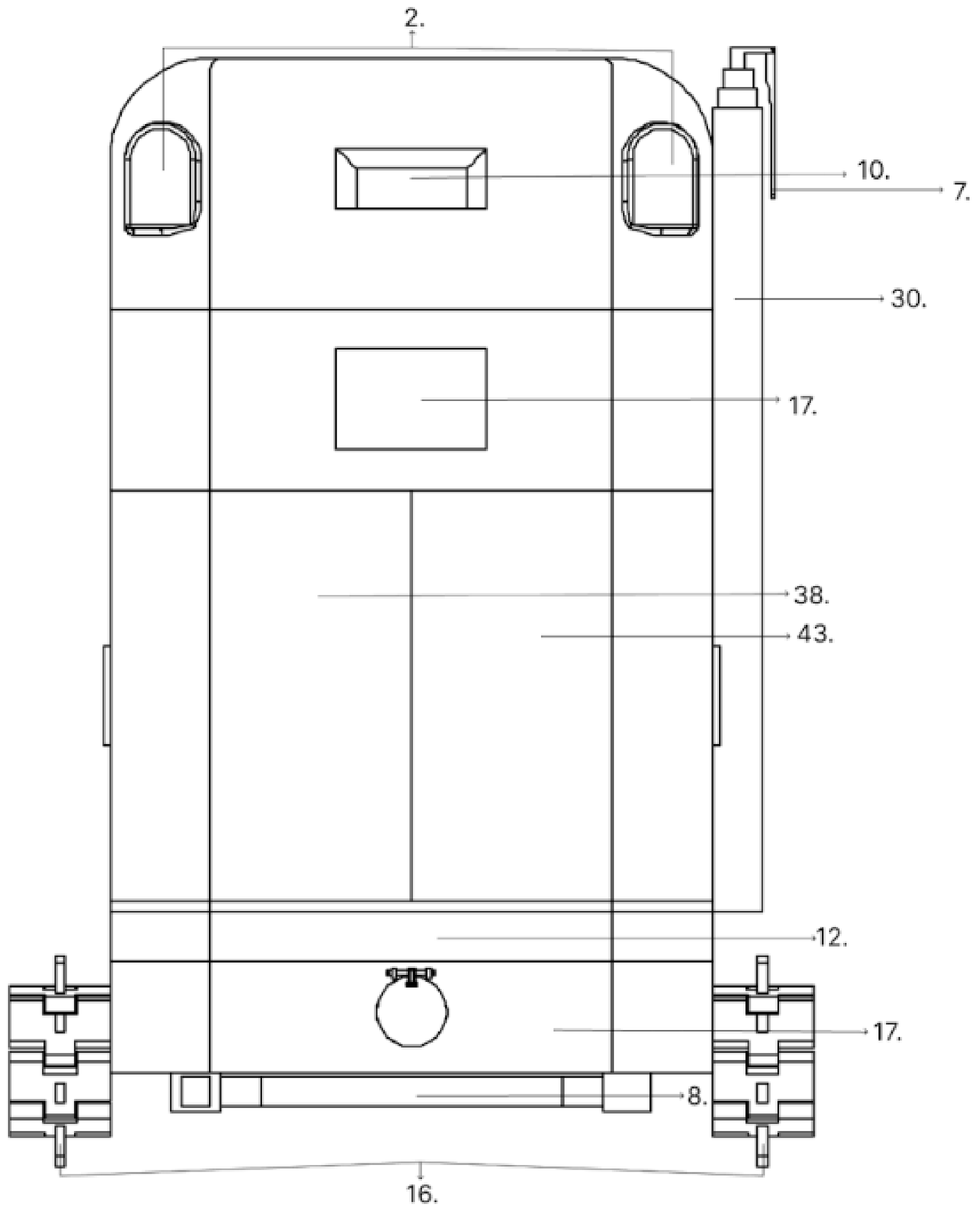

Figure 2

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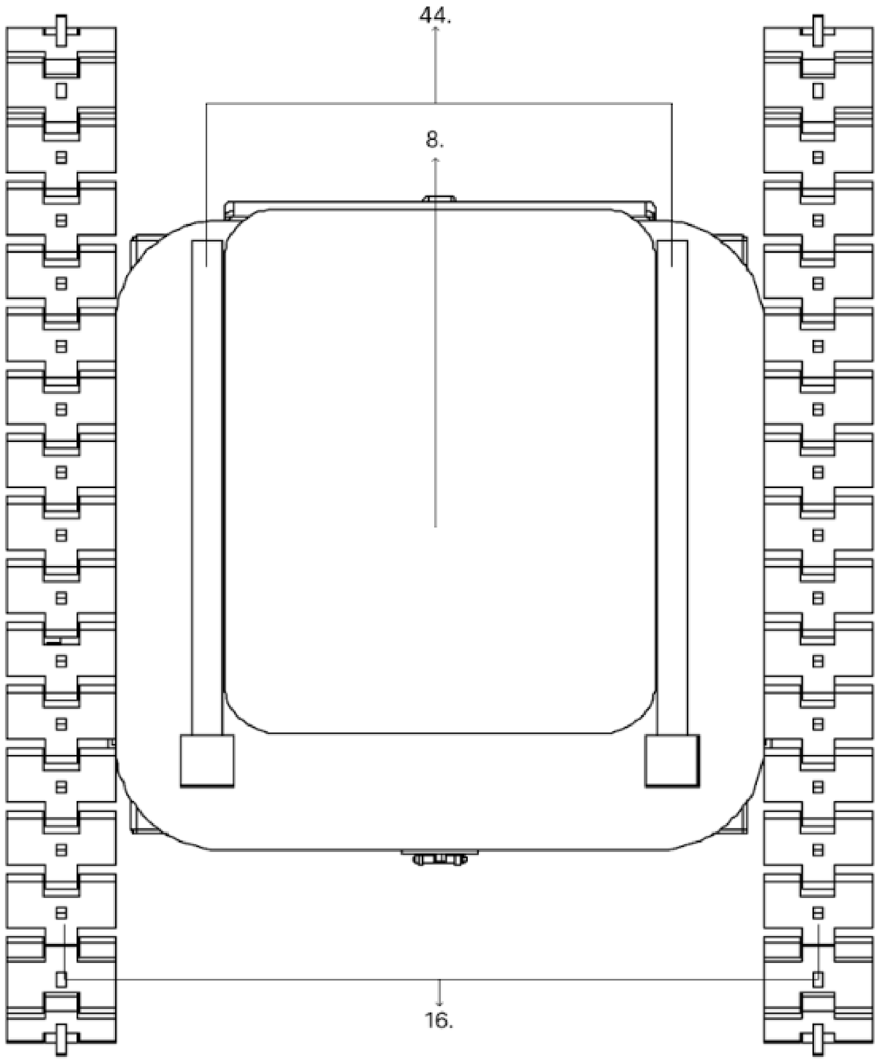

