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(54) **MULTI-FUNCTIONAL ROBOT WITH REMOTE AND VIDEO SYSTEM**

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4,717,364 A	1/1988	Furukawa	446/175
4,736,826 A *	4/1988	White et al.	264/297.2
D297,749 S	9/1988	Rodis-Jamero	D21/150
D437,368 S	2/2001	Tsai	D21/637
6,243,623 B1 *	6/2001	Takenaka et al.	370/259
6,266,576 B1 *	7/2001	Okada et al.	703/23
6,289,265 B1 *	9/2001	Takenaka et al.	706/10
6,317,652 B1 *	11/2001	Osada	711/112
6,374,157 B1 *	4/2002	Takamura	382/209
6,415,203 B1 *	7/2002	Inoue et al.	700/245
2001/0047226 A1 *	11/2001	Saijo et al.	700/261

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(58) **Field of Search** 700/245, 250, 700/253, 257, 258, 259, 264; 318/568.11, 568.12, 568.13, 568.16, 568.21, 587; 701/23

(56) **References Cited**

U.S. PATENT DOCUMENTS

D251,628 S	4/1979	McQuarrie et al.	D21/150
D258,900 S	4/1981	Lanusse	D21/150
D262,643 S	1/1982	Wong	D21/150
D287,986 S	1/1987	Matsui	D21/150
4,654,659 A	3/1987	Kubo	340/825.76
D293,344 S	12/1987	Shiraishi	D21/150

OTHER PUBLICATIONS

Kuroki, A small biped entertainment robot, 2001, IEEE, pp. 3-4.*

Mohamed et al., Emulation of the human torso dynamic effects during walking gait, 2001, IEEE, pp. 562-567.*

Sardain et al., Gait analysis of a human walker wearing robot feet as shoes, 2001, IEEE, pp. 22852-2292.*

(List continued on next page.)

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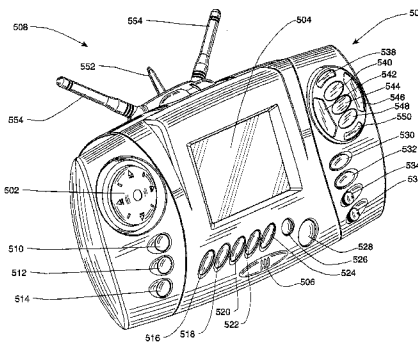
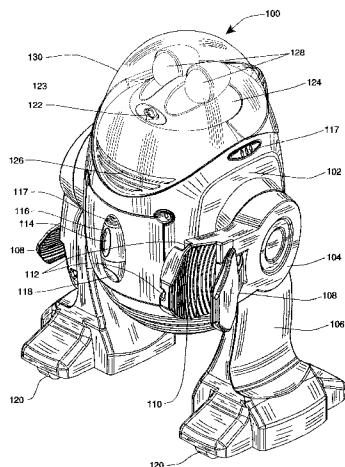
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(57) **ABSTRACT**

A robot which incorporates a body, two arms, two legs, several sensors, an audio system, a light assembly, and a video device. The sensors located throughout the body of the robot combined with an edge detection sensor allows the robot to interact with objects in the room, and prevents the robot from traveling off an edge or bumping into obstacles. The audio system allows the robot to detect and transmit sounds. The video device allows a user to remotely view the area in front of the robot. Additionally, the robot may operate in a plurality of modes which allow the robot to operate autonomously. The robot may operate autonomously in an automatic mode, a security mode, a greet mode, and a monitor mode. Further, the robot can be manipulated remotely.

54 Claims, 17 Drawing Sheets



OTHER PUBLICATIONS

Ishituro et al., Robovie: A robot generates episode chanins in our daily life, 2001, Internet, pp. 1-6.*

"Introducing the iRobot-LE™", iRobot Corporation: The iRobot-LE, <http://www.irobot.com/ir/index.htm>, downloaded Dec. 5, 2000, 2 pages.

"Elder Care", iRobot Corporation: The iRobot-LE: Many Uses, http://www.irobot.com/ir/iR_many_uses.htm, downloaded Dec. 5, 2000, 1 page.

"The Package", iRobot Corporation: The iRobot-LE: The Package, http://www.irobot.com/ir/iR_package.htm, downloaded Dec. 5, 2000, 2 pages.

"The Power to Transport Yourself Anywhere in the World", iRobot Corporation; The iRobot-LE: Take Control, http://www.irobot.com/ir/iR_take_control.htm, downloaded Dec. 5, 2000, 2 pages.

"All You Need is a High Speed Internet Connection", iRobot Corporation: The iRobot-LE: Requirements, http://www.irobot.com/ir/iR_requirements.htm, downloaded Dec. 5, 2000, 2 pages.

"Questions and Answers About the iRobot-LE™", iRobot Corporation: The iRobot-LE: Questions and Answers, <http://www.irobot.com/ir/qa.htm>, downloaded Dec. 5, 2000, 6 pages.

"iRobot-LE™ Technical Specifications", iRobot Corporation: The iRobot-LE: Technical Specifications, <http://www.irobot.com/ir/tech.htm>, downloaded Dec. 5, 2000, 2 pages.

Hamilton, Anita "Robots Take Over Toyland", Time for Kids, Feb. 23, 2001, p. 7.

"Here are just a few of the uses of the iRobot-LE™," iRobot Corporation: The iRobot-LE: Many Uses, http://www.irobot.com/ir/iR_many_uses.htm, downloaded Dec. 5, 2000, 2 pages.

