

SPECIFICATION

Mine sweeping robot

TECHNICAL FIELD

The present invention relates to a mine sweeping robot for removing mines buried under the ground safely without human assistance.

BACKGROUND ART

Regional disputes are increasing after the end of the so-called cold war between the West and the East, as known well, human casualties by mines used in the disputes are causing international problems even after the disputes. To solve this problem, it has been attempted to remove the mines buried under the ground by an international scale, but the conventional methods had problems in efficiency, safety and economy.

In a typical method, a worker searches for a mine by using a metal detector or the like, and removes its fuse or destroys the mine itself, but its working efficiency is poor and it is very dangerous. As a safe method, a rocket connecting a wire is launched toward the mine field, and the wire is brought into contact with the ground to explode, but a tremendous number of rockets must be used in order to destroy all mines, and the economy is very poor.

In such situation, the present applicant developed an unmanned self-propelled mine sweeping robot that is safe,

very efficient, and economical, and already acquired its patent right (Japanese Patent No. 2516534). This mine sweeping robot is a uniaxial self-propelled robot mainly composed of an outer frame having a pair of cylindrical side frame bodies rotatably coupled coaxially, and a main body provided inside the outer frame for propelling the outer frame by rotating and driving the both frame bodies independently by remote control. By rotating and driving the pair of cylindrical frame bodies from a safe place by remote control, the robot moves the mine field freely in all directions while keeping a wide ground contact area, so that the mines can be destroyed efficiently, safely and securely.

However, this unmanned self-propelled mine sweeping robot has its own problems, and the following problems are known in relation to the geography of the mine field.

As reported in news, the mine field is often a rough and undulated land. The mine sweeping robot previously developed by the applicant is a so-called uniaxial type, and since there is no interaxial space as in the biaxial type, it can run along the ground surface even in a rough and undulated land, but it cannot climb a steep slope because the both cylindrical frame bodies roll downward and the main body idles within the outer frame. Therefore, its place of use is limited.

In spite of the uniaxial type, in the case of mine field having multiple small bumps and dents, the outer frame may pass over the dents, and mines may be left undetected, and it is not perfect in effect, and its place of use is also limited in this respect.

The invention is devised in the light of the above background, and it is hence an object thereof to present a mine sweeping robot capable of destroying the mines safely and securely regardless of the geography of the mine field.

SUMMARY OF THE INVENTION

To achieve the object, a first mine sweeping robot of the invention comprises an outer frame composed by coupling coaxially a pair of cylindrical frame bodies at both sides rotatably, a main body provided in the outer frame for propelling the outer frame by rotating and driving the both frame bodies independently by remote control, and a guide bar located sideward of the outer frame at least on one side of the main body, and extending at least forward or backward of the running direction of the outer frame so that the leading end may project to the outer side of the outer circumference of the frame body.

A second mine sweeping robot of the invention comprises an outer frame composed by coupling coaxially a pair of cylindrical frame bodies at both sides rotatably, a main body provided in the outer frame for advancing the outer

frame by rotating and driving the both frame bodies independently by remote control, and plural probes made of elastic material, extending radially to the outer side from each outer circumference of the both frame bodies.

A third mine sweeping robot of the invention comprises an outer frame composed by coupling coaxially a pair of cylindrical frame bodies at both sides rotatably, a main body provided in the outer frame for propelling the outer frame by rotating and driving the both frame bodies independently by remote control, a guide bar located sideward of the outer frame at least on one side of the main body, and extending at least forward or backward of the running direction of the outer frame so that the leading end may project to the outer side of the outer circumference of the frame body, and plural probes made of elastic material, extending radially to the outer side from each outer circumference of the both frame bodies.

In the first mine sweeping robot of the invention, the guide bar is provided at least on one side of the main body. Each guide bar extends at least forward or backward of the running direction sideward of the outer frame so that the leading end may project to the outer side of the outer circumference of the frame body. When the outer frame climbs a steep slope by extending the guide bar backward, the main body idles within the outer frame, but the leading

end of the guide bar touches down on the inclined land surface, and hence this idling is prevented. Moreover, the guide bar acts as a support to prevent backward move of the outer frame, and the ground contact force of the frame bodies is increased by the reaction received from the land surface through the guide bar, and the climbability is increased. Therefore, it is free to travel on a steep rough land.