Figure 3

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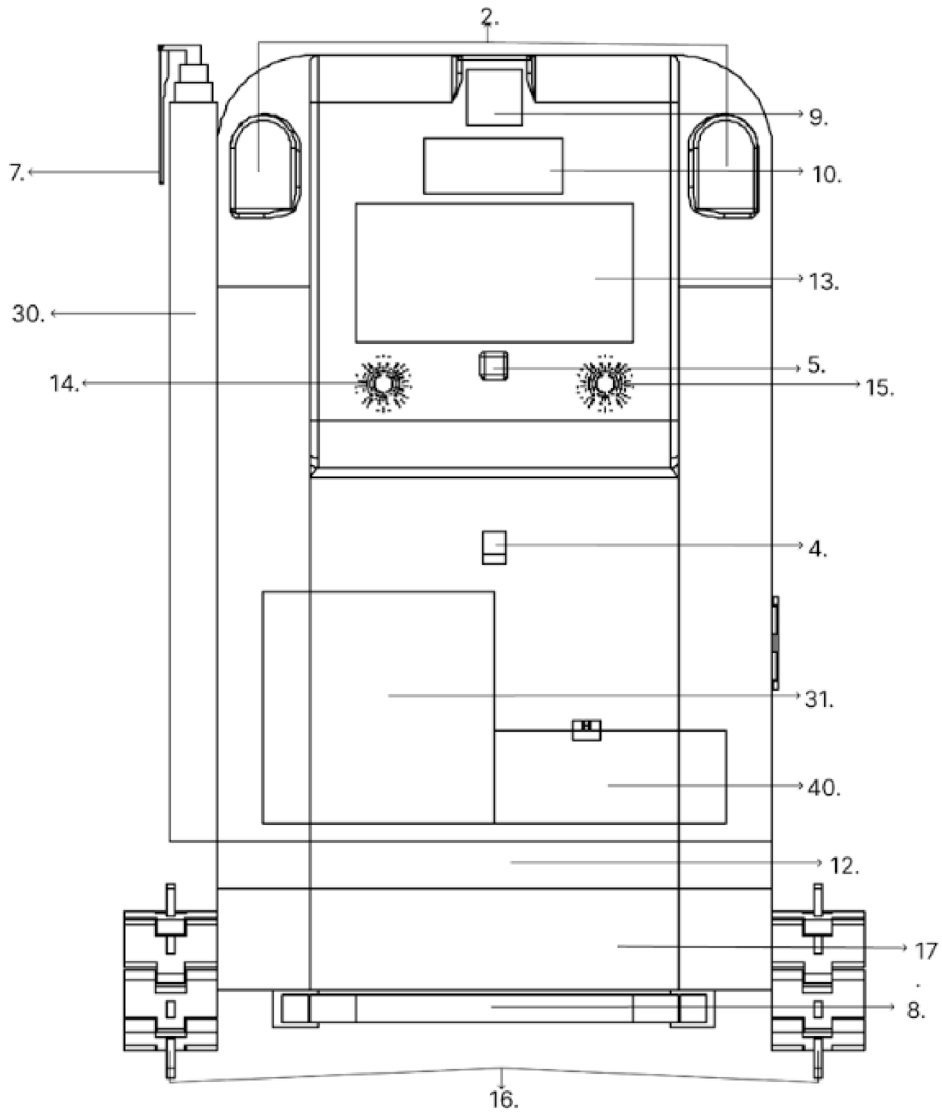