* cited by examiner

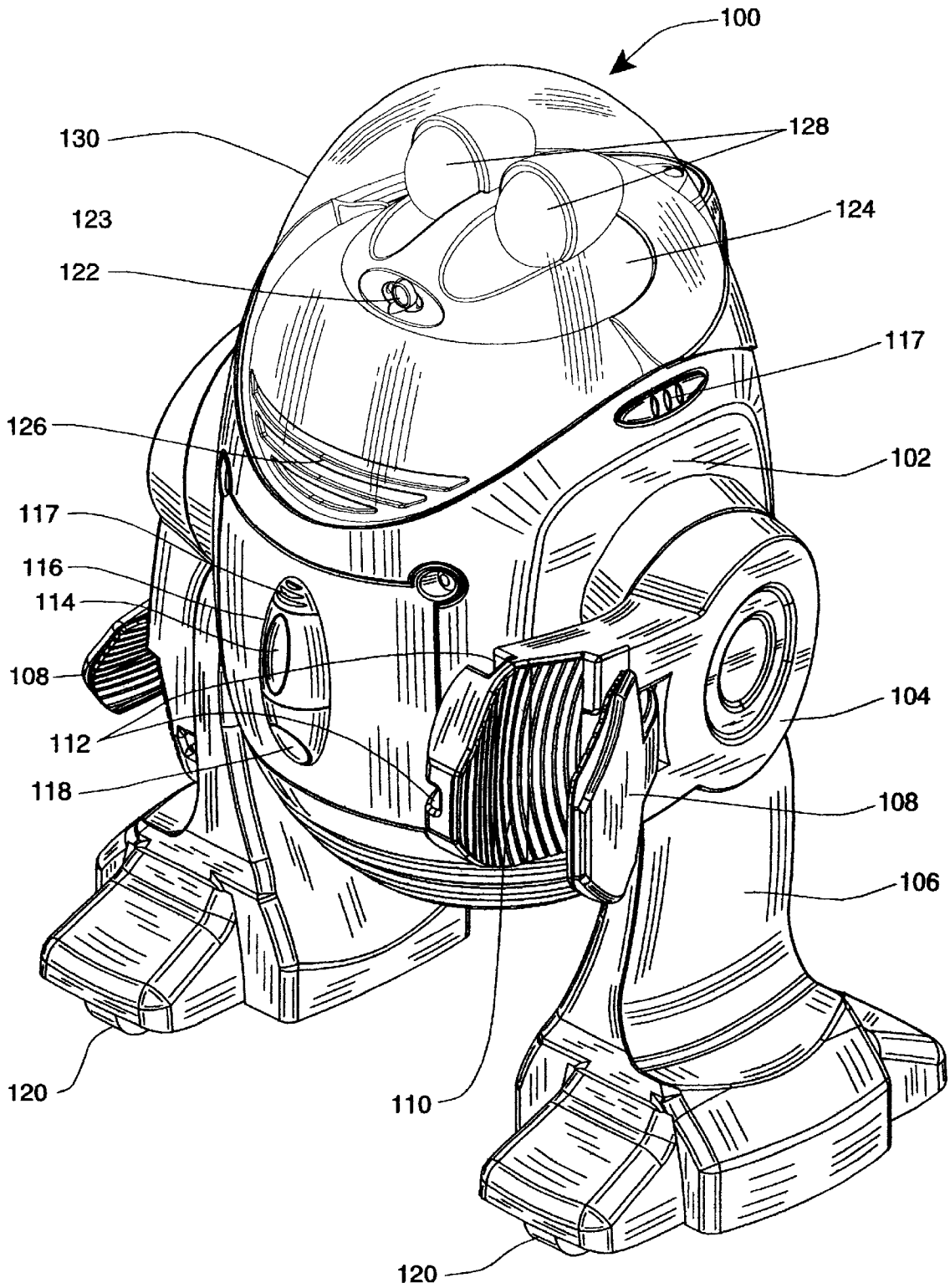


FIG. 1

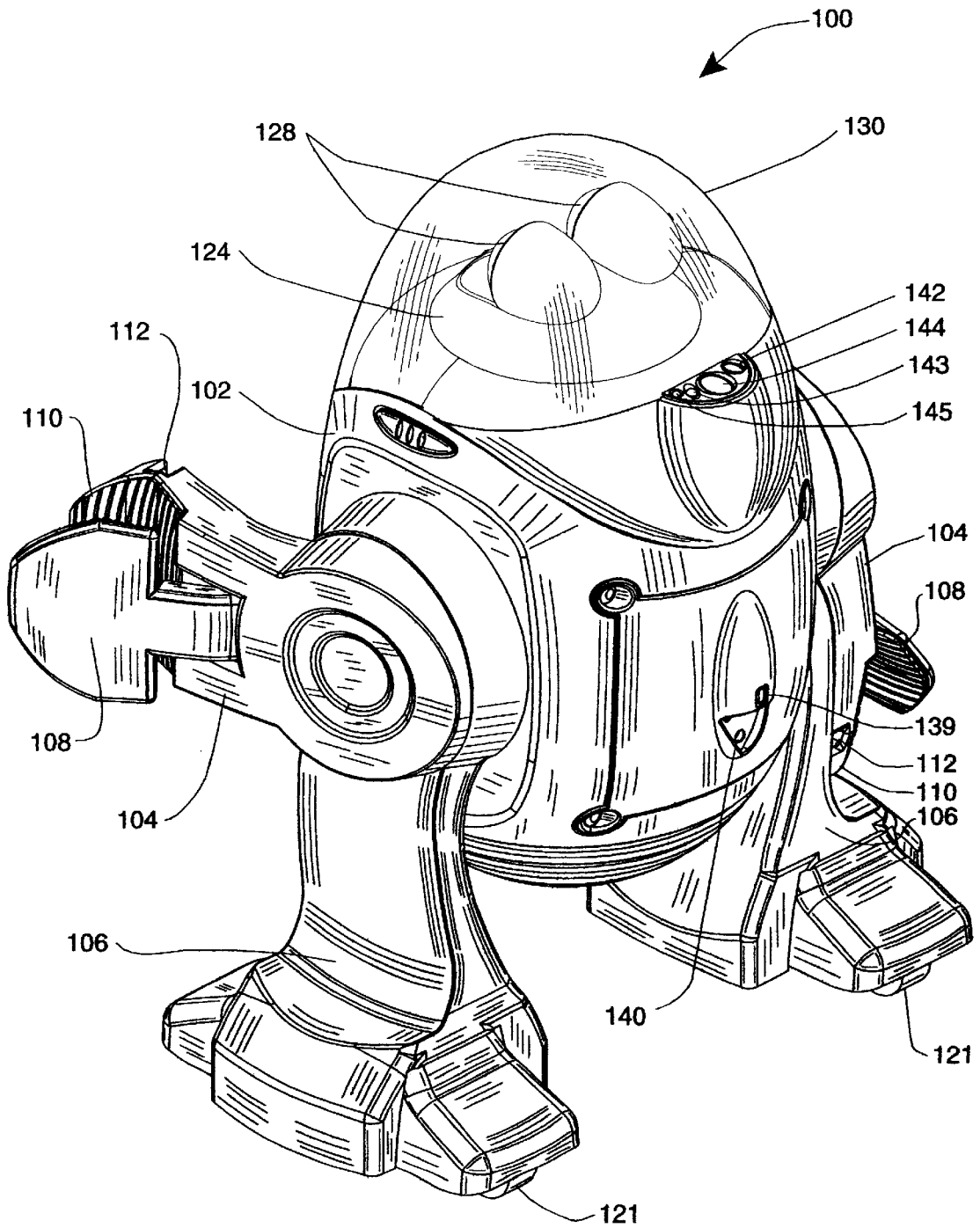


FIG. 2

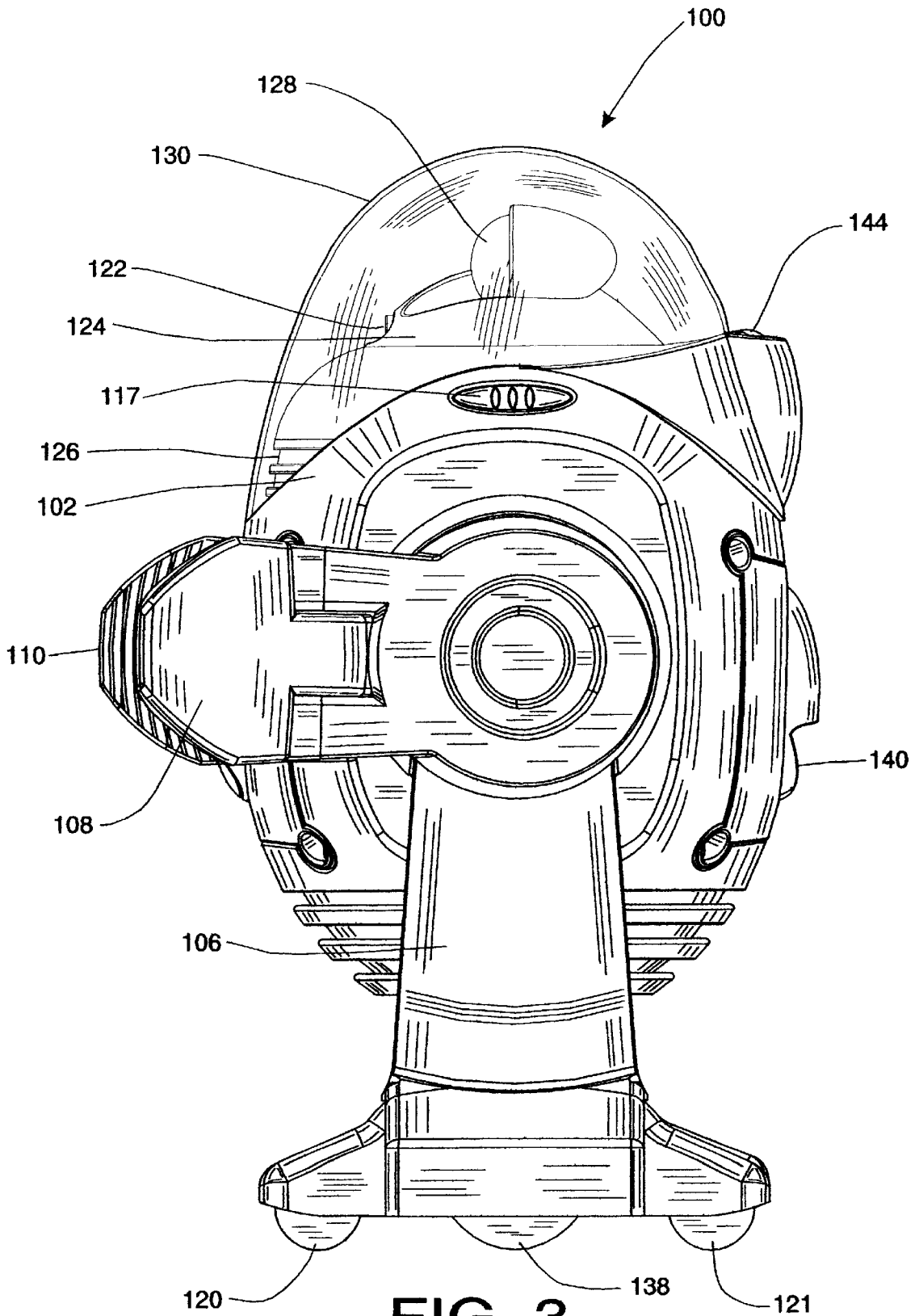


FIG. 3