In the second mine sweeping robot of the invention, since plural probes made of elastic material are attached radially to the outer circumference of the frame bodies, while the mine sweeping robot is running, the outer frames moves while the plural probes are hitting the land surface by the rotation of the frame bodies. Accordingly, when the outer frame passes over a dent, an effective impact can be given to the land surface in the dent. Therefore, no mine is left over even in the mine field having multiple small dents and bumps.

In the third mine sweeping robot of the invention, since the first mine sweeping robot of the invention and the second mine sweeping robot of the invention are combined, the climbability is excellent and no mine is left undetected.

Incidentally, in the case of the second mine sweeping robot of the invention, the climbability may be lowered

because of the elastic probes interposing between the frame bodies and the land surface, but in the case of the third mine sweeping robot of the invention, lowering of climbability by probes can be effectively compensated by the guide bar.

Preferably, the guide bar should be provided at both sides of the main body from the viewpoint of running stability of the outer frame, but it is not a serious problem if provided at one side of the main body only in the case of rotating one frame body. In order to function also in the backward move, the guide bar is preferred to be designed to extend both forward and backward in the running direction of the outer frame. More specifically, a bar longer than the outside diameter of the frame body is provided so that its center may be positioned nearly in the axial center of the frame body. If the guide bar is too low, it may be an obstacle in ordinary running.

The guide bars and probes are preferred to be detachable from the main body and frame bodies. As a result, they can be used selectively, and flexible setting depending on the local geography is possible.

Preferably, the probes are disposed at intervals in the outer circumferential direction of the frame body, and the plural probes are detachably planted in plural base members fitted and fixed on the outer circumference, at intervals

in the longitudinal direction of the members.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a partially cut-away perspective view of mine sweeping robot in an embodiment of the invention, Fig. 2 is a cross sectional plan view of the outer frame, Fig. 3 is a schematic structural plan view of the main body, Fig. 4 is a perspective view of the joint, Fig. 5 is a side view of the same mine sweeping robot, Fig. 6 is a side view for explaining the climbing state of the mine sweeping robot, Fig. 7 is a front view for explaining the state of the mine sweeping robot when passing over a dent, and Fig. 8 is a side view for explaining other mounting structure of probes.

BEST MODE OF CARRYING OUT THE INVENTION

An embodiment of the invention is described below while referring to the drawings. Fig. 1 is a partially cut-away perspective view of mine sweeping robot in an embodiment of the invention, Fig. 2 is a cross sectional plan view of the outer frame, Fig. 3 is a schematic structural plan view of the main body, Fig. 4 is a perspective view of the joint, Fig. 5 is a side view of the same mine sweeping robot, Fig. 6 is a side view for explaining the climbing state of the mine sweeping robot, and Fig. 7 is a front view for explaining the state of the mine sweeping robot when passing over a dent.

The mine sweeping robot of this embodiment of the

invention is an example of the third mine sweeping robot of the invention, combining the first mine sweeping robot of the invention and the second mine sweeping robot of the invention.

This mine sweeping robot comprises, as shown in Fig. 1, a cylindrical outer frame 10, a main body 20 provided inside the outer frame 1 for propelling the outer frame 10, plural probes 30, 30, ... provided radially on the outer circumference of the outer frame 10, and a pair of guide bars 40, 40 on both sides provided on both sides of the main body 20.

The outer frame 10 is, as shown in Fig. 2, composed of a pair of cylindrical frame bodies 11, 11 on both sides, being coupled coaxially by means of a joint 15, so as to rotate in both directions independently from each other.