Figure 4

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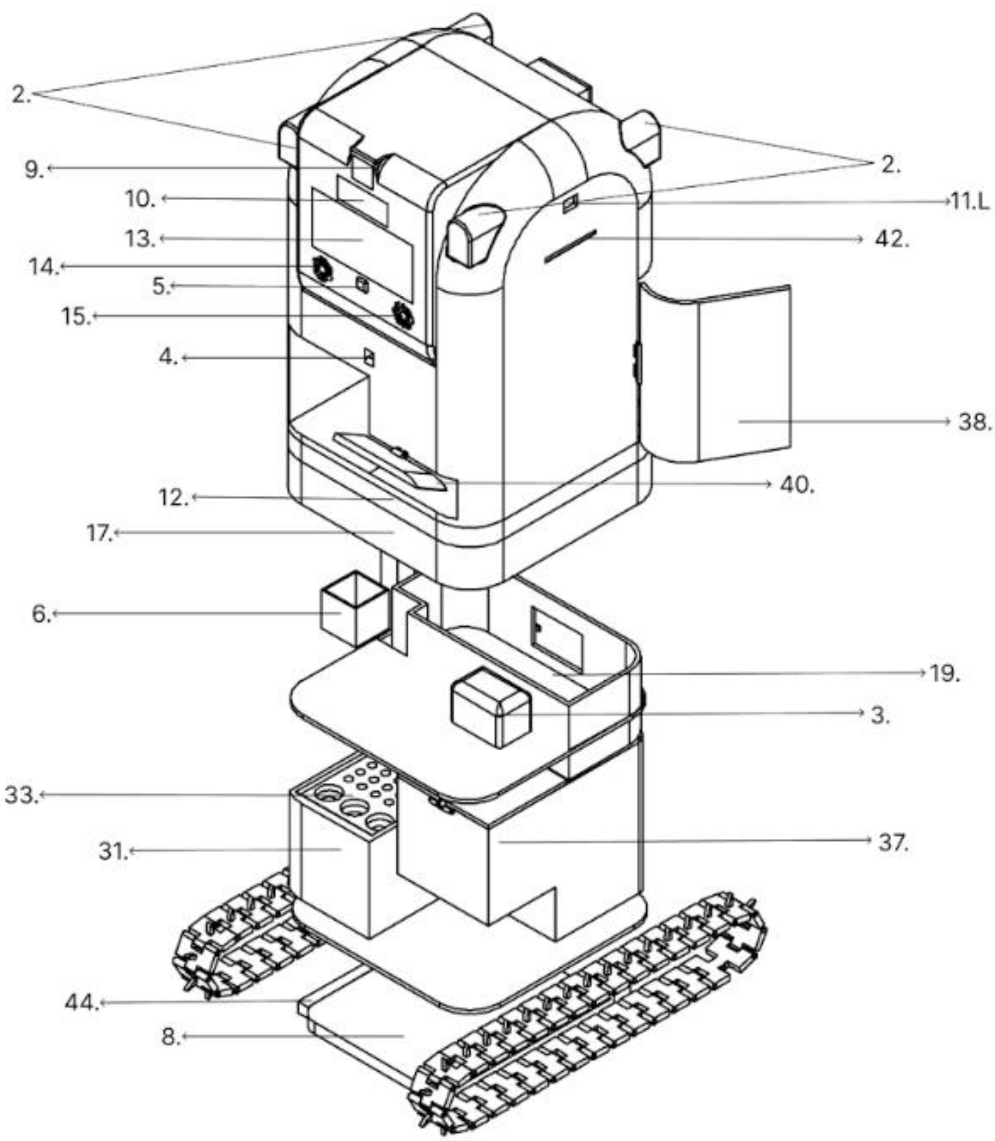

Figure 5

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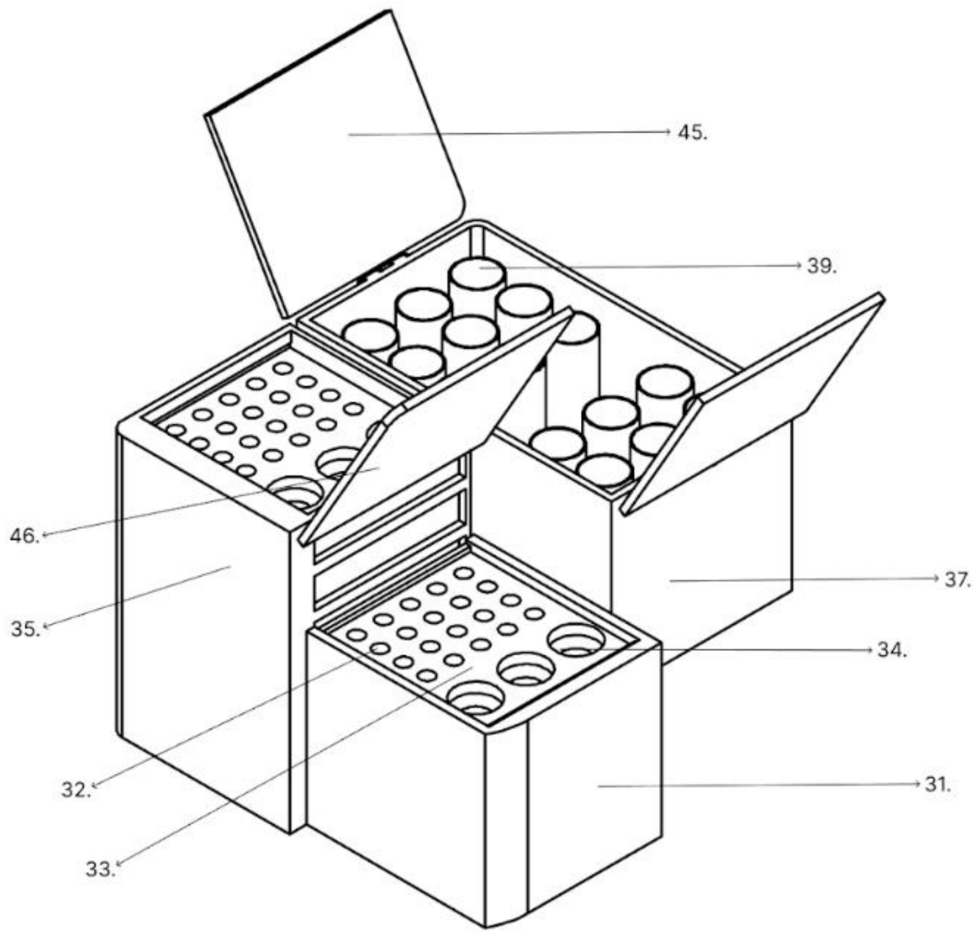