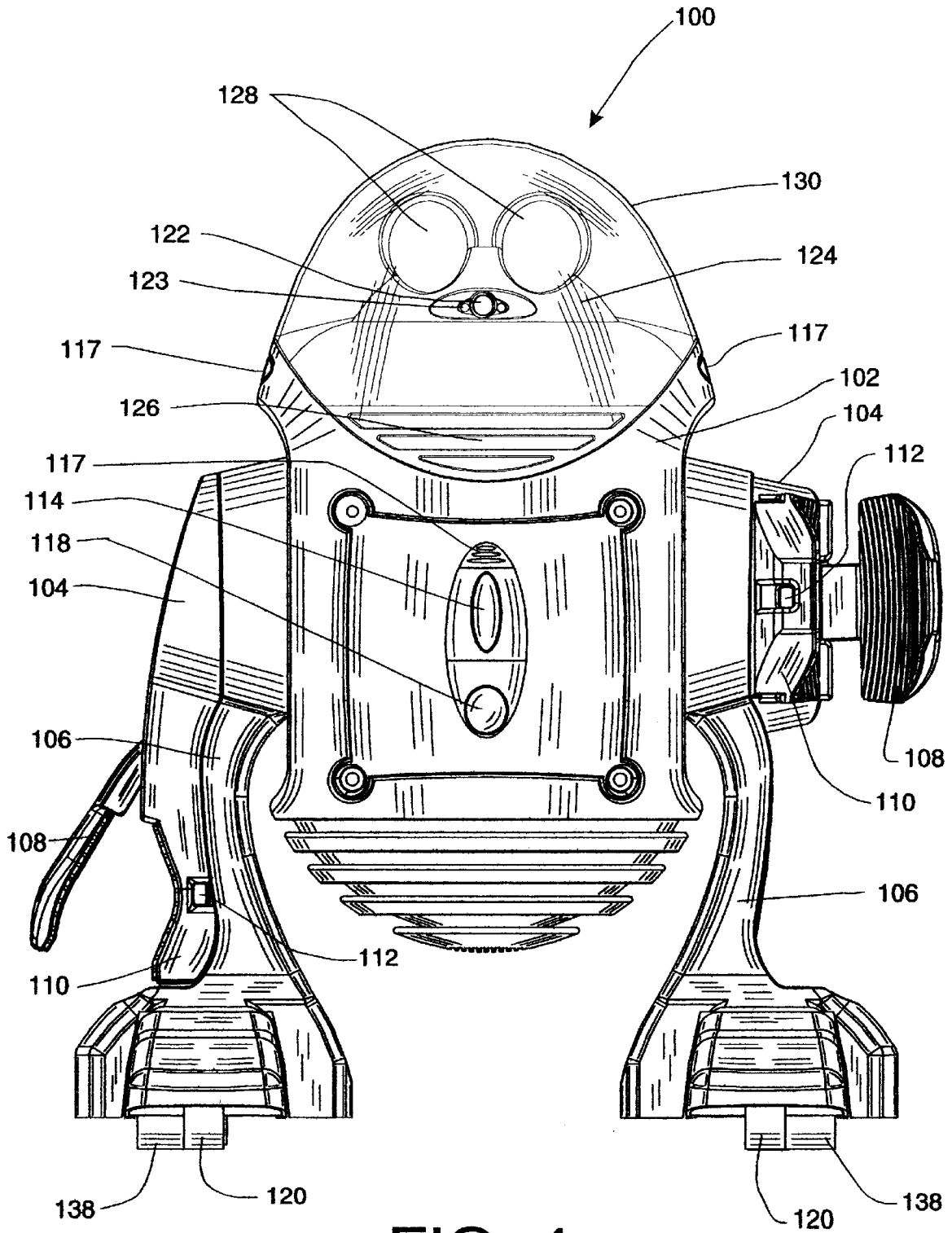


FIG. 4

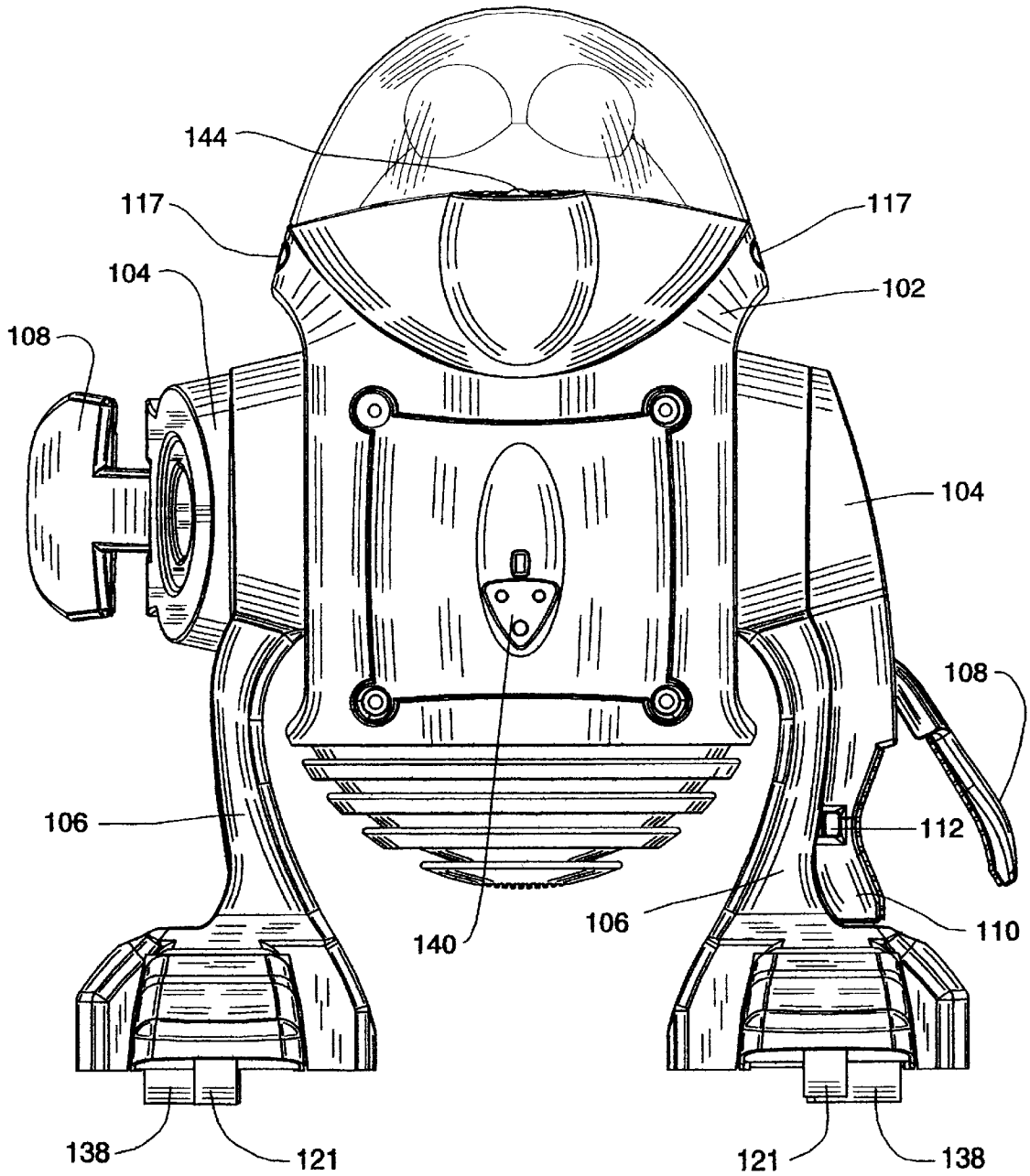


FIG. 5

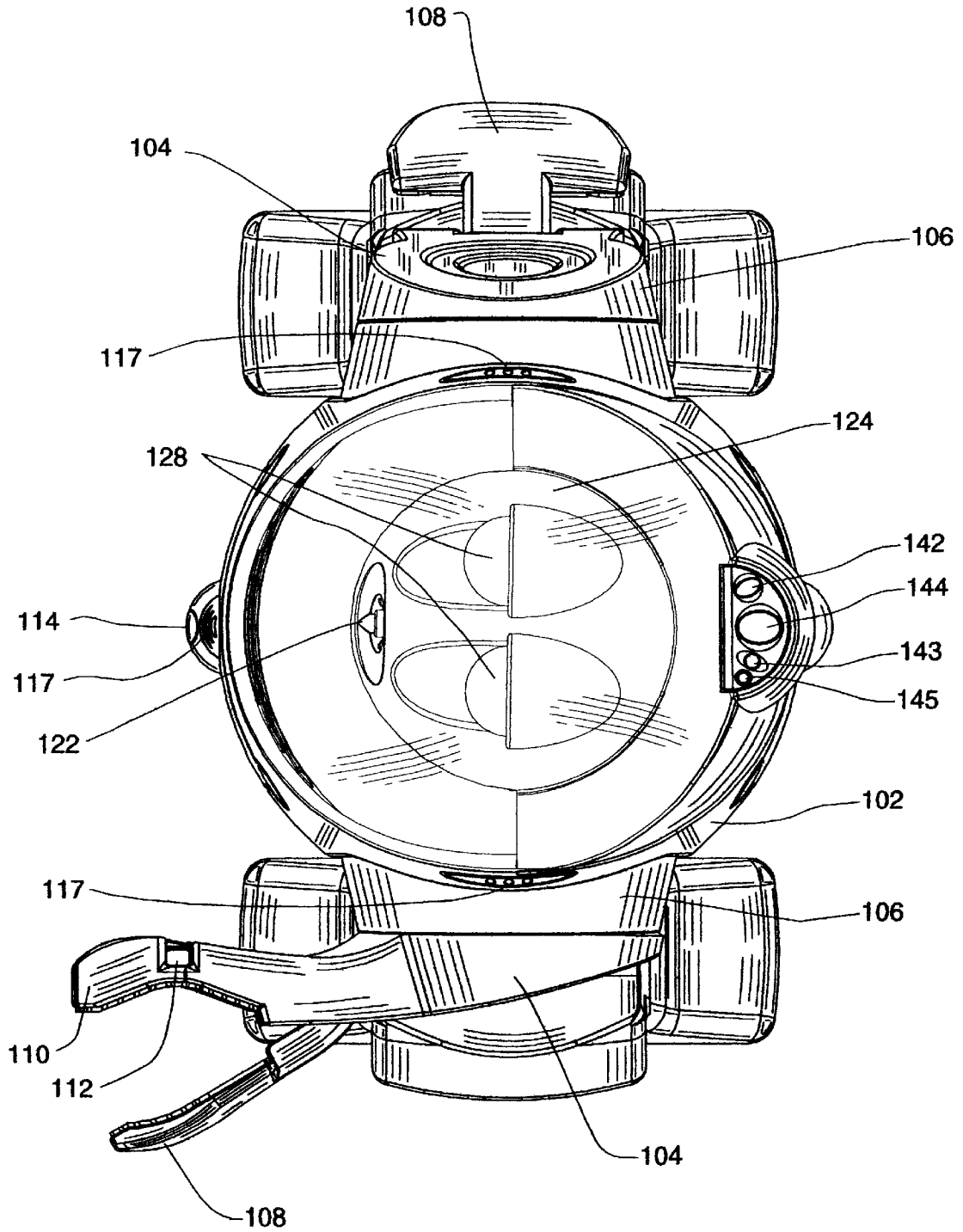


FIG. 6

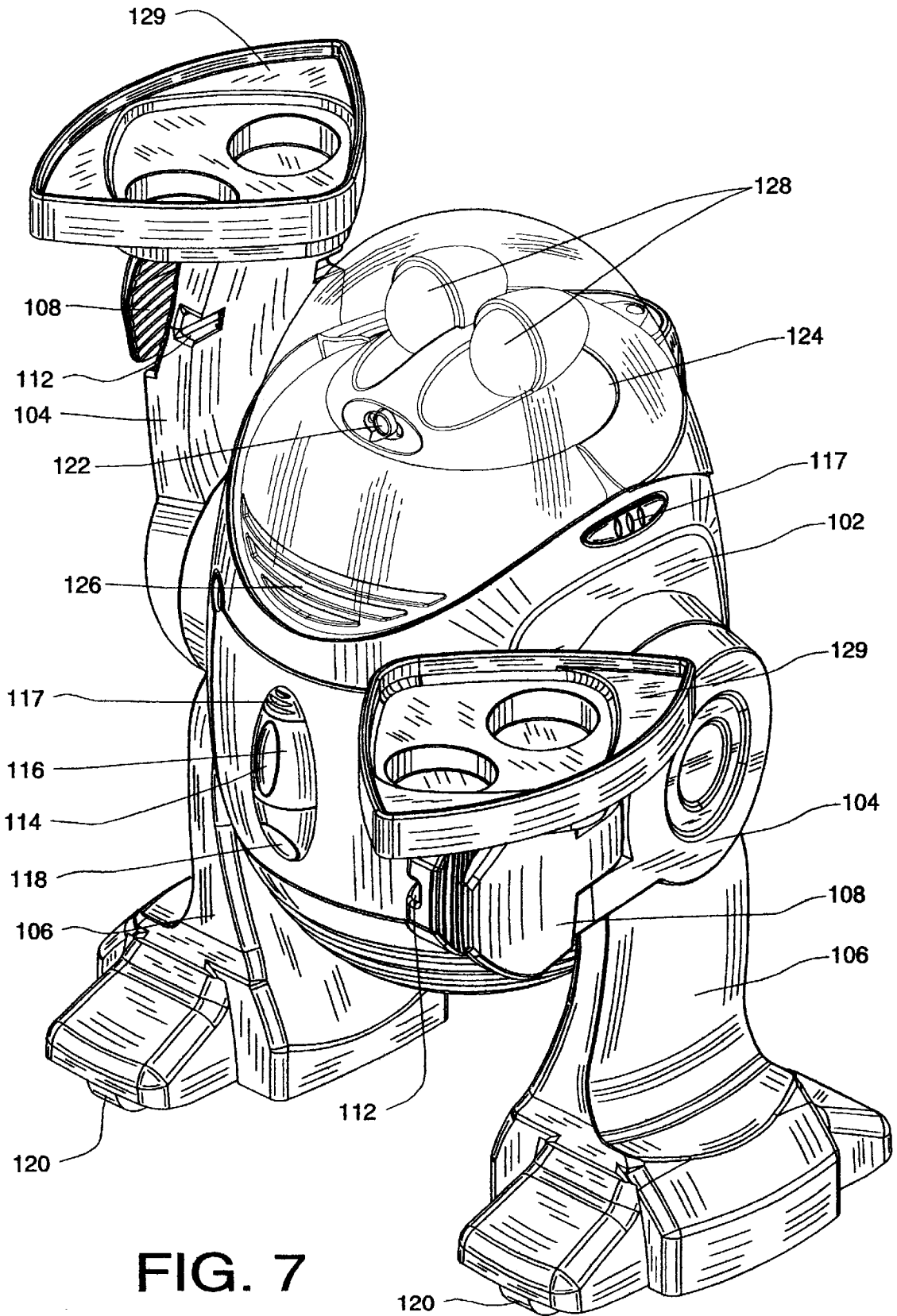


FIG. 7