The frame bodies 11, 11 are made of resin such as FRP, and multiple ribs 12, 12, ... extending in the axial direction are formed on each outer circumference at equal intervals in the circumferential direction. Further, on each inner circumference of the frame bodies 11, 11, three guide grooves 13, 13, 14 continuous in the circumferential direction are formed at specified intervals in the axial direction. The joint 15 includes, as shown in Fig. 4, a flange-shaped main body 16 having sleeves at both sides, and bearings 17, 17 at both sides externally fitted into the

both sleeves, and by fitting the bearings 17, 17 internally into the ends of the frame bodies 11, 11, the frame bodies 11, 11 are rotatably coupled coaxially to compose one outer frame 10.

Plural probes 30, 30, ... provided at the outer side of the outer frame 10 are provided on each outer circumference of the outer frames 11, 11, at equal intervals in the axial direction and circumferential direction. Each probe 30 is made of an elastic material, herein, and formed like a whisk by bundling a plurality of fine bars made of strongly restoring material such as bamboo and spring, and each set of a specified number of pieces is planted at equal intervals in the base material 31 extending in the axial direction of each frame body 11. Plural base materials 31, 31, ... are fitted between adjacent ribs 12, 12 by each specified number of pieces of the frame bodies 11, 11 and fixed by using bolts, so that the plural probes 30, 30, ... are detachably provided in the outer circumference of each outer frame 11, at specified intervals in the axial direction and circumferential direction.

On the other hand, the main body 10 provided at the inner side of the outer frame 10 comprises, as shown in Fig. 3 and Fig. 5, a case 21 straddling over the frame bodies 11, 11, and a pair of drive units 22, 22 at both sides assembled in both sides of the case 21, among others. Each

drive unit 22 includes a motor 23 assembled in the case 21, four drive wheels 24, 24, ... driven synchronously by the motor 23, a holding wheel 25 projecting upward from the ceiling side of the case 21, a receiver 26 of remote control of the motor 23, and a battery 27 for driving the motor 23.

The four drive wheels 24, 24, ... are rubber wheels, and project downward from four bottom positions of the case 21. Two left drive wheels 24, 24 are fitted into the left guide groove 13 of the three guide grooves 13, 13, 14 provided in the inner circumference of the frame body 11. Two right drive wheels 24, 24 are fitted into the right guide groove 13 of the three guide grooves 13, 13, 14. The holding wheel 25 is a rubber wheel same as the drive wheels 24, 24, ..., and is fitted into the middle guide groove 14, and presses the drive wheels 24, 24, ... to the bottom of the guide grooves 13, 13.

Of the four drive wheels 24, 24, ..., the two front drive wheels 24, 24 are coupled by an axle 24', and the two rear drive wheels 24, 24 are also coupled by an axle 24'. As the rotation of the motor 23 is transmitted to the front and rear axles 24', 24' through a reduction gear 28 and a chain 29, the four drive wheels 24, 25 rotate synchronously in the same direction to rotate the frame body 11.

A pair of guide bars 40, 40 attached to both sides of

the main body 20 are positioned sideward of the outer frame 10, and both are horizontal bars at right angle to the central axis of the frame body 11. Each guide bar has a length sufficiently larger than the outside diameter of the frame body 11, and its middle is detachably fastened with screw through a support member 41 to the side of the case 21 of the main body 20, so that the middle may be positioned nearly in the axial center of the frame body 11. As a result, both ends of each guide bar 40 projects by the same length forward and backward in the running direction of the outer frame 20 from the outside position of the frame body 11.

The method of use of the mine sweeping robot according to the embodiment of the invention is described below.

First, the mine sweeping robot is placed at a safe place before the mine field, and the operator remote-controls from a safe place, and the mine sweeping robot advances into the mine field.

Herein, when both drive units 22, 22 provided in the main body 20 are operated simultaneously in the forward direction, the both frame bodies 11, 11 for composing the outer frame 10 rotate synchronously in the forward direction. Therefore, the mine sweeping robot (outer frame 10) moves forward. When the both drive units 22, 22 are operated simultaneously in the reverse direction, the both

frame bodies 11, 11 rotate synchronously in the reverse direction, so that the mine sweeping robot (outer frame 10) moves backward.