Figure 6

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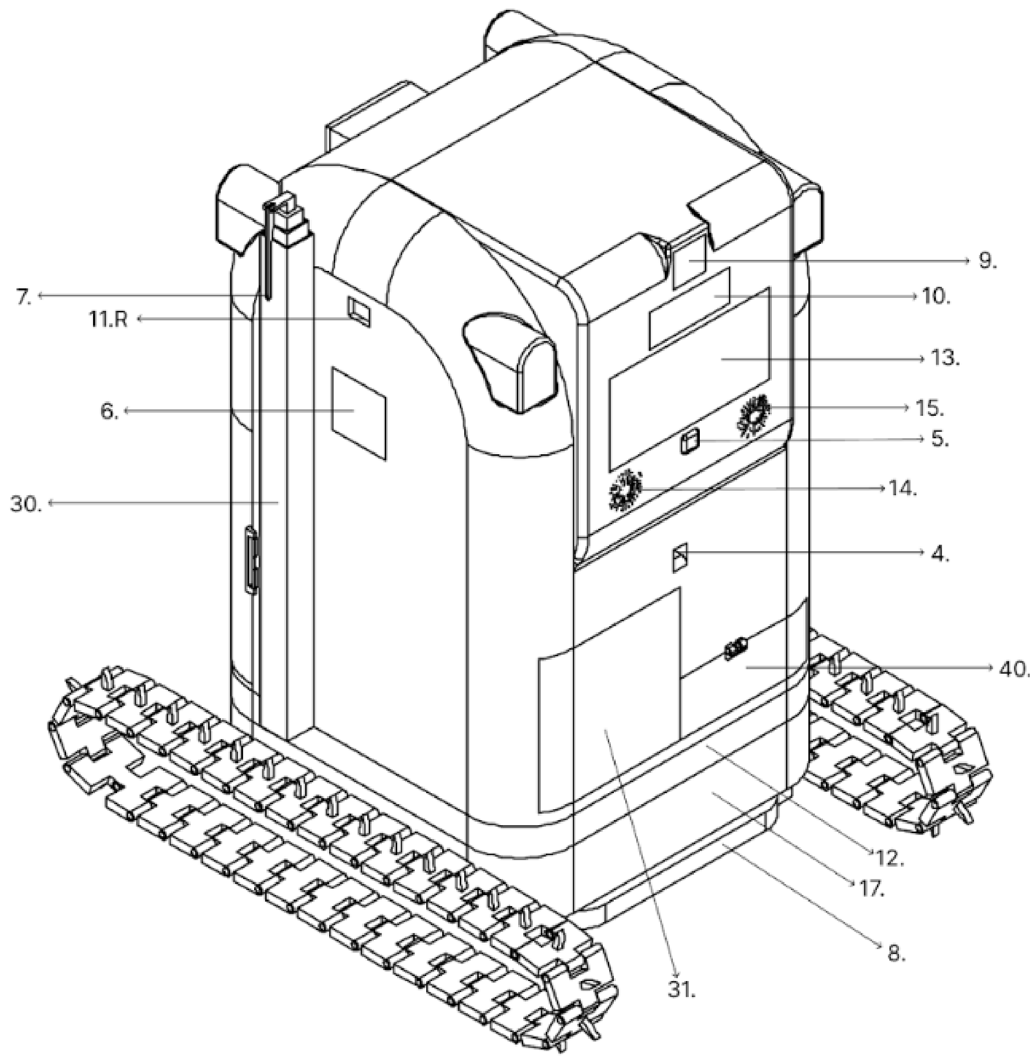

Figure 7

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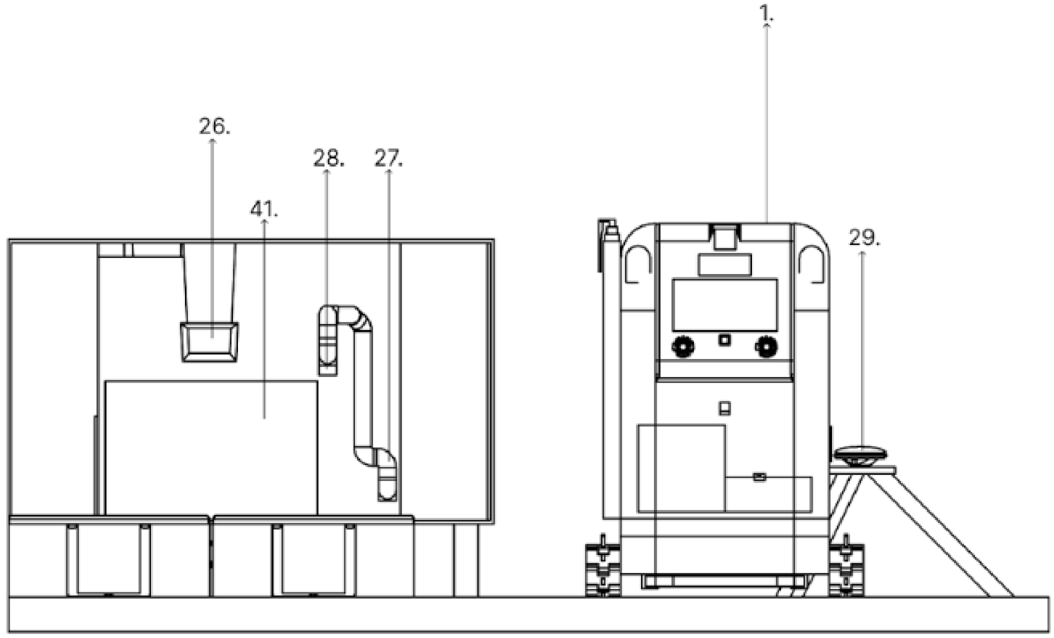