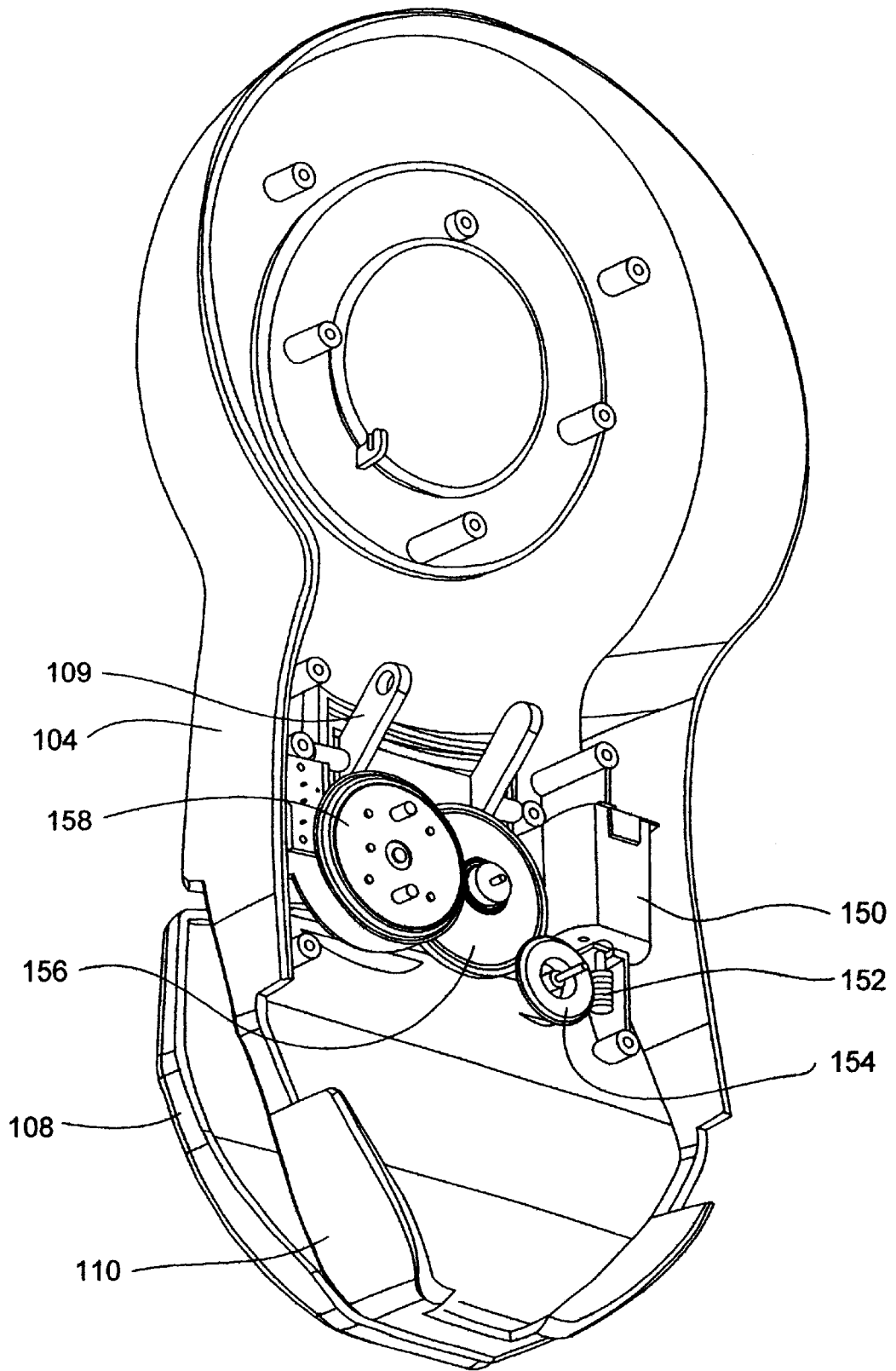


FIG. - 8

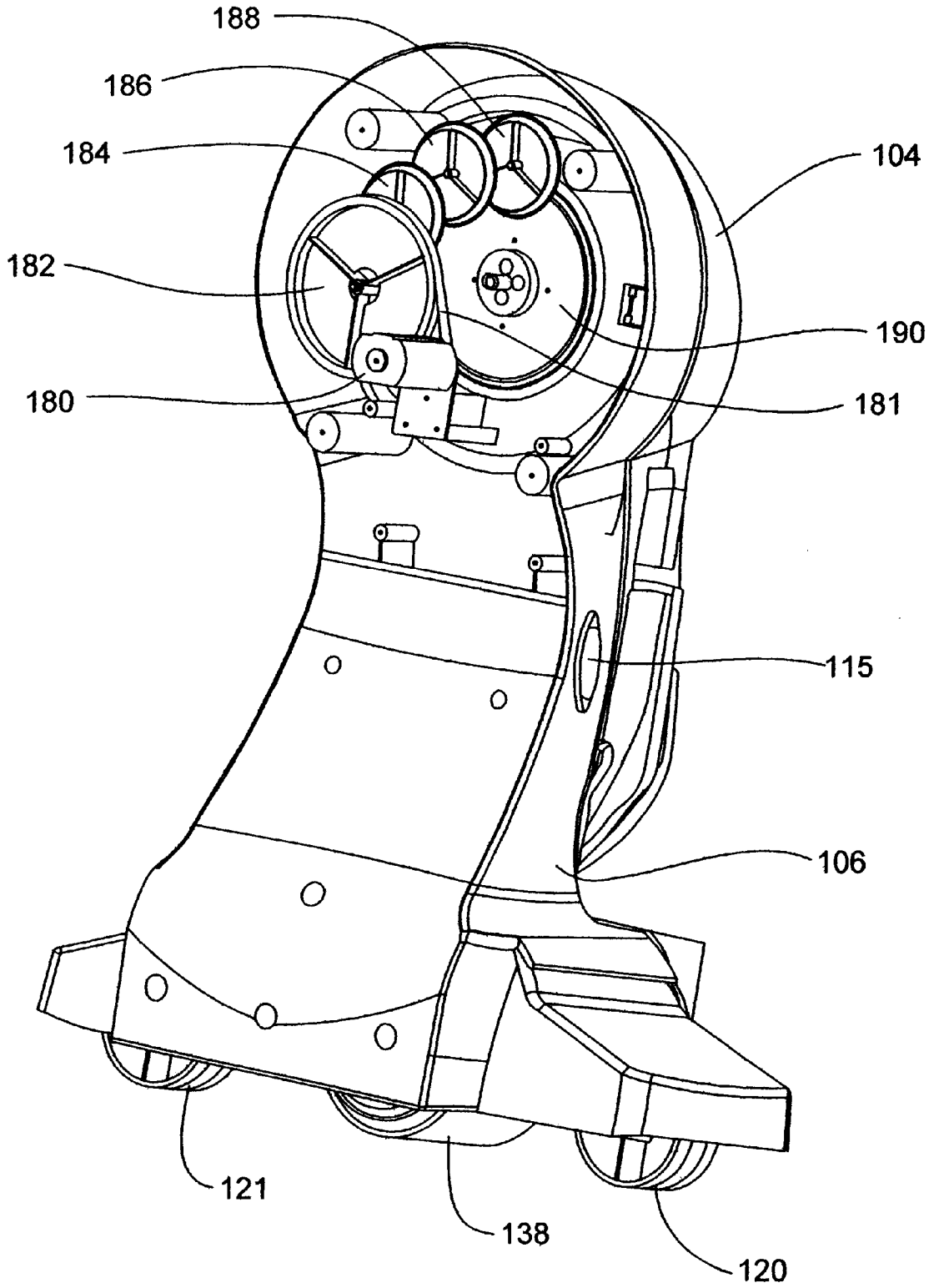


FIG. - 9

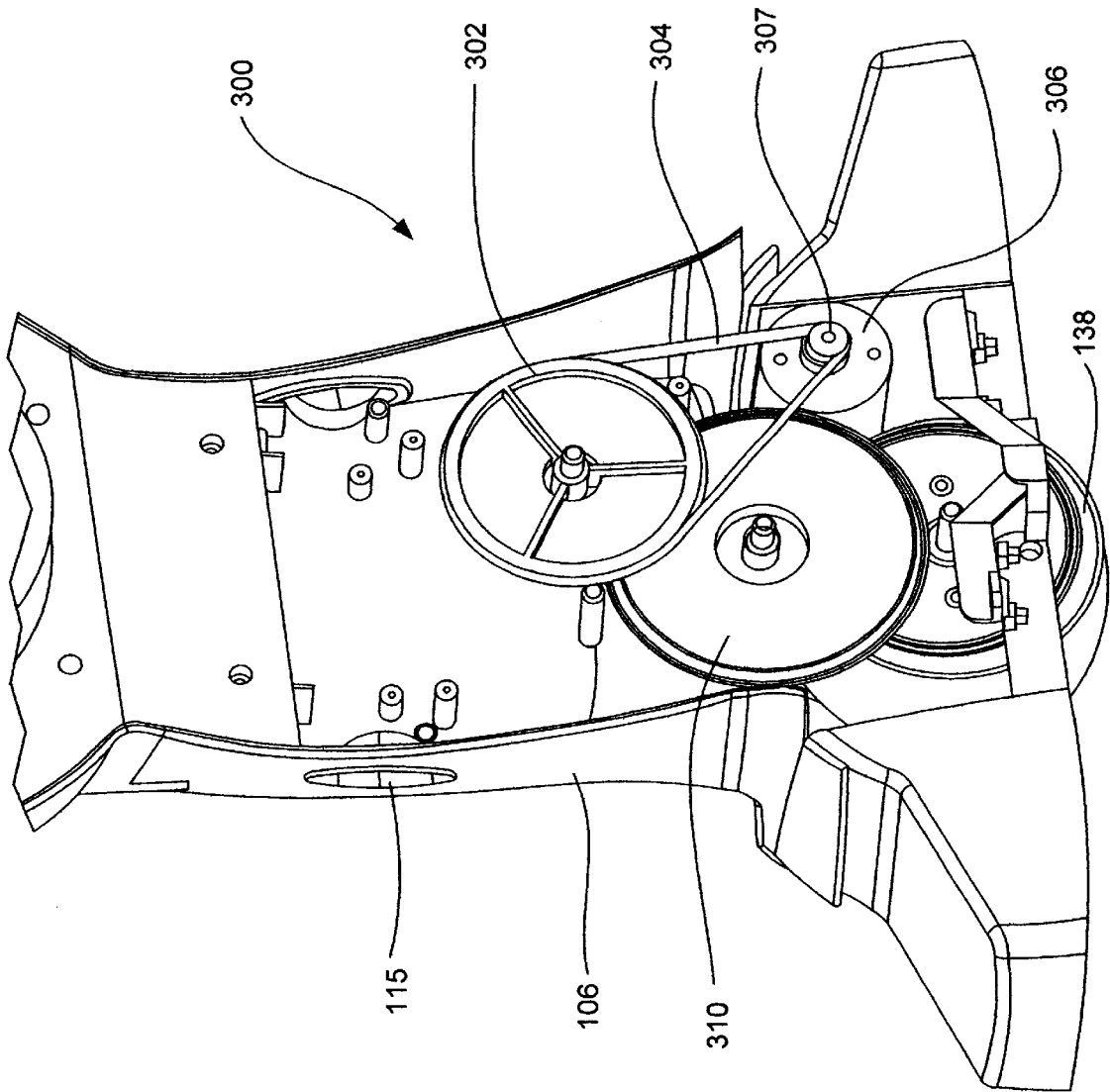
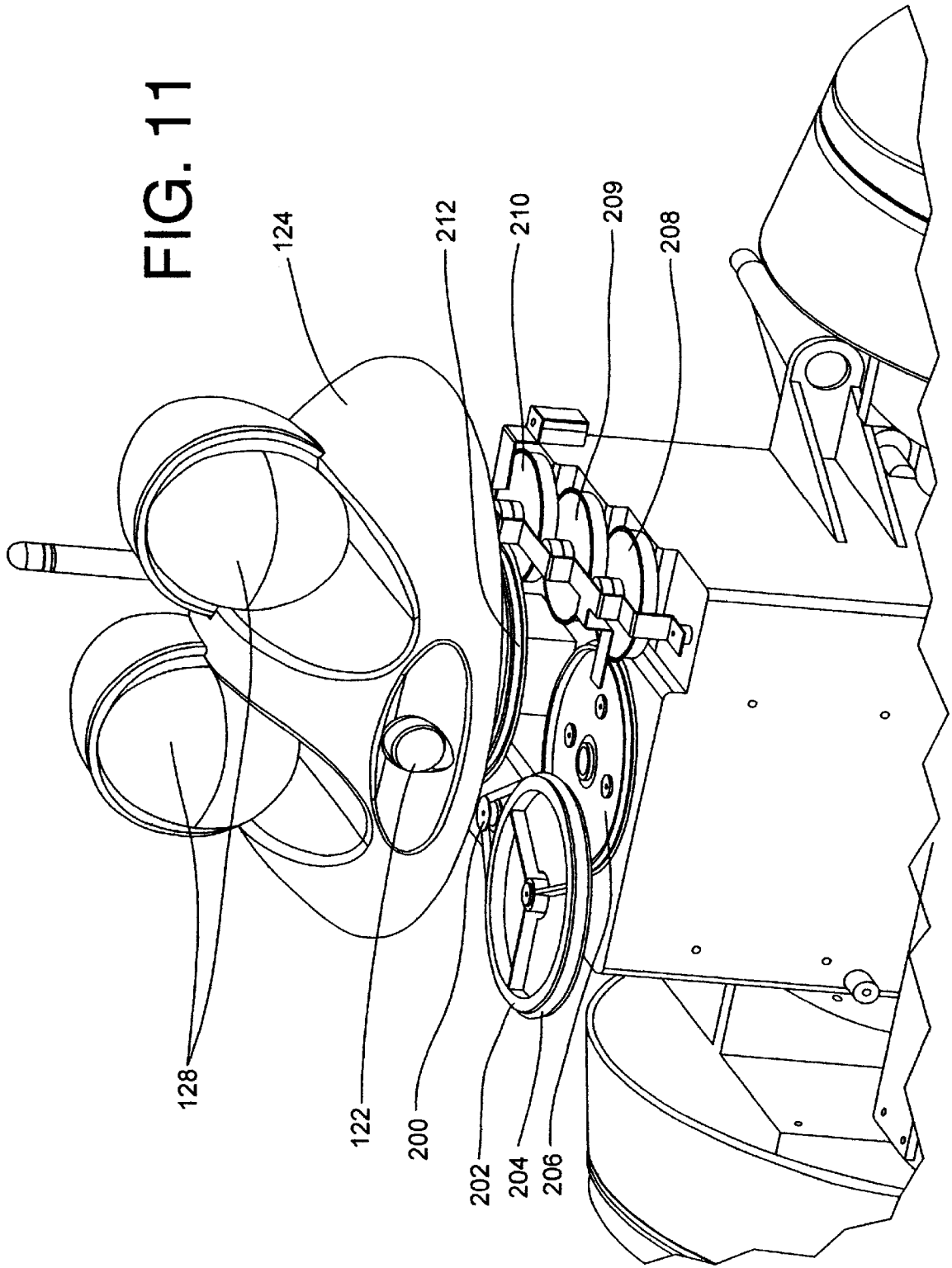