When one drive unit 22 is operated in the forward direction and other drive unit 22 is stopped, the mine sweeping robot (outer frame 10) makes a large turn to the stop side. When one drive unit 22 is operated in the forward direction and other drive unit 22 is operated in the reverse direction, the mine sweeping robot (outer frame 10) makes a small turn to the reverse rotation side.

By combining these operations, the mine sweeping robot can move the mine field freely in all directions, and steps on and destroys the mines.

When the geography of the mine field is relatively horizontal and relatively flat, the both guide gars 40, 40 are almost horizontal, and the both ends are sufficiently lifted from the ground. Therefore, the guide bars 40, 40 are not obstacles for running of the mine sweeping robot.

When the mine sweeping robot climbs up a steep slope, as shown in Fig. 6, the main body 20 inclines backward, idling within the outer frame 10. Hence, the rear ends of the guide gars 40, 50 contact with the ground. As a result, idling of the main body 20 is prevented. Moreover, backward move of the mine sweeping robot (outer frame 10) on an upward slope is prevented, and the ground contact

force of the frame bodies 11, 11 is increased by the reaction received from the ground through the guide bars 40, 40, so that the climbability is increased. Therefore, even in a rough land of steep slopes, free running of uniaxial structure is assured.

The length of the guide bars 40, 40 is required to be larger than the outside diameter of the frame bodies 11, 11, owing to the necessity of projecting the leading end to the outer side from the outer circumference position of the frame body 11, and from the standpoint of enhancing the ground contact force, it is preferred to be more than two times the outside diameter of the frame bodies 11, 11. If too long, however, the ends of the guide bars 40, 40 may touch the ground in normal running, and the running may be impeded, and therefore the upper limit should be preferably within five times of the outside diameter of the frame bodies 11, 11.

When the mine sweeping robot travels in an area having small bumps and dents, as shown in Fig. 7, the outer frame 10 may step over a dent. However, since plural probes 30, 30, ... made of elastic material are radially attached to plural positions on the outer circumference of the frame bodies 11, 11, the probes 30, 30, ... rotate along with rotation of the frame bodies 11, 11. Accordingly, the mine sweeping robot (outer frame 10) travels while hitting the

ground by the plural probes 30, 30, As a result, when the outer frame 10 passes over a dent, an effective impact can be given to the ground within the dent. Therefore, even in the case of a mine field having multiple small dents and bumps, no mine is left undetected.

In addition, the mine destroying range is expanded, and the certainty of destruction is enhanced. This mine sweeping robot is a so-called disposable type, basically, being broken by explosion, but in actual use, since the probes 30, 30, ... run ahead of the outer frame 10 and destroy the mines, the risk of destruction by explosion is lowered. Therefore, it may be used repeatedly depending on the circumstance. Or it may be reused by a slight repair. Hence the economy is improved.

The length of the probe 30 is preferred to be $1/10$ to $1/3$ times of the outside diameter of the frame body 11. If the probe 30 is too short, it is hard to destroy securely, or if too long, the running performance is impaired.

Mounting positions of the probes 30 may be several to about ten positions in the circumferential direction of the frame body 11. The probes 30 may be also continuous in the axial direction, so far as no large clearance is left over in the axial direction of the frame body 11. In the case of the probes 30 not continuous in the axial direction of the frame body 11, in order to avoid failure in destroying

between the adjacent probes 30, 30, it is preferred to be expanded in the width direction of the frame body 11 as in this embodiment.

Depending on the geography of the mine field, if the guide bars 40, 40 or probes 30, 30, ... are not particularly necessary, either or both of them may be removed as required. In other words, they can be used selectively depending on the geography of the mine field.

Incidentally, in this mine sweeping robot, the climbability may be lowered because of the elastic probes 30, 30, ... interposing between the frame bodies 11, 11 and the ground, but such lowering can be effectively suppressed by the guide bars 30, 30.

Fig. 8 is a side view for explaining other mounting structure of probes.