Figure 8

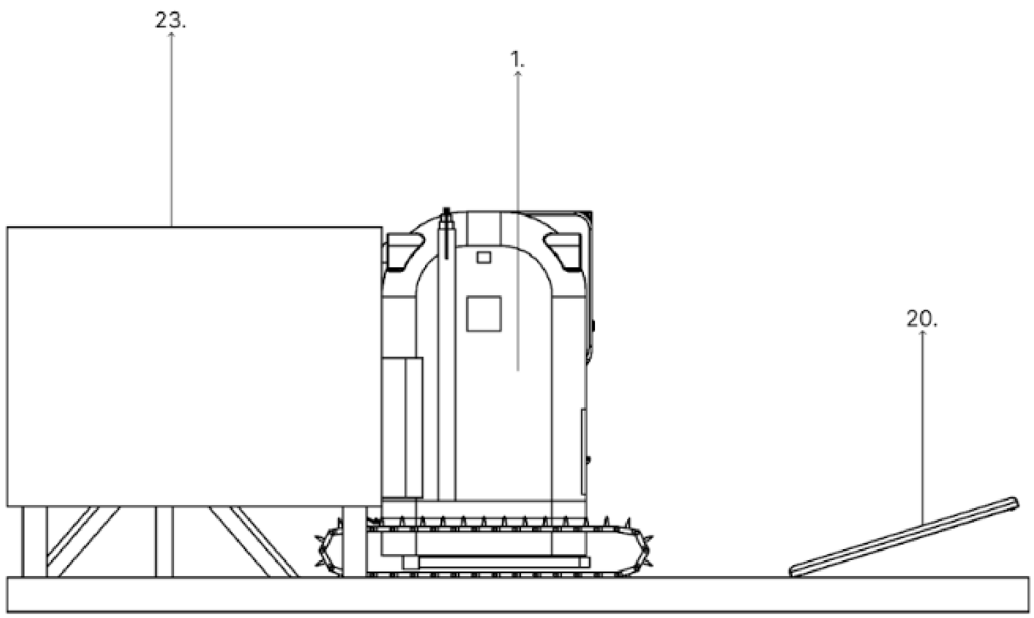

Figure 9

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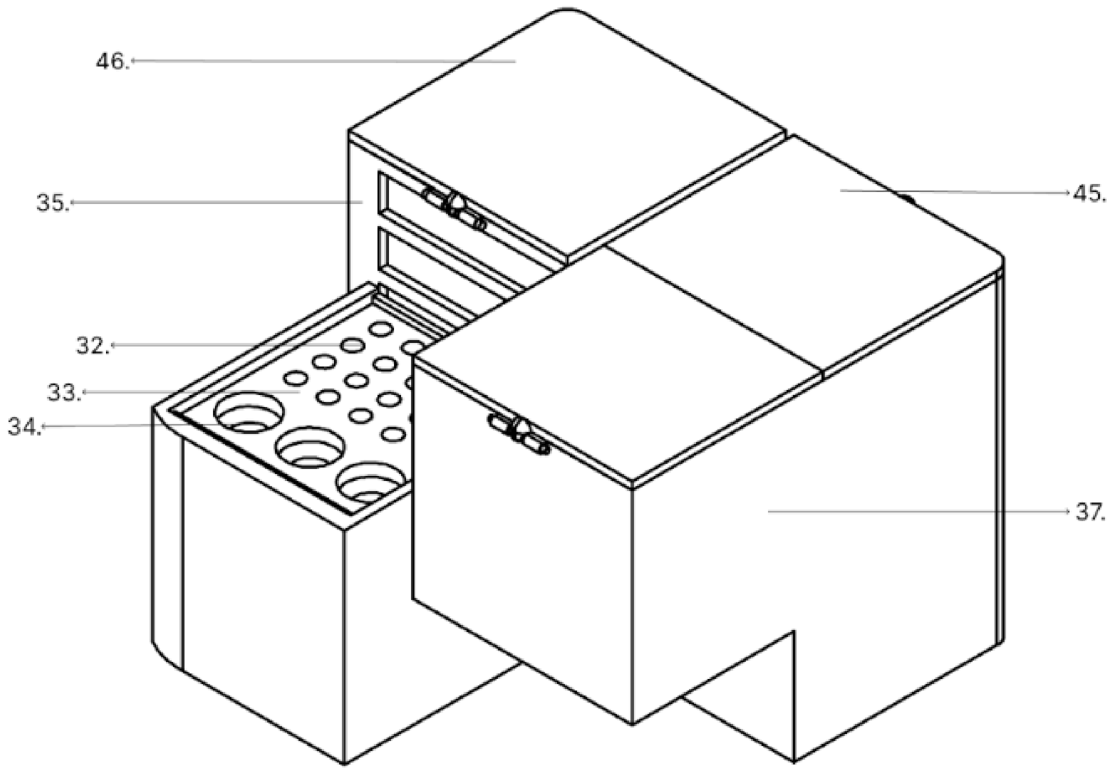