FIG. 10

FIG. 11



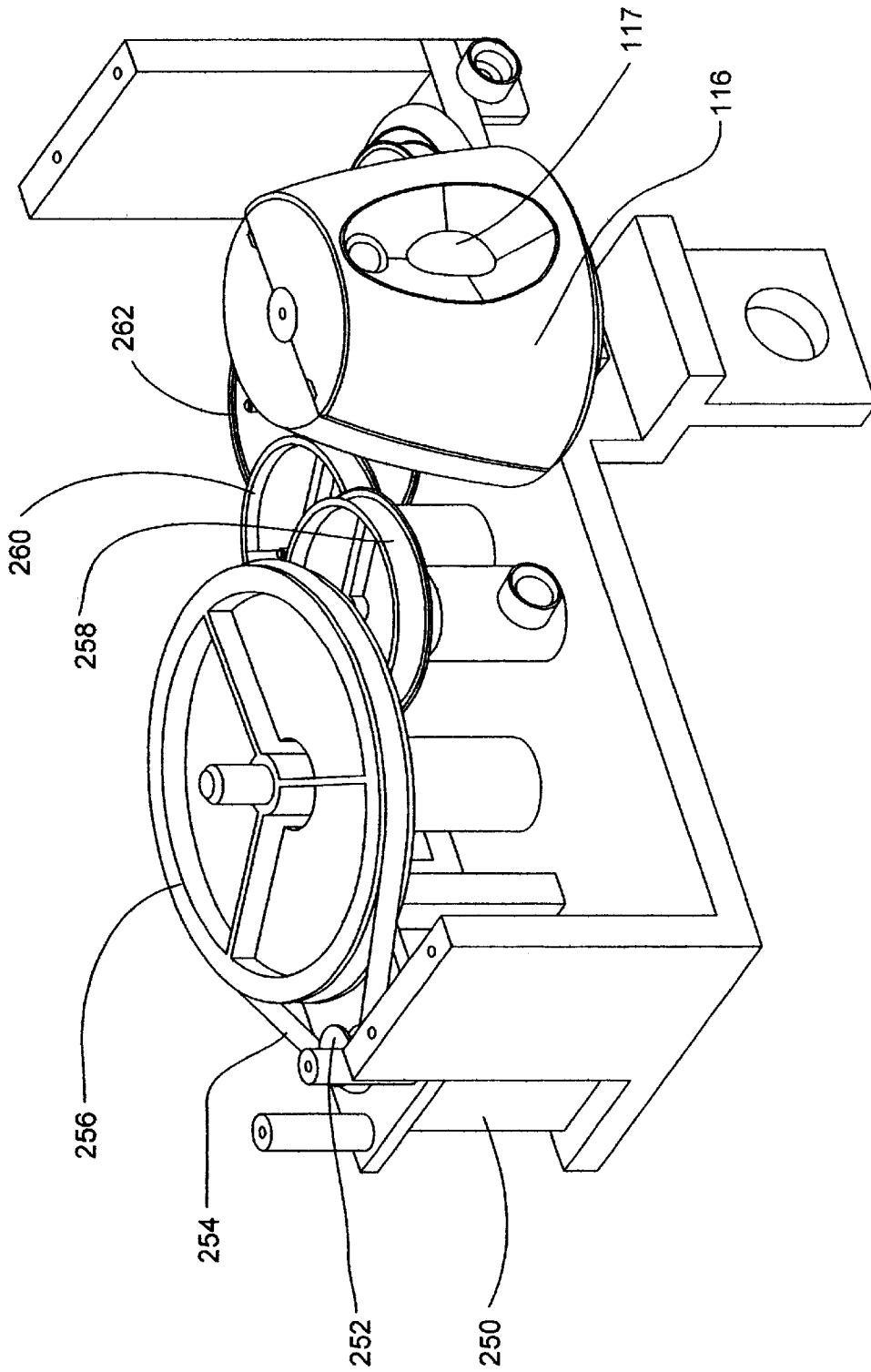


FIG. 12

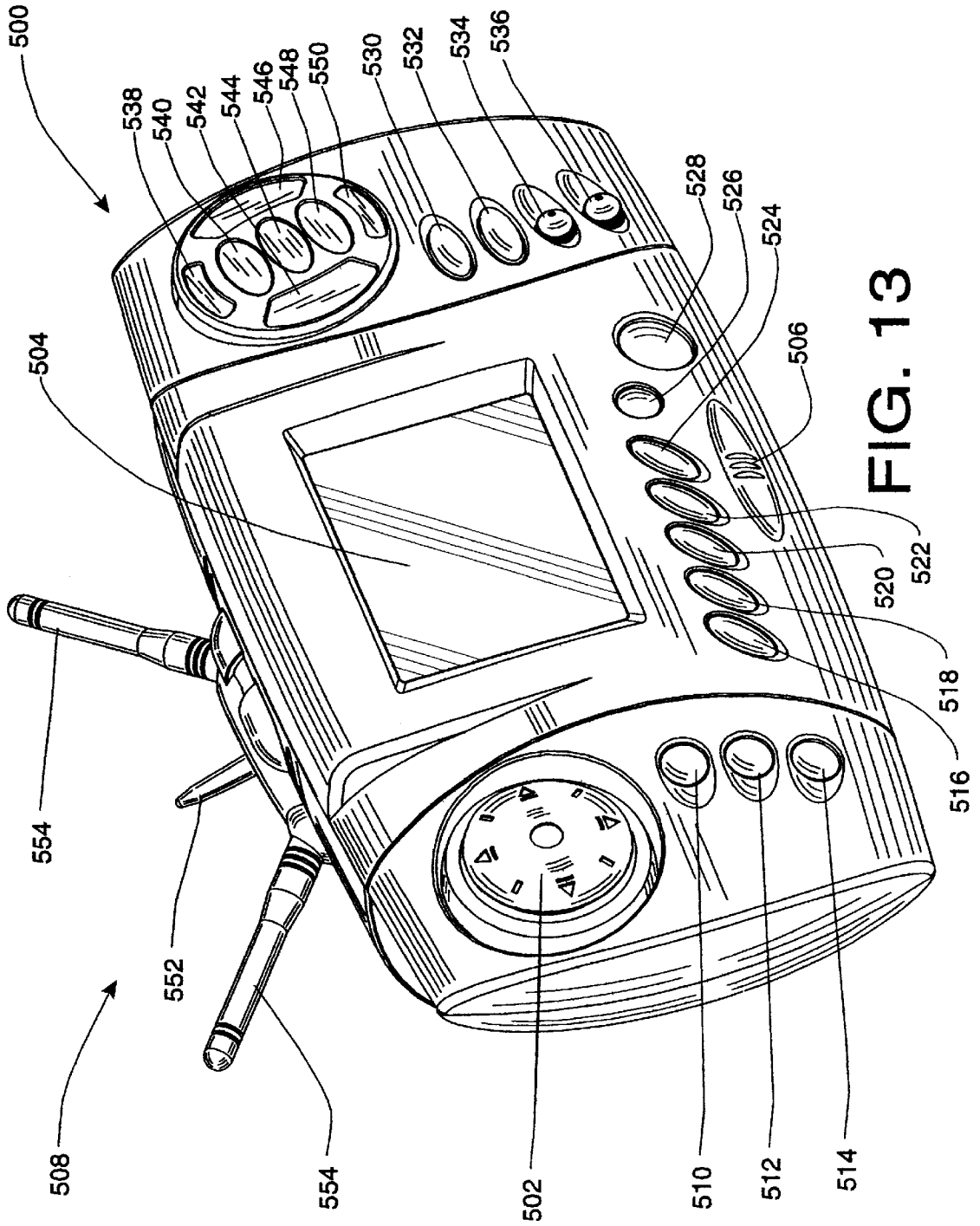


FIG. 13

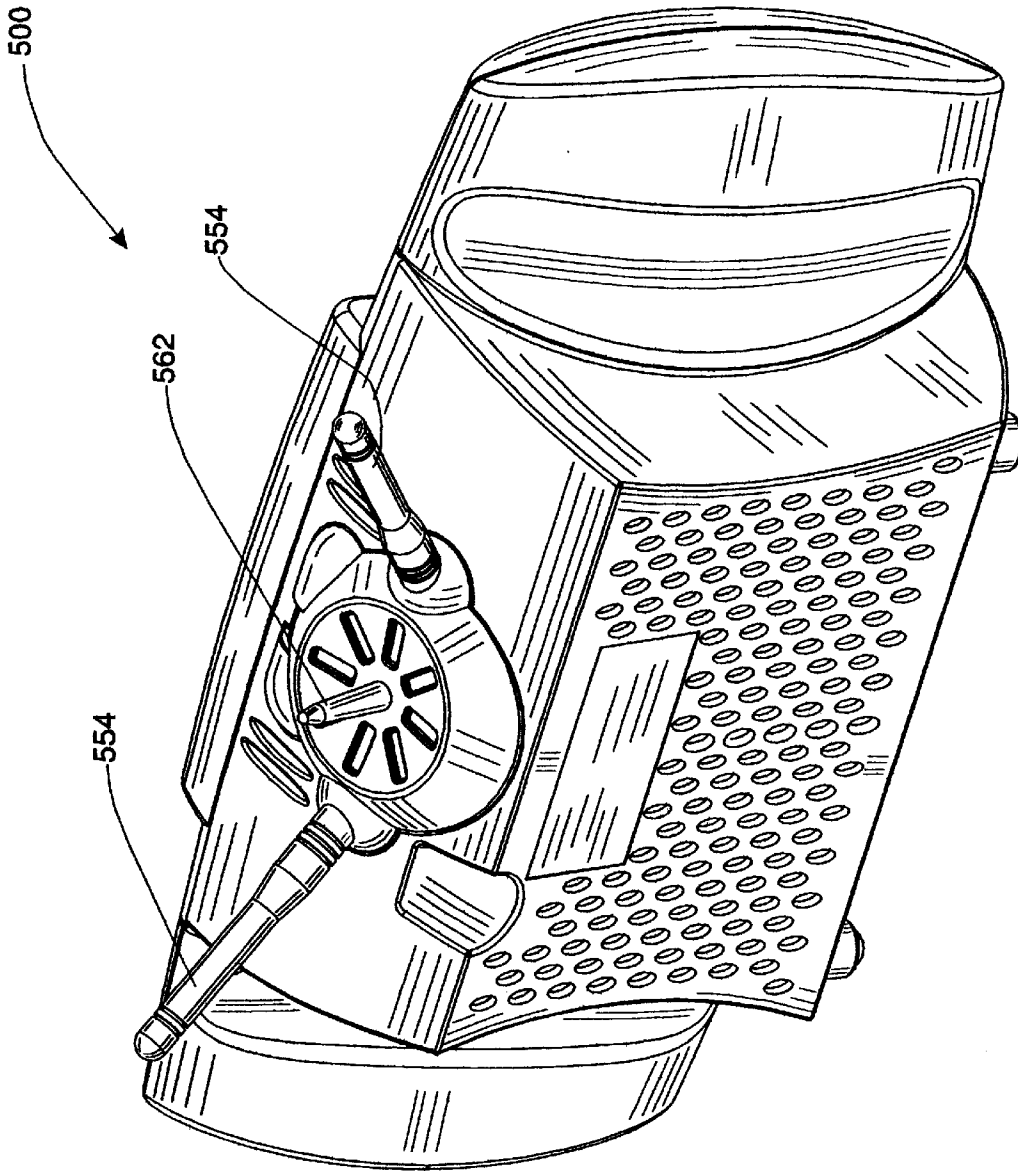


FIG. 14

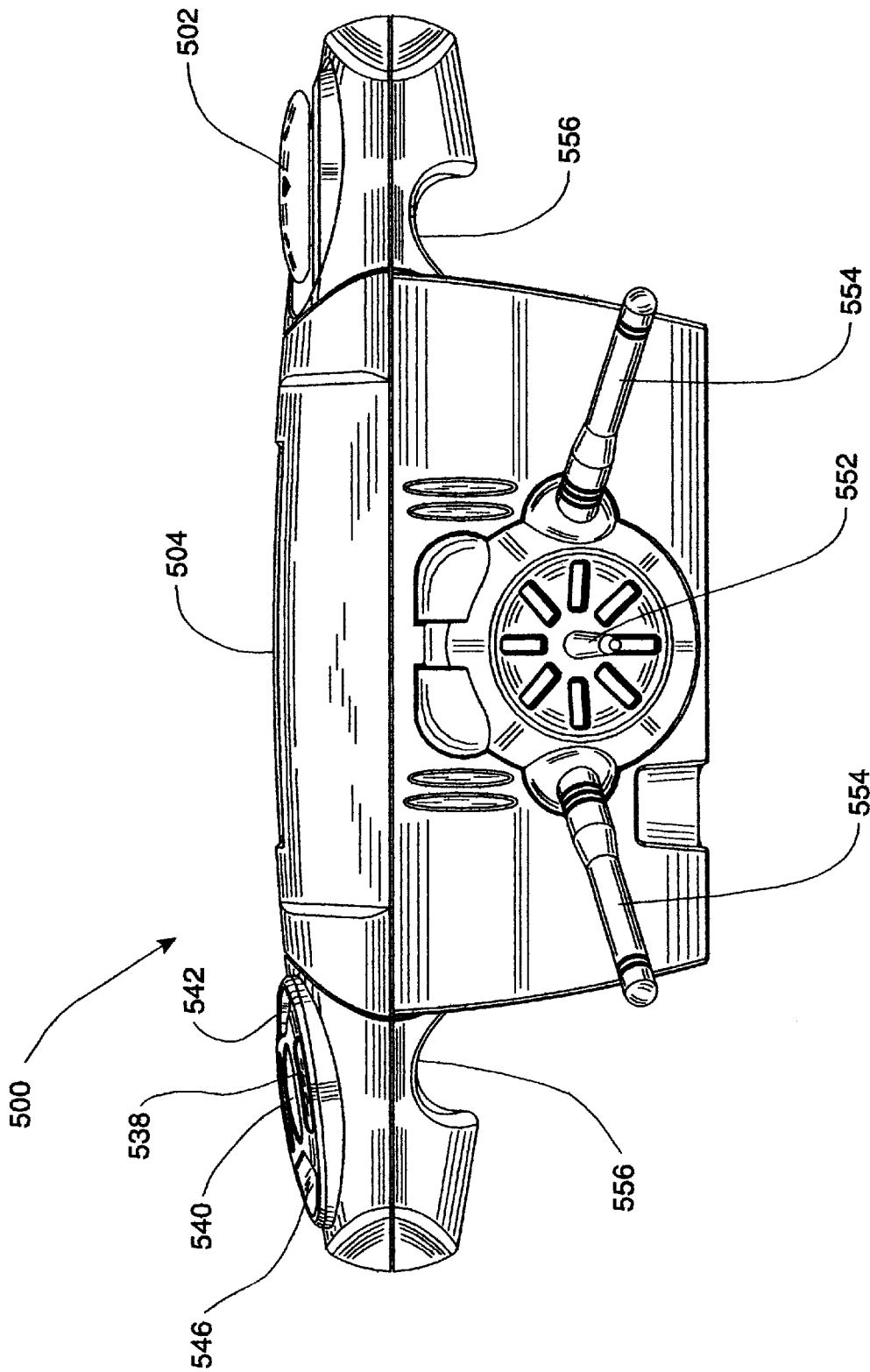


FIG. 15

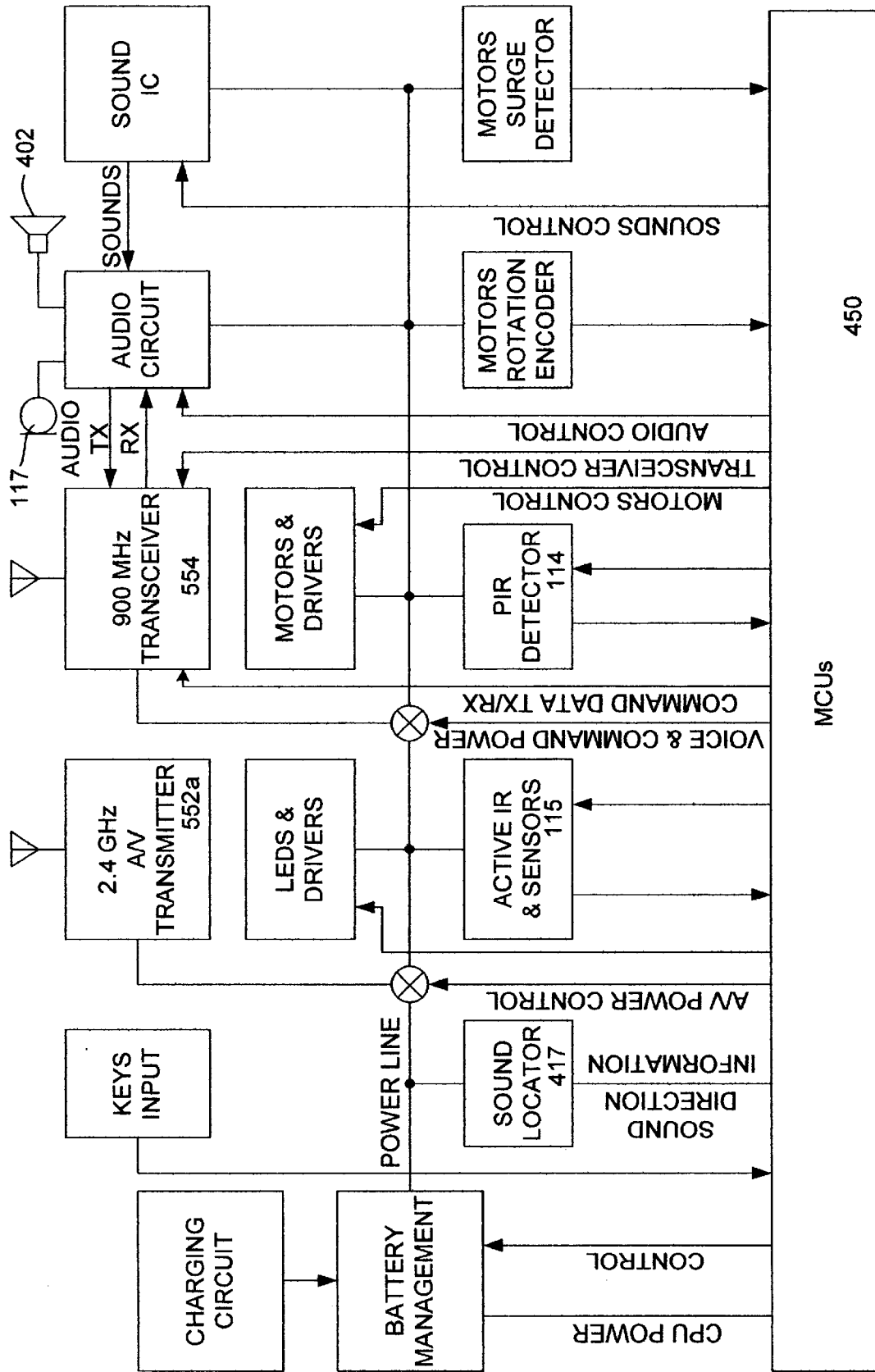


FIG. 16

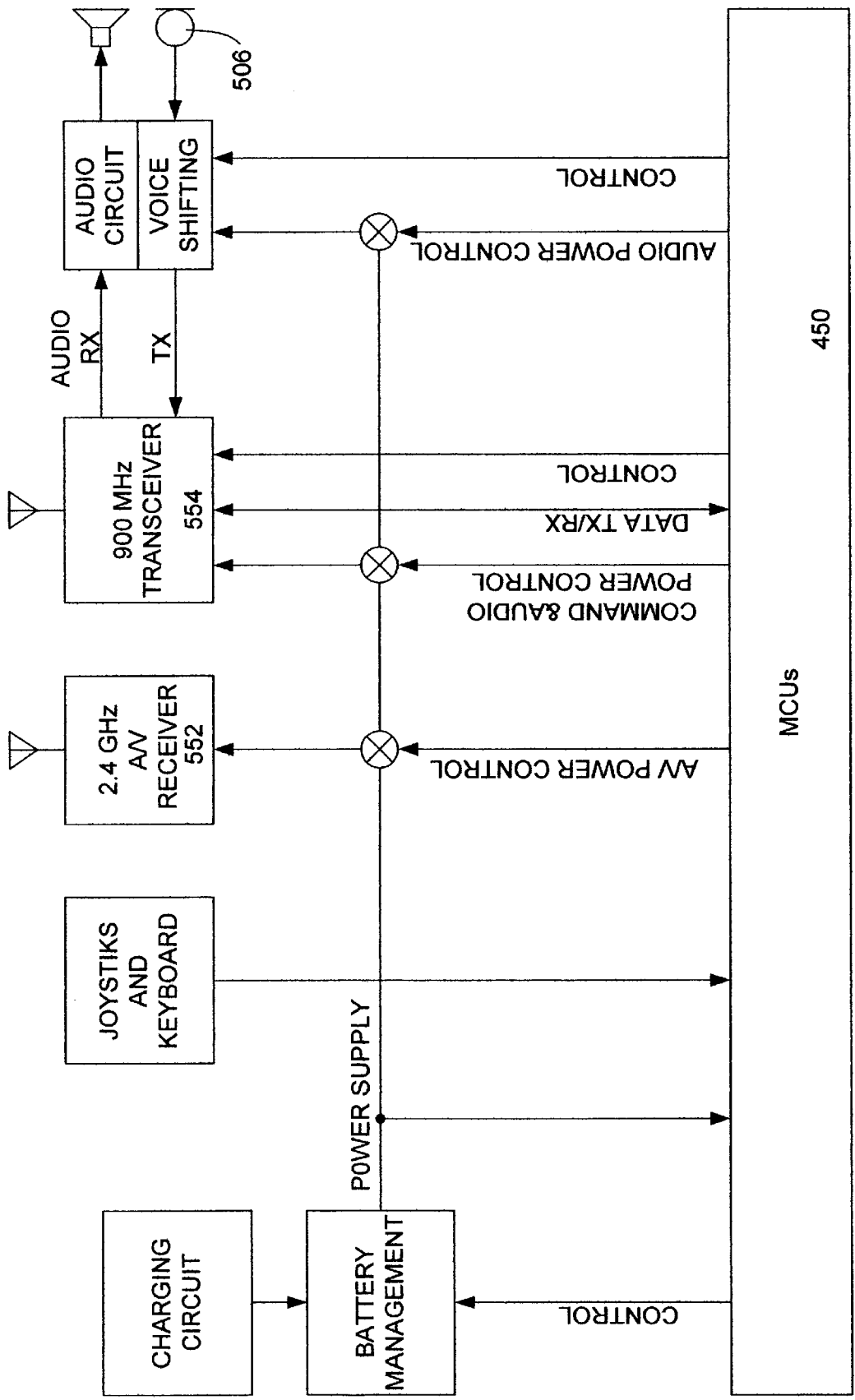


FIG. 17

MULTI-FUNCTIONAL ROBOT WITH REMOTE AND VIDEO SYSTEM

FIELD OF THE INVENTION

The present invention relates generally to a robot that can be manipulated remotely by a user or operate autonomously. More particularly, the robot can detect and avoid bumping into obstacles and traveling off an edge, thus allowing the robot to interact with objects in a room. Further, the robot can be manipulated remotely without the user requiring a line-of-sight with the robot. All of these features allow the robot to provide various security measures.

BACKGROUND

Remote controlled robots allow users to manipulate the robot using a remote control device, allowing the user to move the robot and perform simple tasks. Typically, to be able to see where the user is moving the robot, the user must have a line of sight with the robot. Otherwise, the user cannot see where the robot is and risks damage to the robot by driving it off an edge or colliding with an object.

Therefore, there is a need for a remote control device to have a video screen allowing the user to see the area in front of the robot. With a video screen on the remote control device, a user can move the robot in areas that are not in the user's line of sight. Thus, the robot can be moved into more areas.

Additionally, a robot traditionally cannot interact with people on its own. The user must typically manipulate every action of the robot. Therefore, there is a need for a robot to operate autonomously and interact with people it encounters. To accomplish this, a robot must have the ability to detect moving and stationary objects in the immediate vicinity. To safely operate autonomously, a robot must also have an edge detection system so as to not travel over an edge and damage itself.

Some robots have video cameras, enabling a user to view the area in front of the robot. However, typically the user may only view the image from the video camera through a computer. Therefore, there is a need for a hand-held remote control device with a video screen that a user can easily transport.

SUMMARY OF THE INVENTION

The present invention is a multi-function robot. The robot can operate autonomously or be manipulated remotely by a remote control device. To interact with people in a room, the robot is designed with two arms, legs, eyes, a mouth, and a head. The arms can rotate in several positions and further contains a hand-grip device. The hand-grip device allows the robot to hold and release objects. The legs of the robot are designed to move the robot throughout a room. The mouth and eyes of the robot allow it to communicate with people in the room and provide emotions.

To operate autonomously the robot has multiple sensors to avoid bumping into obstacles within the room and traveling off an edge. The sensors include infrared devices located on the body of the robot and an edge detection element located in the legs of the robot. The robot also has several modes by which it can operate autonomously. For example, an automatic mode allows the robot to move autonomously throughout the room, detect people within the room, and interact with the people. The robot can also provide security to the household when it is the security mode. In security

mode the robot can detect noise and send an alarm signal to the remote control device to alert the user that an object has been detected. The robot can also greet people when in the greet mode. Additionally, the robot may be placed in the monitor mode, which allows a user to remotely view objects in front of the object and hear sounds within the vicinity of the robot. Finally, the robot can be placed in the remote control mode which allows a user to remotely manipulate the robot.

To enhance the operation of the modes described above, the robot can display moods through lighting of its eyes and mouth. Depending on the mode the robot is operating from and the type of speech the robot is making, the eyes will change colors to express a different mood. Further, while the robot is speaking the mouth will display different patterns.

To operate manually, a remote control device is used to manipulate the robot remotely. The remote control device contains all the functions a user will need to manipulate the robot. For example, the remote control device contains a joystick, video display, a microphone, a transmitter/receiver, and several other controls to manipulate the robot. The joystick allows the user to translate motion of the robot in several directions. The video display allows the user to remotely view the area in front of the robot through the video camera on the robot. The user can also transmit his voice to the robot such that his voice is projected from the robot.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front perspective view of an embodiment of the robot of the invention with the left arm in a raised position and both hands in an open position;

FIG. 2 is a rear perspective view of the robot with the left arm in a raised position and both hands in an open position;

FIG. 3 is a left side view of the robot with the left arm in a raised position and the hand in an open position;

FIG. 4 is a front view of the robot with the left arm in a raised position and both hands in an open position;

FIG. 5 is a rear view of the robot with the left arm in a raised position and both hands in an open position;

FIG. 6 is a top view of the robot with the left arm in a raised position and both hands in an open position;

FIG. 7 is a front perspective of the robot thereof with the left arm in a 90° raised position carrying a tray, and the right arm in a 180° raised position carrying a tray;

FIG. 8 is a cutaway view of an arm of the robot illustrating the mechanism to open and close the hands of the robot;

FIG. 9 is a cutaway view of a leg of the robot illustrating the mechanism to rotate the arms;

FIG. 10 is a cutaway view of a leg of the robot illustrating the drive mechanism;

FIG. 11 is a cutaway view of the body of the robot illustrating the mechanism to rotate the rotatable platform;

FIG. 12 is a cutaway view of the mechanism to drive the scanning passive infrared sensor;

FIG. 13 is a perspective view of an embodiment of the remote control device of the invention;

FIG. 14 is a top rear perspective view of the remote control device;

FIG. 15 is a top view of the remote control device;

FIG. 16 is a block diagram for the controls of the robot; and

FIG. 17 is a block diagram illustrating the controls for the remote control device.

DETAILED DESCRIPTION

Referring now to FIGS. 1-7, the robot 100 contains a body 102, arms 104, legs 106, video device 122, mouth 126, eyes 128, light 118, microphones 117, active infrared emitter 115, a passive infrared scanner 114, and multiple sensors to assist the robot 100 from running into obstacles or traveling off an edge.

