Development of Assistive Mobility Equipment Modeled on Pedal Crawling Locomotion of Terrestrial Gastropod

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Abstract

In order to develop an indoor assistive mobility equipment, we paid attention to the mechanism of locomotion in a snail, or a terrestrial gastropod molluscs. It is known that the snail moves by propagation of a pedal wave generating on a pedal surface of the snail and a pedal locomotion has flexibility for ground condition. An air mattress with a function of a pedal-like locomotion mechanism was developed and the performance of the pedal locomotory air mattress as mobility equipment was discussed.

Introduction

Recently an aging society is rapidly growing in our country. A mobility equipment as assistive technology is required in order to promote the self-support for the disabled and the aged having difficulty in walking. In particular, the bedridden want a bed or a mattress to carry them to the direction as they want without vibration and noise in a room. The research on mobility equipment suitable for them has brought the idea that no wheel mobility equipment is fit for them. So we paid attention to the mechanism of locomotion in a snail or a terrestrial gastropod molluscs. The snail moves forward by propagating pedal waves of muscular contraction generating on the pedal surface from the posterior to the anterior end of the sole. We illustrated a pedal locomotion mechanism modeled on the locomotion mechanism of the snail[1)]. In this paper, an air mattress with a function of the pedal-like locomotion mechanism was developed. The performance of the pedal locomotory air mattress and the applicability of the air mattress to the mobility equipment for the bedridden are discussed.

Model of pedal –like locomotion mechanism

When a snail moves, dark transverse bands appear under the surface of the sole and proceed from the posterior to the anterior of the sole. The movement of the bands seems to be a propagation of the pedal waves formed by the muscular contraction of the sole. The pedal wave involves vertical as well as horizontal displacement of the pedal surface.

Figure 1 shows a model of a sole of the snail as a shape of the pedal wave is supposed to be a triangle wave. Here a region of the sole which goes upward and forward by muscular contraction represents an active phase, while a region in the condition of relaxation and rest on the musculature of the sole represents a static phase. When the pedal wave propagates by the forward movement of alternating active phase and static phases, the snail moves.

Figure 2 shows a model of pedal-like locomotion mechanism is represented by a series of inflated rubber balloons attached to each other. The mechanical effect of longitudinal contraction can be achieved by deflation, and extension by inflation of the balloon[2)]. (a)The posterior balloon 3 is contracted vertically and horizontally and forms a pedal wave. (b)A deflated balloon 2 when situated between two inflated ones, is lifted off the ground and the pedal wave is formed. (c)When the anterior one is inflated and rests on the ground, the whole chain of balloons moves in advance.

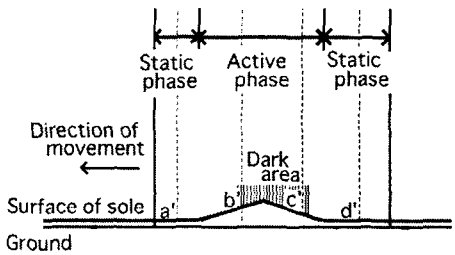

Fig.1 Model of sole of snail

Pedal locomotory air mattress

A schematic drawing of a pedal locomotory air mattress modeled on a pedal-like locomotion mechanism is shown in Fig.3. The pedal locomotory air mattress consists of air tubes (1) with a circular section made of high polymer film, a unit of electro-magnetic valves, a pump (6) for

supply and exhaust of air and a controller (9). Each air tube has a tap for supply and exhaust of the air, and is connected to a unit of electro-magnetic valve (5), which controls the flow of air. Remote controller (9) includes a programmed IC for controlling the unit of electro-magnetic valves. An air tube keeps circle in shape by elastic belts as it exhausts air. An elastic control material (4) between the air tubes and a sheet (3) enables the bedridden to carry with the air mattress. A photograph of a pedal locomotory air mattress made experimentally is shown in Fig.4. The air mattress consists of eight air tubes connected with nine rubber belts.

In this experiment, a personal computer (CPU:AMD K6-2 500 MHz) is used as a controller. Each air tube works the alternating behavior of inflation, deflation and rest according to the program for control of an electro-magnetic valve. The behavior of which the pedal wave propagates from the posterior to the anterior air tube is one cycle. In experiment, the distance of movement of the anterior air tube was measured after the behavior of ten cycles and the locomotion velocity of the pedal locomotory air mattress was obtained by calculation.

Results

The experiment was carried out in the case that the number of pedal wave generated over the whole series of air tubes is one. The relationship between propagation velocity of pedal wave and locomotion velocity of pedal locomotory air mattress is shown in Fig.5. The locomotion velocity of the air mattress was proportional to the propagation velocity. In the region of high propagation velocity, the locomotion velocity decreased because the air tube could not enough deflate and the response on the behavior of inflation and deflation of air tube became worse.

Conclusions

A pedal locomotory air mattress modeled on the mechanism of locomotion in a snail was developed and the performance of locomotion was investigated. The motion of the air mattress was confirmed and it was suggested that the pedal locomotory air mattress has the applicability to the mobility equipment for the bedridden and the function of prevention of bedsore.

Acknowledgement

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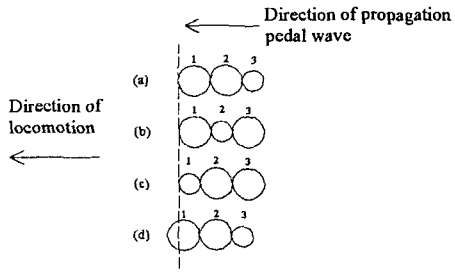

Fig.2 Model of pedal-like locomotion mechanism

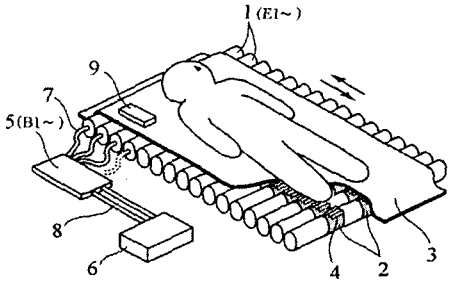

Fig.3 Schematic drawing of pedal locomotory air mattress

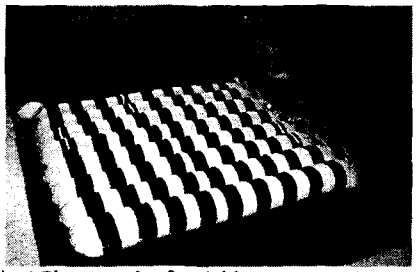

Fig.4 Photograph of pedal locomotory air mattress

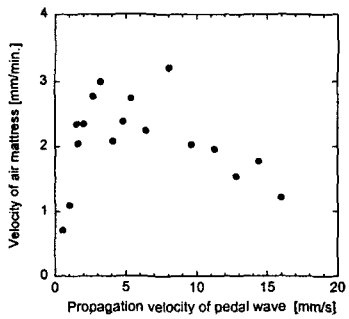

Fig.5 Relation between propagation velocity and locomotion velocity of pedal locomotory air mattress

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