Figure 10

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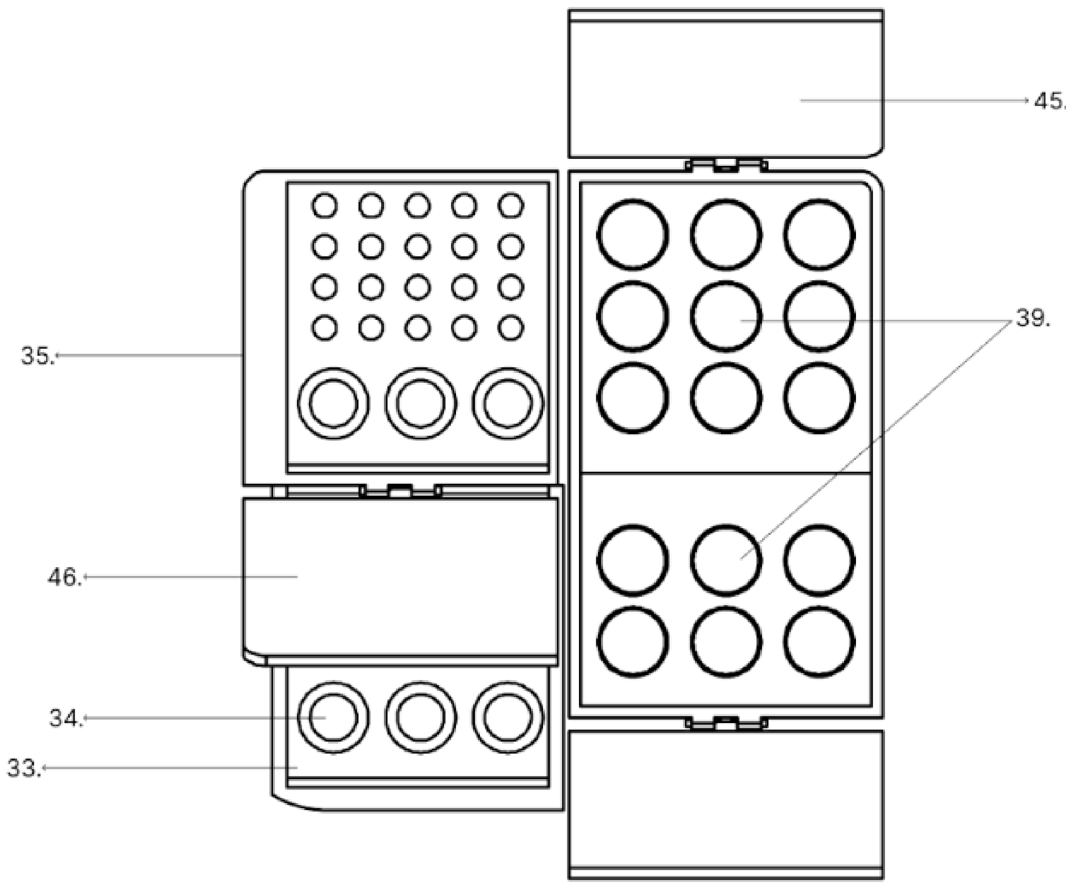

Figure 11

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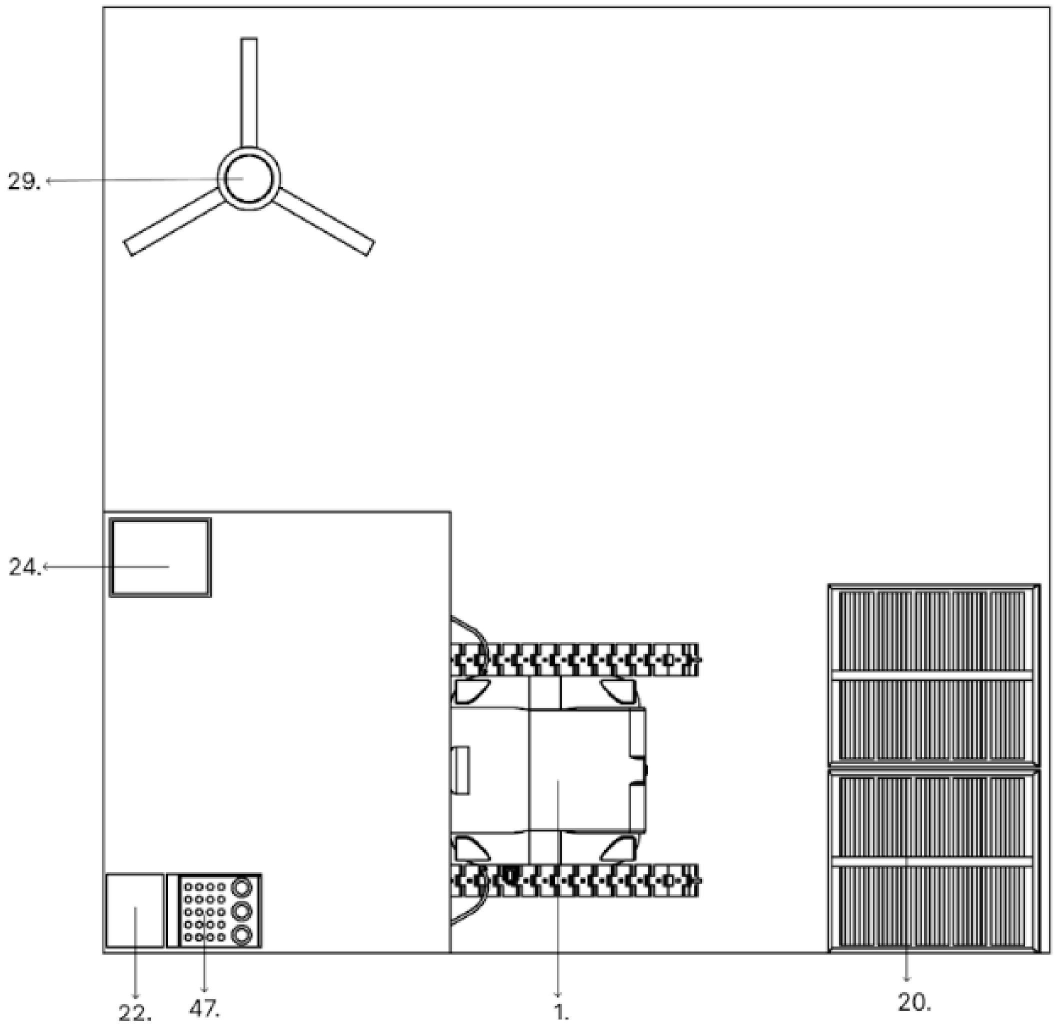