The arms 104 are connected with the body 102. The arms 104 can be positioned in multiple locations and further can be positioned in pre-set "serving" locations. As shown in FIG. 7, the two pre-set serving positions are at the 90° and 180° positions. Both arms 104 can be adjusted to either position independently. Further, to ensure that the arms 104 will not rotate when in either serving position, the arms 104 can be located so that the remote control 500 cannot activate the arms 104. Referring now to FIG. 9, the mechanism for rotating the arms 104 can be seen. The motor 180, via a flexible belt 181, drives gear 182, which drives gear 184, which drives gear 186, which drives gear 188, which drives gear 190. Gear 190 is attached to the arm 104. To lower the cost and complexity of the mechanism, gears 184, 186, and 188 are the same part. An optical emitter/receiver monitors the movement and location of gear 190 via a toothed wheel (not shown) attached coaxially to gear 190. Such a device is commonly referred to as an optical position encoding device throughout the industry. Therefore, it is known to one of ordinary skill in the art and does not need to be further described. The monitoring through the above described optical position encoding device allows the robot 100 to know the position of the arms 104. When the robot 100 is turned on, the arms 104 are calibrated by moving them through a range of motion that the robot 100 can track their position from the starting position.

To grip and hold an object, the arms 104 also contain a hand grip device. The hand grip device contains a first finger 100 and a second finger 108. As shown in FIG. 1, the first finger 110 is stationary and has cavities 112 for holding a serving device (See FIG. 7). The second finger 108 opens and closes to grip and release an object. However, one of ordinary skill in the art will appreciate that the second finger 108 may be stationary while the first finger 110 opens and closes. A spring closure mechanism biases the second finger 108 in a closed position. As the mechanism is commonly known to one of ordinary skill in the art, the mechanism does not need to be further described. The spring closure mechanism will not apply more than five pounds of pressure to an object placed between the first finger 110 and the second finger 108. Limiting the pressure to five pounds will prevent damage to an object held between the first finger 110 and the second finger 108.

A separate motor operates to activate the second finger 108. Referring now to FIG. 8, a leadscrew 152 on the shaft of the motor 150 turns gear 154, which turns gear 156, which turns gear 158. Each stage reduces the RPM and increases torque. The gear 158 has a pin on its underside which pulls a steel linkage which is attached by springs to the lever arms 109 of the second finger 108. As the steel linkage is commonly known to one of ordinary skill in the art, the steel linkage does not need to be further described. This double-spring gripper can thus be forced open or shut against a spring force without damage to the mechanism.

The legs 106 are also connected with body 102. The legs 106 provide lateral support to keep the body 102 elevated and substantially perpendicular to the ground. The legs 106 also provide the ability for the robot 100 to move about. Each leg 106 contains a drive mechanism 300 to move the

robot 100. The robot mechanism 300 located in each leg 106 can move the robot forward, reverse, left and right and both forward and reverse directions, and can spin the robot in place by controlling the rotation of the center wheel 138. Counters on each drive mechanism 300 control the straight forward motion with the two drive mechanisms 300 in synchronization.

The drive mechanism 300 is illustrated in FIG. 10. The motor 306 has an attached pulley 307 to drive the pulley 302 via the flexible belt 304. The pulley 302 has a small gear which also drives the center wheel 138. The small gear is a common toothed wheel which is commonly known to one of ordinary skill in the art. The flexible belt 304 provides tolerance for heavy loads which would otherwise damage a motor or gear train. Also, the flexible belt 304 reduces noise over using hard gears for first-stage reduction. A counter (not shown) mounted on the gear 310 counts the rotation of the center wheel 138 via an attached toothed wheel for indexing and monitoring speed. As the counter is a device which is commonly known to one of ordinary skill in the art, it will not be described further. Other optical position encoding devices can be used with wheel 138 as is known in the art. As the center wheel 138 is the only wheel propelled by the drive mechanism 300, the movement of the robot 100 is dependant solely on the center wheel 138. The front end wheel 120 and rear end wheel 121 rotate freely upon contact with a surface and provide lateral support to keep the body 102 substantially perpendicular with the ground.

The robot 100 has several sensors to prevent the robot 100 from running into obstacles and traveling off an edge. The sensors includes ambient light sensors 123, active infrared emitters 115, passive infrared sensor 114, motor sensors (not shown), a tilt sensor and an edge sensor (not shown but described later). As the motor sensor and the tilt sensor are commonly known to one of ordinary skill in the art, they will not be described herein.

The ambient light sensor 123 determines if the ambient area in front of the robot 100 is below a minimum illumination. If the intensity of the ambient light is not enough to view objects through the video display 504 of the remote control 500 without additional light, an infrared mode of the video device 122 will be activated, allowing a user to see objects at night.

To help the robot 100 avoid bumping into obstacles and traveling off an edge, the robot 100 contains active infrared emitters 115, a passive infrared (PIR) sensor 114 and four edge sensors 107, described hereafter. Avoiding obstacles is an important function of the robot 100 so that the robot 100 can operate autonomously. Each leg 106 contains three active infrared sensors 115. The PIR sensor 114 is located on the front of the body 102. The edge sensors 107 are located in the legs 106, whereby one sensor is located in each toe and heel of the leg 106.

The robot 100 contains six active infrared emitters 115, with three in each leg 106. Signals emitted by the active infrared emitters 115 are detected by signal receiving device located within housing 116. The three active infrared emitters 115 located in each leg 106 emits a signal at a different angle. The pattern is identical in both the legs 106. For example, if the three active infrared emitters 115 are aligned in a vertical pattern, the top emitter would emit a signal in a substantially 90° angle from the surface of leg 106. Additionally, the middle emitter would emit a signal approximately 30° offset towards the ground from the top emitter. The bottom emitter would emit a signal approximately 30° offset towards the ground from the middle

emitter. Since each emitter **115** emits a signal at a different angle, the signal will reflect off an object at different places in a room.