In the foregoing embodiment, the base member 31 on which the probes 30, 30, ... are planted is fitted and fixed by using bolts between the ribs 12, 12 formed on the outer circumference of the frame body 11, but as shown in Fig. 8 (a), a base member 31 of locking type may be inserted from the side into a groove 18 of locking type formed in the outer circumference of the frame body 11, or, as shown in Fig. 8 (b), a base member 31 of locking type may be inserted from the side into a rib 18 of locking type formed on the outer circumference of the frame body 11. In

either structure, the frame body 11 is made of resin and easy to process, and hence it is easy to carry out. Including the structure in the foregoing embodiment, since the probes 30, 30, ... can be attached and detached easily, it is suited to field setting or repair.

In the foregoing embodiment, the probe 30 is described as a member like whisk formed by bundling a plurality of fine bars made of a strongly restoring material, but not limited to this, for example, a strongly restoring band material or the like may be used. As the material, bamboo, or other inexpensive materials available in the field are preferred.

As for the side bar 40, in order to increase the ground contact area, it is effective to fold the end in an L-shape.

As described herein, in the first mine sweeping robot of the invention, since idling of the main body is prevented and the climbability is increased by the guide bars provided at the sides of the main body, free running is possible even in rough and steep land. Therefore, the mines can be destroyed safely and securely regardless of the geography of the mine field.

In the second mine sweeping robot of the invention, having plural probes made of elastic material attached radially to the outer circumference of the frame body, the mine buried in a dent is securely destroyed when passing

over the dent, and no mine is left over. Therefore, the mines can be destroyed safely and securely regardless of the geography of the mine field. Moreover, the mine destroying range is wide, it is excellent in certainty, small in damage by explosion, and high in economy.

The third mine sweeping robot of the invention is a combination of the first mine sweeping robot of the invention and the second mine sweeping robot of the invention, and therefore the climbability is excellent, and no mine is missed. Therefore, the mines can be destroyed safely and securely regardless of the geography of the mine field. Moreover, it is excellent in running performance, certainty, and economy.

Since the guide bars and probes are detachable, they can be used selectively in the field depending on the geography of the mine field.

INDUSTRIAL APPLICABILITY

Thus, the mine sweeping robot of the invention is useful for removing mines buried in the ground by unmanned operation, and in particular it is suited to safe and secure destruction of mines regardless of the geography of the mine field.



WHAT IS CLAIMED IS:

1. A mine sweeping robot comprising an outer frame composed by coupling coaxially a pair of cylindrical frame bodies at both sides rotatably, a main body provided in the outer frame for propelling the outer frame by rotating and driving the both frame bodies independently by remote control, and a guide bar located sideward of the outer frame at least on one side of the main body, and extending at least forward or backward of the running direction of the outer frame so that the leading end may project to the outer side of the outer circumference of the frame body.

2. A mine sweeping robot of claim 1, wherein said guide bar is detachable from said main body.

3. A mine sweeping robot comprising an outer frame composed by coupling coaxially a pair of cylindrical frame bodies at both sides rotatably, a main body provided in the outer frame for advancing the outer frame by rotating and driving the both frame bodies independently by remote control, and plural probes made of elastic material, extending radially to the outer side from each outer circumference of the both frame bodies.

4. A mine sweeping robot of claim 3, wherein said probes are detachable from said main body.

5. A mine sweeping robot comprising an outer frame composed by coupling coaxially a pair of cylindrical frame



bodies at both sides rotatably, a main body provided in the outer frame for propelling the outer frame by rotating and driving the both frame bodies independently by remote control, a guide bar located sideward of the outer frame at least on one side of the main body, and extending at least forward or backward of the running direction of the outer frame so that the leading end may project to the outer side of the outer circumference of the frame body, and plural probes made of elastic material, extending radially to the outer side from each outer circumference of the both frame bodies.

6. A mine sweeping robot of claim 5, wherein said guide bar is detachable from said main body.

7. A mine sweeping robot of claim 5 or 6, wherein said probes are detachable from said main body.