Figure 12

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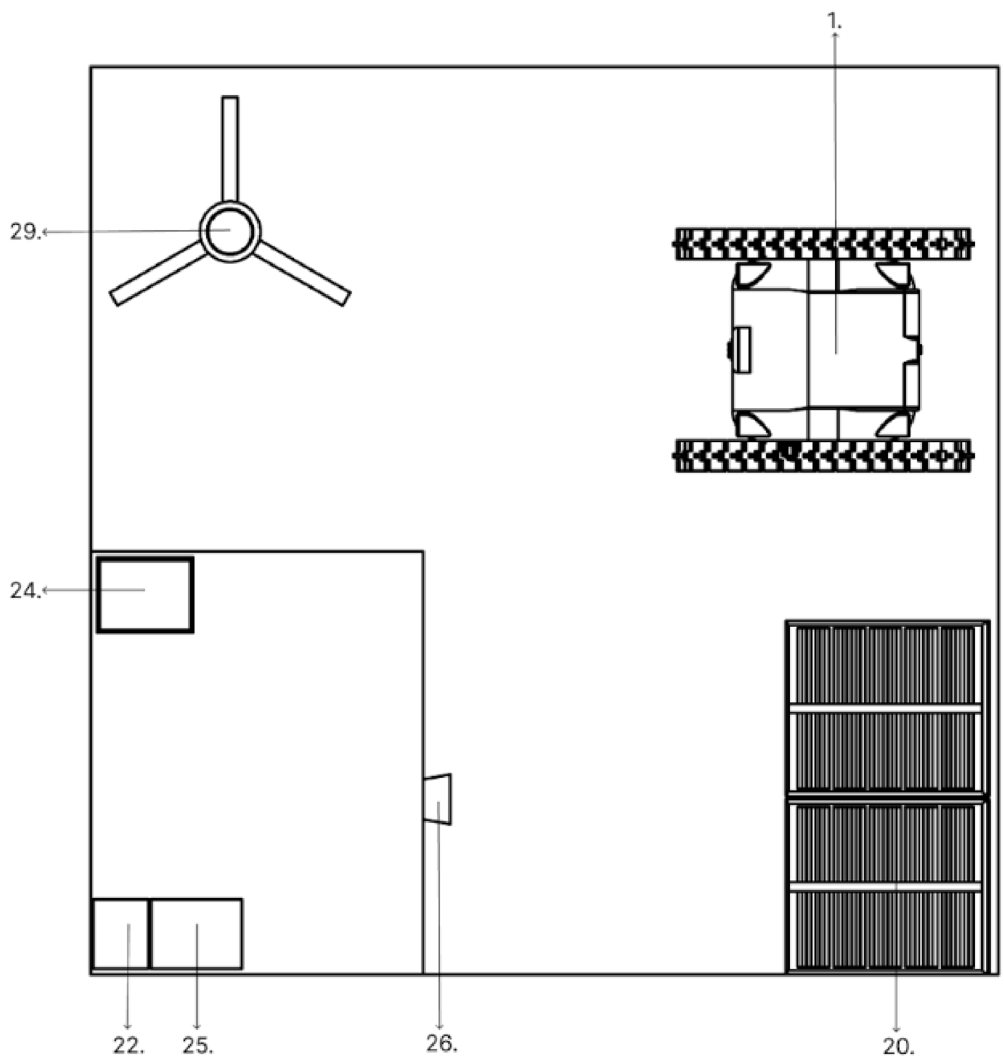