This pattern of active infrared emitters **115** allows for each emitter **115** to detect an object at a different distance or time. For example, since the top emitter emits a signal substantially parallel to the ground, the top emitter will indicate that an object is in front of the robot **100**, but at a distance far away. As the middle emitter emits a signal toward the floor, the middle emitter will indicate that an obstacle is in front of the robot **100** and closer than if the top emitter would have detected the object. Similarly, as the bottom emitter substantially emits a signal toward the ground, the top or middle emitter may not detect an object very close. Thus, the bottom emitter, by not receiving a signal, will indicate that an object is directly in front of the robot **100** and that the obstacle is very near, such as an edge.

Each active infrared emitter **115** emits a signal. However, only one emitter **115** emits a signal at a time. The six emitters **115** time share the signal receiving device. By only allowing one active infrared emitter **115** to send a signal at a time, the signal receiving device knows which emitter **115** sent the signal. Thus, the robot **100** can determine if the object is far away, near or immediately in front of it. Further, as the emitters **115** continuously emit a signal, the robot **100** can monitor and update the position of objects and edges. With three emitters **115** located on each leg **106**, the robot **100** can distinguish if the obstacle or edge is on the left or right side.

The PIR sensor **114** is a separate system from the active infrared emitters **115**. The PIR sensor **114** does not emit a signal. Instead, the PIR sensor **114** detects heat. Normally, a passive infrared sensor is not able to detect an object emitting heat if the object is stationary because a typical passive infrared sensor detects a change in temperature. However, the robot **100** can detect a stationary object that emits heat because the PIR sensor **114** is mounted in housing **116**, which continuously rotates through a range.

Referring now to FIG. **12**, the motor **250** has an attached pulley **252** to drive the pulley **256** via the flexible **254**. The pulley **256** drives the pulley **258**, which drives the pulley **260**, which drive the pulley **262**, which drives the housing **116**. Similar to the drive mechanism **300**, this drive belt provides tolerance for heavy loads and reduces noise over using hard gears. An optical emitter/receiver (not shown and similar to these described above) monitors the movement and location of the gear that drives the housing **116**. The PIR sensor **114** will detect heat signals as it moves through the range dictated by the housing **116**. For example, as the housing **116** rotates through its range, the temperature differential between the person and the surrounding environment will be detected by the PIR sensor **114**. The robot **100** will know the location of the person in relation to the robot **100** by the angle the housing **116** is at the moment the PIR sensor **114** detects the heat differential.

The edge detection system relies on feedback from the active infrared emitters **115**, the signal receiving device, and an edge detection element **107** located in leg **106**. The active infrared emitters **115** sequentially send out signals as previously described. When the signal receiving device detects an edge from the signal emitted by an active infrared emitter **115**, the robot **100** will then slow down, thus allowing the edge detection element **107** in leg **106** to confirm that there is an edge. The edge detection element **107** is a leaf switch **111** connected with the front wheel **120** and the rear wheel **121**. As the robot **100** moves slowly forward, if the front

wheel **120** or the rear wheel **121** travels a predetermined distance downward, the leaf switch **111** will close and complete a circuit to send a signal to the robot **100** that there is an edge. Thus, the robot **100** will not continue to travel in that direction. Instead, the robot **100** will change direction and continue to operate autonomously. The edge detection element **107** also serves as a backup to the active infrared sensors **115** ability to detect an edge. For example, the signals sent by the active infrared emitters **115** will not reflect from a black carpet. Therefore, the signal receiving device will not detect an edge. In this case, the edge detection element **107** will be the first and only method to detect an edge.

The motor sensors located within the body **102** monitor current surges to the motors to tilt the body **102**, rotate the arms **104**, rotate the rotating platform **124**, and drive the center wheel **138**. If a surge in current exceeds a minimum threshold, the robot **100** will notify the user by speaking from its vocabulary (e.g., "ouch," "stop it," "that hurts," "that's heavy," etc.).

Robot **100** has several modes by which the robot **100** can operate. Several modes allow the robot **100** to operate autonomously, while other modes require a user to remotely manipulate the robot **100**. The mode settings include a remote control mode, a monitor mode, an automatic mode, a security mode, a greet mode and a demonstration mode.

When the automatic mode is selected, the robot **100** begins to move autonomously throughout the room. As explained above, the active infrared emitters **115** assist the robot **100** to avoid bumping into obstacles and traveling off an edge. While the robot **100** is moving throughout the room it will occasionally speak from the auto vocabulary, depending on sensor input. Simultaneously, the PIR sensor **114** scans the area in front of the robot **100** to detect a heat source. When the robot **100** detects a heat source, the rotatable platform **124** will turn toward the object and speak from its "roam" vocabulary (e.g., "Nice to see you again," "How are you," etc.).

The motor mechanism which drives the rotatable platform **124** is shown in FIG. **11**. A motor has an attached pulley **200** to drive the pulley **202** via flexible belt **204**. As the motor is commonly known to one of ordinary skill in the art, the motor will not be described further. The pulley **202** drives the pulley **206**, which drives the pulley **208**, which drives the pulley **209**, which drives the pulley **210**, which drives the pulley **212**. The pulley **212** drives the rotatable platform **124**. The pulley **208**, **209** and **210** are the same to lower the cost and complexity of the mechanism. The motor mechanism allows the rotatable platform **124** to rotate either left or right, up to 135°.

The robot **100** can also detect the location of a noise. Three microphones **117** are placed around the robot **100** at approximately 120° angles apart from each other. The microphones **117** can detect the phase difference in a sound detected so that the robot **100** can determine what direction the sound originated from. When a noise is detected, the robot **100** will turn its rotatable platform **124** towards the object as if it is speaking directly to the object.

The robot **100** can also provide security to a household. When the security mode is selected, the robot **100** stands still with minimum power consumption. When the microphones **117** on the robot **100** detect noise above a minimum threshold, the rotatable platform **124** turns towards the noise source and the PIR sensor **114** begins to scan. If a heat source is detected, the robot **100** turns on the light **118**, the rotatable platform **124** turns towards the heat source, and the

robot **100** makes an announcement from the security vocabulary. Further, the robot sends an alarm signal to the remote control device **500** to alert a user that an object has been detected.

Robot **100** can also greet people. When the greet mode is selected, the robot **100** scans with the PIR sensor **114** to search for a detectable object (e.g., a person). If a heat source is detected, the robot **100** turns the rotatable platform **124** towards the source and makes an announcement from the greeting vocabulary.

Robot **100** can also demonstrate many of its functions through a pre-programmed routine. When the demonstration mode is selected, the robot **100** performs several motions to display various functions that the robot can operate. For example, the robot will rotate its arms **104** through the full range of motion, tilt its body and speak.

The robot **100** can also be manipulated remotely by a user. When the remote control mode is selected, the robot **100** is manipulated remotely by a user via a remote control device **500** (See FIG. **13**) or via the Internet.

Finally, when the monitor mode is selected, the drive mechanism **300** is disabled so that the robot cannot move. However, the robot **100** can transmit audio and video signals to the remote control device **500** so that a user can remotely view objects in front of the robot and hear sounds within the vicinity of the robot **100**. A user is not limited to the range of remote control device **500** if the user is remotely manipulating the robot **100** via the Internet.

The robot **100** can also display moods to enhance or compliment the specific mode the robot **100** is operating in. The different moods are expressed by the eyes **128** and the mouth **126**. The eyes **128** allow the robot **100** to express moods through different combinations of lighting. The eyes **128** contain several lights where each light emits at least one color. The lights may be arranged in several combinations. The combination of lights may be activated to display at least one color. Specifically, the lights within eyes **128** consist of one blue light, two amber lights and two red light. The preferred embodiment for the eyes **128** is such that the blue light is positioned in a forward position while the two red and two amber lights are positioned in a rearward position. A reflective surface is placed in the eyes **128** facing the amber and red lights so that the amber and red lights emit light in a forward direction to blend with the blue light. The color emitted from the eyes **128** can be any combination of the blue, amber, and red lights. The combination of lights activated depends on whether the robot **100** is in the night light mode, the monitor mode, the security mode, the remote control mode, the automatic mode or the greet mode.

When the robot **100** is in the night light mode, two amber and two red lights are activated and emitted from the eyes **128**. When the robot **100** is in the monitor mode, one amber light is activated and emitted from the eyes **128** at all times. When the robot **100** is in the security mode, the lights activated depend on whether the robot **100** is talking or not talking. When the robot **100** is not talking, one blue light is activated and emitted from the eyes **128**. When the robot **100** is talking, one blue light and two red lights are activated and emitted from the eyes **128**.

When the robot is the remote mode, automatic mode or greet mode, the lights activated depend on whether the robot **100** is not talking, talking, tired, or tired and talking. When the robot **100** is not talking in either of these modes, one blue light and one amber light are activated and emitted from the eyes **128**. When the robot **100** is talking, one blue light and two amber lights are activated and emitted from the eyes

128. When the robot **100** is tired, one blue light and one red light is activated and emitted from the eyes **128**. Lastly, when the robot **100** is tired and talking, one blue light and two red lights are activated and emitted from the eyes **128**.

To compliment all speech, the robot **100** also has a mouth **126** to express emotions. The mouth **126** consists of several rows of red LED's that can be individually activated. Depending on the sensor input and vocabulary spoken, the robot **100** can demonstrate emotions such as a smile, a frown, puzzled, surprise, concentration and thinking. When the robot **100** is speaking, the LED's continuously change in pattern.

Another feature of robot **100** is a low battery indicator **139** (See FIG. **2**). The low battery indicator **139** contains five rectangular LED's on the back panel of the robot **100**. When the robot **100** is fully charged, all five LED's are lighted. When the power level is down to one lighted LED, the robot **100** has a vocabulary to indicate that the power is low and the robot **100** needs recharging. As the robot **100** detects that the battery becomes discharged, the robot **100** will reduce its functions to preserve power in the following order: first, the video functions, then, the audio functions, then, the locomotion functions will be eliminated. The remote control device **500** also has a low battery circuit which includes an audio power display and power cutoff. The power cutoff function is very important as lead-acid batteries will last through many more discharge cycles if they are not fully discharged with each use.

The control block diagram for the robot **100** is shown in FIG. **16**. As shown, there are several microcontroller units (MCU) **400** that coordinate all the functions of the robot **100**. The MCU **400** consists of several, independent integrated circuits to control different functions of the robot. As explained above and illustrated by FIG. **16**, the active infrared emitters **115** are the PIR sensor **114** are independently controlled.

Referring now to FIG. **13**, the remote control device **500** is used to manipulate the robot **100** remotely. The remote control device **500** is a separately powered device from the robot **100**. An on/off button **328** may be depressed to turn the remote control device **500** on and off. The remote control device **500** contains a joystick **502**, video display **504**, a microphone **506**, a transmitter/receiver **508** and several controls by which a user can manipulate the robot (which will be disclosed later in this application). The joystick **502** is at a height suitable for use with the single thumb of a user. The joystick **502** has eight compass points to translate motion of the robot **100**. The eight compass points include left forward, straight forward, right forward, spin left, spin right, left backward, straight backward, and right backward. When any forward position of the joystick **502** is engaged for more than three seconds the robot **100** will increase speed in the direction engaged, limited by a maximum speed.

The video display **504** allows the user to remotely view the area in front of the robot **100**. The robot **100** has a video device **122** which is located on the rotatable platform **124**. The image transmitted by the video device **122** is displayed in the video display **504**. By turning the rotating platform **124** or moving the robot **100** in a different direction, a user may see a different area of the room. The contrast knob **536** helps the user adjust the contrast of the video display **504** to optimize the image displayed. To conserve battery power, the video display **504** may be turned off by depressing the display power button **256**. Even though the video display **504** is off, the robot **100** can still be manipulated by the remote control **500**.

The microphone **506** allows a user to transmit his voice to the robot **100** so that the user's voice is projected from the robot **100**. The remote control **500** has three voice input buttons **510**, **512** and **514**. By depressing and holding down any of the voice input buttons, a user may speak into the microphone **506** and the voice will be transmitted to the robot **100**. The voice input button **510** allows the user's voice to be transmitted to the robot **100**. The voice input buttons **512** and **514** activate an audio circuit which distorts the user's voice before it is transmitted to the robot **100**. Thus, the user's voice projected from the robot **100** is disguised. The voice input buttons **512** and **514** distort the user's voice in a different manner. In addition to transmitting your voice to the robot **100**, the remote control **500** can receive sounds detected by the robot **100**. The microphones **117** on the robot **100** detect surrounding noise and transmit it back to the remote control **500** so that a user may hear them. The volume control knob **534** allows the user to turn the volume of the noise up or down.

The transmitter/receiver **508** has two antennas. First, a 2.4 GHz antenna **552** sends audio and video signals from the robot **100** to the remote control device **500**. The second antenna is a 900 MHz antenna **554** that sends control signals from the remote control device **500** to the robot **100**. 900 MHz and 2.4 GHz are common frequencies by which many household devices operate on. To insure that the remote control device **500** will not interfere with other devices in the house (e.g., a cordless phone) each antenna has additional channels which the user may select. Specifically, the 2.4 GHz antenna **552** has two channels and the 900 MHz antenna **554** has three channels a user may select to avoid interfering with other similar devices in the house (each cordless phone).

The robot **100** can perform many functions. Several of the functions include tilting the body **102**, rotating the arms **104**, gripping an object, rotating the rotatable platform **124**, and moving the robot **100**. The body **102** can tilt 180° forward 30° rearward. Tilting the body **102** forward is accomplished by pressing control button **550**. Tilting the body **102** rearward is accomplished by pressing control button **538**. By pressing and holding either button, the body **102** will continue to rotate, stopping when the button is released or the body **102** reaches its maximum tilt angle.

The arms **104** can rotate through many positions, including two "serve" positions which are located at the 90° and the 180° positions from rest (See FIG. 7). By depressing briefly the up direction button **540** or the down direction button **548**, the arms **104** will increment to the next position in the direction indicated. Longer button depressions will control motion of the arms **104** manually, stopping at a position when the button is released. Both the up direction button **540** and the down direction button **548** are divided into a left and right half, whereby the right half controls the right arm **104** and the left half controls the left arm **104**. Thus, both arms **104** can be controlled independently of the other.

To grip an object, the second finger element **108** can move to a width opening of approximately 75 millimeters away from the first finger element **110**. The second finger element **108** can be opened and closed via the hand control button **544** on the remote control **500**. Similar to the direction buttons, by quickly depressing the hand control button **544**, the second finger element **108** will move to the next preset position. As the motor **150** that controls the movement of the second finger element **108** only rotates in one direction, the second finger element **108** simply cycles through an open and close position. By holding down the hand control button

544 is also divided into a left and right portion. The left half of the hand control button **544** controls the left hand and the right half of the hand control button **544** controls the right hand grip. Thus, the hand grips can be controlled independently. Thus, holding down the hand control button **544** cycles the second finger element **108** through the entire range of motion. The second finger element **108** is also clutched in both directions.

The serving positions of the arms **104** can be automatically accessed by depressing serving button **530**. Each time the serving button **530** is depressed, the following positions of the arms **104** are achieved. First, the right arm **104** rotates to a 90° position. Second, the right arm **104** rotates to a 180° position. Third, the left arm **104** rotates to a 90° position. Fourth, the right arm **104** returns to the 90° position. Fifth, the right arm **104** returns to the 180° position. Sixth, the left arm **104** rotates to the 180° position.

The rotatable platform **124** can also be controlled remotely by depressing the left rotate button **542** and the right rotate button **546**. The rotatable platform **124** can rotate approximately 135° in either direction. By intermittently depressing either the left control button **542** or the right control button **546** the rotatable platform **124** will turn incrementally. If the rotatable platform **124** is not at the center position when the drive control is activated, the rotatable platform **124** will automatically return to the center/forward position. This function allows the user to view when the robot **100** is traveling.

The remote control **500** can also be used to select which mode the robot **100** will operate. When the mode button **516** is selected, the robot **100** enters into the automatic mode. When the mode button **518** is selected, the robot **100** enters the monitor mode. When the mode button **520** is selected, the robot enters the security mode. When the mode button **522** is selected, the robot **100** enters the greet mode. When the mode button **524** is selected, the robot **100** enters the remote control mode. If the robot **100** is operating in an autonomous mode, the user may depress the mode button **524** to end the autonomous mode and then the robot **100** can be controlled again by the remote control device **500**.

The remote control device **500** can also activate the light **118**. If it is dark within the room and a user wishes to provide additional light in front of the robot **100**, the user may do so by depressing the light button **532**. By depressing the light button **532** once, the light **118** is turned on. Depressing the light button **532** a second time activates the bright setting of the light **118**. Depressing the light button **532** a third time turns the light **188** off.

Referring now to FIG. 17, a block diagram illustrates the control of the remote control **500**. The microcontroller units (MCU) **450** independently receive signals from the keyboard and joystick. These signals are then sent to the 900 MHz transceiver **554** for transmitting to the robot **100**. FIG. 17 also shows that signals received by the microphone **506** are sent to the voice shifting device and then to the 900 MHz transceiver **554** and finally transmitted to the robot **100**.

There are several controls which are located on the robot **100** and not on the remote control **500**. For example, a user may press and hold the message button **142** located on the back of the robot **100** to record a message for up to fifteen seconds. Once the message is recorded, the message button **142** may be pressed again to hear the recorded message played back. In addition, the find remote button **143** sends an announce signal to the remote control **500** whereby the remote control **500** will make a noise allowing the user find the remote control device **500**. The power button **144** is also

located on the back of the robot **100**. The power button **144** can be pressed to turn the robot **100** on and off. Further, if the user presses and holds the power button **144** for approximately two seconds the robot will enter the demonstration mode.

The foregoing description of preferred embodiments of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obviously, many modifications and variations will be apparent to the practitioner skilled in the art. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, thereby enabling others skilled in the art to understand the invention for various embodiments and with various modifications that are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalence.

What is claimed is:

1. A multi-function remote controlled robot, the robot comprising:

a body;

at least one arm connected with the body, whereby said arm may be positioned in a plurality of positions, and further contains a hand-grip device;

at least one leg connected with the body, whereby each said leg contains a drive mechanism to move the robot;

a plurality of sensors to identify obstacles in front of the robot, thus allowing the robot to interact with objects in the vicinity of the robot and further to prevent the robot from traveling off an edge;

at least one audio system to detect and transmit sound, whereby the audio system contains a memory element to store vocabulary;

a light assembly for illuminating an area in front of the robot;

at least one video device to allow a user to remotely view an area in front of the robot;

whereby the robot may operate in a plurality of modes; and

whereby a user may remotely manipulate the robot.

2. The multi-function remote controlled robot according to claim **1**, whereby the plurality of sensors includes at least one of the following: an ambient light sensor, an active infrared sensor, a passive infrared sensor, a motor sensor, a tilt sensor and an edge sensor.

3. The multi-function remote controlled robot according to claim **2**, whereby the ambient light sensor determines if an ambient area is below a minimum threshold so that an infrared mode of the video device may be activated.

4. The multi-function remote controlled robot according to claim **2**, whereby the robot contains a plurality of infrared sensors to identify obstacles or edges in front of the robot.

5. The multi-function remote controlled robot according to claim **4**, whereby the robot contains three stationary emitters located on each leg of the robot and one sensor which rotates located on the front of the body of the robot.

6. The multi-function remote controlled robot according to claim **5**, whereby a signal receiving device is located on the front of the robot's body to receive emitted infrared signals from the stationary infrared emitters located on each leg of the robot.

7. The multi-function remote controlled robot according to claim **5**, whereby the sensor that rotates is a passive infrared sensor.

8. The multi-function remote controlled robot according to claim **2**, whereby the motor sensor senses current surges to motors located within the body of the robot.

9. The multi-function remote controlled robot according to claim **2**, whereby the tilt sensor indicates that the robot is not standing upright.

10. The multi-function remote controlled robot according to claim **2**, whereby the edge sensor senses that the robot is proximate to an edge of a surface, thus preventing the robot from traveling off an edge.

11. The multi-function remote controlled robot according to claim **1**, whereby the drive mechanism located in each leg can move the robot forward, reverse, left and right in both forward and reverse directions, and can further spin the robot in place.

12. The multi-function remote controlled robot according to claim **1**, whereby each arm can rotate incrementally to a pre-set serving position or may rotate continuously.

13. The multi-function remote controlled robot according to claim **1**, whereby the hand grip device of each arm allows the robot to grip and hold objects.

14. A multi-function remote controlled robot according to claim **13**, whereby the hand-grip device will not apply more than five pounds pressure to an object held by the hand-grip device to avoid damaging the object.

15. The multi-function remote controlled robot according to claim **1**, whereby the robot's body further contains a mouth and a rotatable platform, both covered by a protective surface.

16. The multi-function remote controlled robot according to claim **15**, whereby the rotatable platform contains the video device and at least two eyes.

17. The multi-function remote controlled robot according to claim **15**, whereby the mouth is comprised of a plurality of lights, such that the lights may be activated to convey multiple expressions.

18. A multi-function remote controlled robot according to claim **15**, whereby the mode settings includes a remote control mode, a monitor mode, an automatic mode, a security mode, a greet mode and a demonstration mode.

19. A multi-function remote controlled robot according to claim **18**, whereby when the automatic mode is selected, the robot will begin moving the use the active infrared emitters to avoid obstacles, while occasionally turning the rotatable platform toward a detected object and speaking.

20. The multi-function remote controlled robot according to claim **18**, whereby when the security mode is selected, the robot stand still and when a microphone on the robot detects noise, the rotatable platform turns toward the noise source and a passive infrared sensor begins to scan.

21. A multi-function remote controlled robot according to claim **20**, whereby if a heat source is detected, the robot turns on a headlight and makes an announcement from a security vocabulary, and further sends an alarm signal to a remote control device.

22. A multi-function remote controlled robot according to claim **18**, whereby when the greet mode is selected, the robot scans with a passive infrared sensor to search for a detectable object.

23. A multi-function remote controlled robot according to claim **22**, whereby if a heat source is detected, the robot turns the rotatable platform toward the source and makes an announcement from a greeting vocabulary.

24. A multi-function remote controlled robot according to claim **18**, whereby when the demonstration mode is selected, the robot enters a demonstration routine of sounds and motions.

13

25. A multi-function remote controlled robot according to claim 18, whereby when the remote control mode is selected, the robot is manipulated by a remote control device.

26. A multi-function remote controlled robot according to claim 18, whereby when the monitor mode is selected, the drive mechanism of the robot is disabled so that the robot cannot move, and further allows the robot to transmit audio and video signals to a remote control device.

27. A multi-function remote controlled robot according to claim 15, whereby the rotatable platform can rotate approximately 135° to the left and right from a center position.

28. The multi-function remote controlled robot according to claim 1, whereby the user may remotely manipulate the robot through a remote control device or the Internet.

29. A multi-function remote controlled robot according to claim 1, whereby the body can tilt approximately 180° forward and 30° rearward.

30. A remote control device to control a robot, the remote control device comprising:

- a locomotion control device;
- a video display for remotely viewing objects in front of the robot;
- a plurality of controls to manipulate the robot;
- at least one microphone so that a user may speak at the remote control device, wherein the user's voice is transmitted from the robot;
- at least one speaker so that a user can monitor sounds surrounding the robot; and
- whereby a transmitter/receiver located on the remote control device sends and receives signals required to operate the robot.

31. A remote control device according to claim 30, whereby the locomotion control device is a joystick, with a height suitable for use with a single thumb of a user.

32. A remote control device according to claim 31, whereby the joystick has eight compass points to translate to motion of the robot, the eight encompass points including left forward, straight forward, right forward, spin left, spin right, left backward, straight backward and right backward.

33. A remote control device according to claim 32, whereby when any forward position of the joystick is engaged for more than three seconds, the robot will increase speed in the direction engaged.

34. A remote control device according to claim 30, whereby the plurality of controls enable:

- moving the robot;
- tilting a body;
- rotating and locking arms;
- activating a hand grip;
- adjusting an intensity of lights;
- turning a rotatable platform;
- voice control;
- mode settings; and
- volume control.

35. A remote control device according to claim 34, whereby one of the plurality of controls allows a user to tilt the body an between approximately 180° forward and 30° rearward.

36. A remote control device according to claim 34, whereby one of the plurality of controls allows a user to rotate the rotatable platform between approximately 135° left and right of center.

37. A remote control device according to claim 34, whereby the volume control allows a user to adjust the volume of a speaker located on the robot.

14

38. A remote control device according to claim 34, whereby the mode settings include a remote control mode, a monitor mode, an automatic mode, a security mode, a greet mode and a demonstration mode, each of which can be selected using the remote control device.

39. A remote control device according to claim 38, whereby when the automatic mode is selected by a user of the remote control device, the robot will begin moving and use its sensors to avoid obstacles, while occasionally turning the rotatable platform toward a detected object and speaking.

40. A remote control device according to claim 28, whereby when the security mode is selected by a user of the remote control device, the robot stands still and when a microphone on the robot detects noise, the rotational platform turns toward the noise source and a passive infrared sensor begins to scan.

41. A remote control device according to claim 40, whereby if a heat source is detected, the robot turns on at least one of the lights and makes an announcement from a security vocabulary, and further sends an alarm signal to the remote control device.

42. A remote control device according to claim 38, whereby when the greet mode is selected by a user of the remote control device, the robot scans with a passive infrared sensor to search for a detectable object.

43. A remote control device according to claim 42, whereby if a heat source is detected, the robot turns the rotatable platform toward the source and makes an announcement from a greeting vocabulary.

44. A remote control device according to claim 38, whereby when the demonstration mode is selected by a user of the remote control device, the robot enters a demonstration routine of sounds and motions.

45. A remote control device according to claim 38, whereby when the remote control mode is selected by a user of the remote control device, the robot is manipulated by the remote control device.

46. A remote control device according to claim 38, whereby when the monitor mode is selected by a user of the remote control device, a drive mechanism of the robot is disabled so that the robot cannot move, and further allows the robot to transmit audio and video signals to the remote control device.

47. A remote control device according to claim 34, whereby the remote control device allows a user to remotely rotate the arms of the robot incrementally to a pre-set serving position, and further allows a user to rotate the arms of the robot continuously.

48. A remote control device according to claim 34, whereby the remote control device allows a user to remotely open and close the hand grip of the robot to grip and hold objects.

49. A remote control device according to claim 34, whereby the remote control device allows a user to remotely adjust the intensity of the lights of the robot to illuminate an area in front of the robot, thus allowing a user to view objects via the video display that would not be visible without additional lighting.

50. A remote control device according to claim 49, whereby the remote control device allows a user to set the lights to a momentary, high, low and off setting.

51. A remote control device according to claim 34, whereby the voice control scrambles the user's voice before transmitting the user's voice to the robot.

15

52. A remote control device according to claim **30**, whereby the remote control device may separately manipulate two robots simultaneously.

53. A remote control device according to claim **30**, whereby the transmitter/receiver operates at two separate 5 frequencies.

16

54. A remote control device according to claim **53**, whereby the signals from the robot to the remote control device travel at 2.4 GHz, and the signals from the remote control device to the robot travel at 900 MHz.

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