Figure 13

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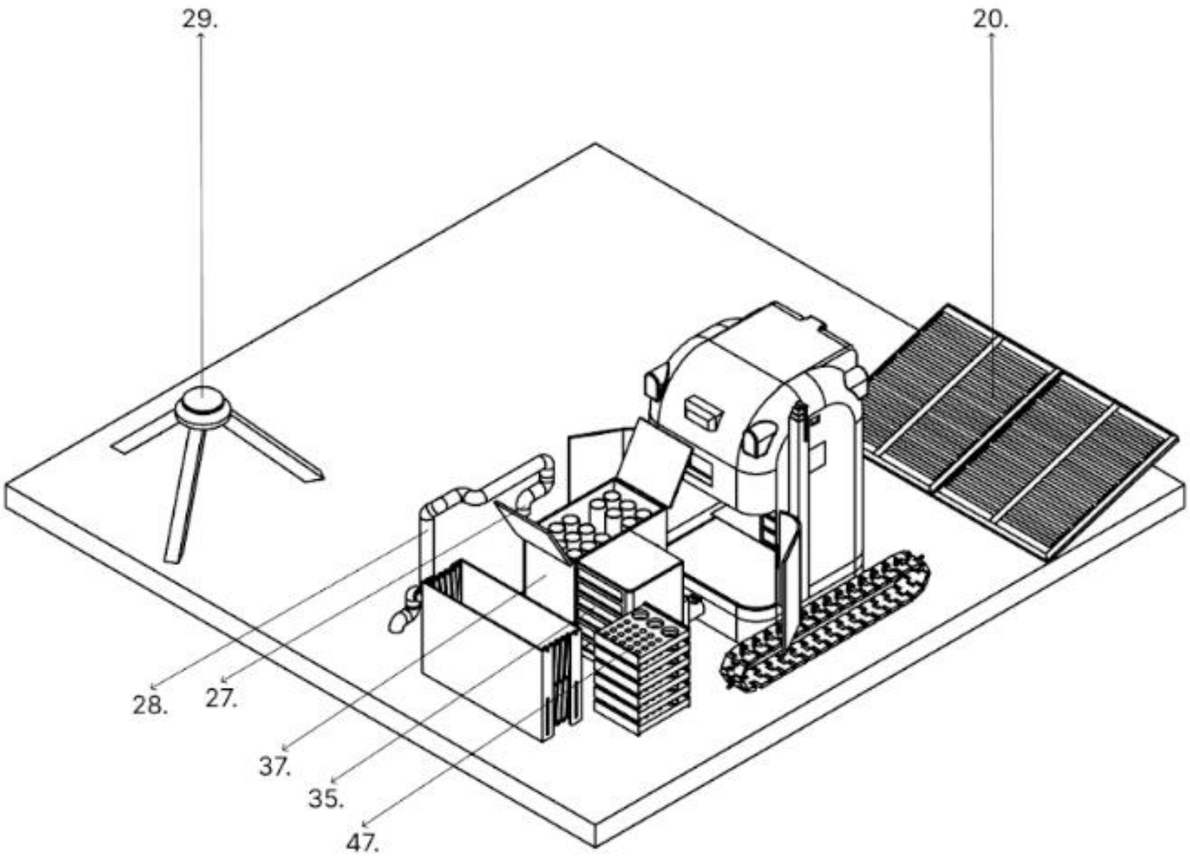

Figure 14

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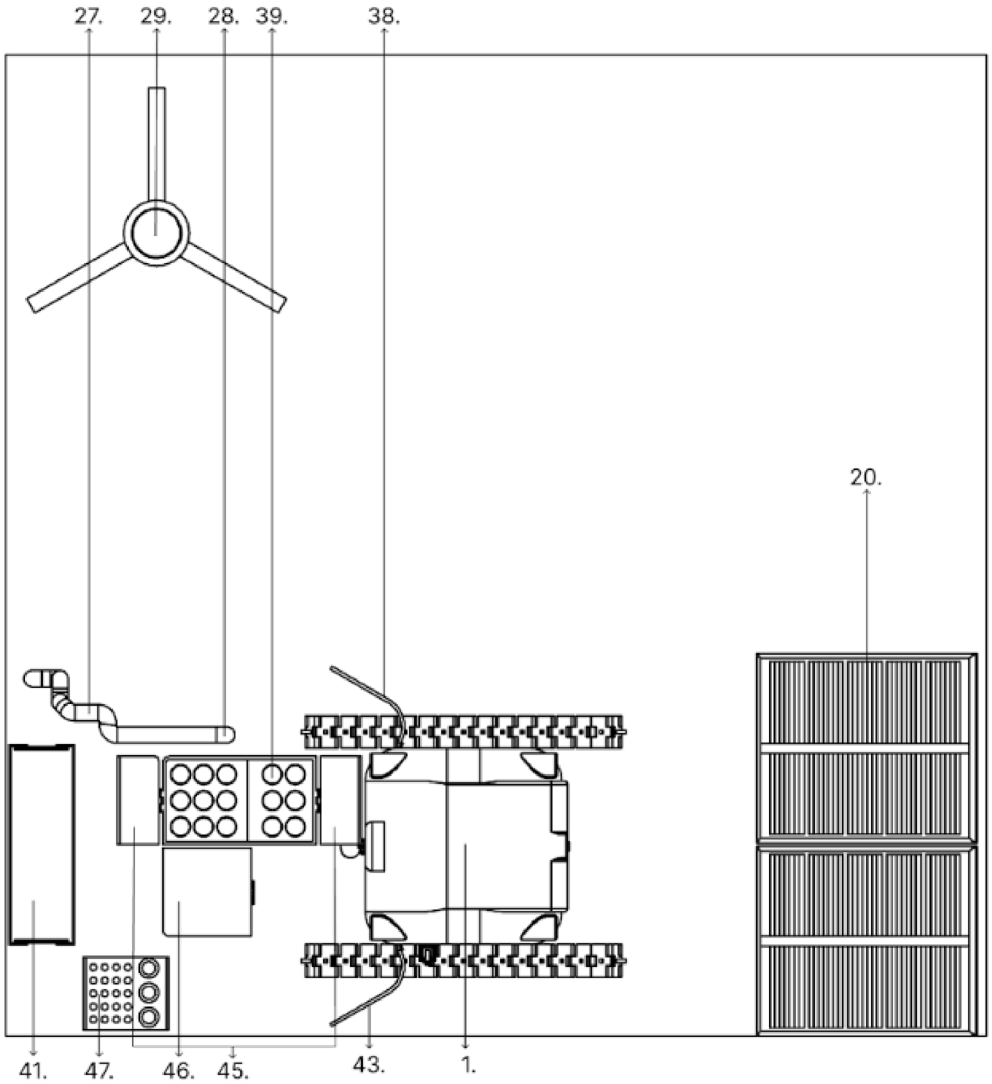

Figure 15

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