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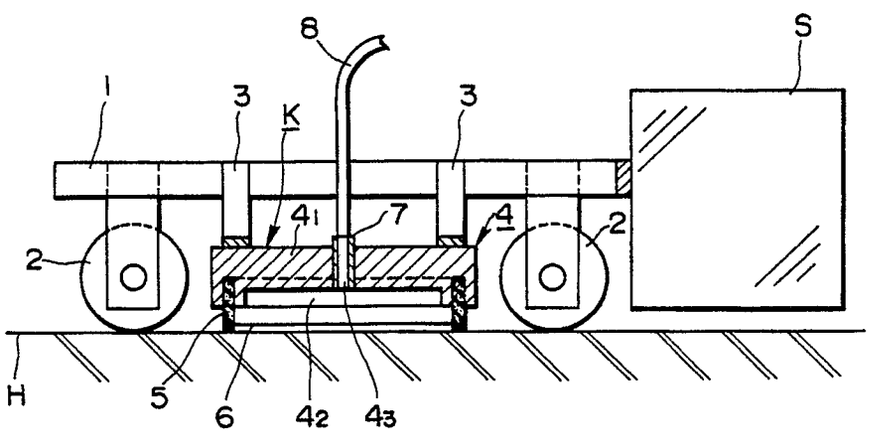
(54) Vacuum held crawler.

(57) A vacuum held crawler capable of substantially reducing frictional resistance between a wall of a building and the crawler, thus increasing the efficiency and reducing the power required for driving the crawler. A flexible seal member is arranged so as to surround a recess of a vacuum chamber and vertically project by a suitable length from the bottom of the vacuum chamber. A low friction member is mounted on the distal end of the seal member. The seal member and low friction member have thin walls. Such construction permits the flexible seal member to be in close contact by means of the low friction member with the wall while being held on the wall by the low friction member by suction, thereby preventing the bottom of the vacuum chamber from coming into contact with the wall.

FIG.1



EP 0 407 745 A2

VACUUM HELD CRAWLER

This invention relates to a vacuum held crawler, and more particularly to a crawler which is adapted to travel on a wall surface of a building or the like by self-propelling operation or driven otherwise, while being held on the wall surface by vacuum suction, to thereby permit any working equipment mounted on the crawler to automatically carry out dangerous operations such as cleaning, painting, maintenance/attendance or the like of the wall, the building or the like.

Such a conventional crawler being held on a wall by vacuum suction is disclosed in the published Japanese Patent Application No. 98595/1978. The crawler includes one single large-size bowl-like sucker for vacuum suction provided on the peripheral edge of the bottom side of the crawler with a flange-like seal member of great width which is outwardly expanded. The crawler is adapted to be suctionally held on a wall by the sucker. The sucker is equipped with wheels, by means of which the crawler is adapted to travel on the wall. Thus, in the conventional crawler, a vacuum created in the large-size sucker causes atmospheric pressure to be exerted to the outside of the overall flange-like seal member to closely hold the sucker on the wall. Unfortunately, due to this a frictional resistance between the sucker and the wall is substantially increased to a degree sufficient to deteriorate the operating efficiency of the crawler and to substantially increase the demand for driving force required for driving the apparatus. In addition, the conventional crawler is so constructed that it is held on the wall by the single large-size sucker by means of vacuum suction. Such a construction results in that the crawler fails to pass any obstacle such as projections, window frames or the like on the wall.

It is an object of the present invention to provide a vacuum held crawler which is capable of substantially decreasing frictional resistance between the apparatus and the wall on which it travels. In particular, the crawler should be capable of continuously and positively traveling on a wall irrespective of any obstacle such as projections or the like on the wall, while being suctionally held on the wall.

This object is solved by a crawler according to the main claim. The subclaims characterize preferred embodiments of the crawler of the invention.

To summerize some aspects of a preferred embodiment of the crawler, it comprises a frame on which a working equipment is adapted to be mounted, a vacuum-suction mechanism mounted on the frame, wheels mounted on the frame and a surface contact mechanism for receiving the vacuum suction force acting between the crawler and the wall which surface contact mechanism travels on the wall. The vacuum-suction mechanism includes a vacuum chamber formed at the bottom thereof, having an opening and being connected to vacuum generating means, a flexible seal member mounted on the bottom of the vacuum chamber in a manner as to surround the bottom opening of the vacuum chamber and to downwardly project by a suitable distance from the bottom of the vacuum chamber. The surface contact mechanism includes a low friction member having a low friction coefficient and being mounted on the distal end of the seal member and being in close contact with the wall.

Embodiments of the present invention will now be described by reference to the accompanying drawings, wherein:

Fig. 1 is a vertical sectional view showing an embodiment of a crawler according to the present invention;

Fig. 2 is a plan view of the crawler shown in Fig. 1;

Fig. 3 is a vertical sectional view showing a seal member and a low friction member mounted on the seal member which are incorporated in the crawler shown in Fig. 2;

Figs. 4 and 5 each are a bottom view showing a vacuum-suction mechanism which may be arranged in the crawler of Fig. 2;

Fig. 6 is a plan view showing another embodiment of a crawler according to the present invention;

Fig. 7 is a side elevation view of the crawler shown in Fig. 6 in use;

Fig. 8 is a vertical sectional front elevation view showing a vacuum-suction mechanism including wheels and lifting means in the apparatus shown in Fig. 6; and

Fig. 9 is a side elevation view partly in section of the surface suction mechanism shown in Fig. 8 with the wheels being removed.

Figs. 1 to 5 illustrate an embodiment of a vacuum held crawler according to the present invention. The crawler includes a frame 1, on which working equipment S such as cleaning equipment or the like is adapted to be mounted. The crawler also includes a vacuum-suction mechanism K and wheels 2 mounted on the frame 1. The vacuum-suction mechanism K includes a vacuum chamber 4 fixed to the bottom portion of the frame 1 by means of support members 3 and being connected to suitable vacuum-generating means (not shown), a seal member 5 fitted to the bottom portion of the vacuum chamber 4 so as to downwardly project

therefrom. A low friction member 6 formed into an annular shape is attached to the distal end of the seal member 5. The vacuum chamber 4 includes a circular recess 4_2 formed on the bottom of a rectangular or square plate 4_1 so as to open to the outside or in downward direction. The rectangular plate 4_1 is formed at its central portion with a small through-hole 4_3 vertically extending between the upper surface of the plate 4_1 and the recess 4_2. An exhaust pipe 7, which is connected by a hose 8 to the vacuum-generating means (not shown) such as an air blower, a vacuum pump or the like is disposed in the through-hole 4_3.

The seal member 5 is formed of a suitable flexible material such as sponge rubber or the like into an annular shape and fitted to the rectangular plate 4_1 so as to surround the circular recess 4_2. The seal member 5 is arranged so as to vertically project by a suitable length or distance from the bottom of the plate 4_1 towards a wall H of a building or the like on which the crawler is to travel. The low friction member 6 is mounted on the annular distal end of the seal member 5. Such an arrangement of the low friction member 6 permits the seal member 5 to be in close contact with the wall H through the low friction member 6. The annular seal member 5 and the low friction member 6 each have a small thickness, and at the end furface facing the wall H has a flat shape. The wheels 2 are arranged on both sides of each of the front and rear portions of the frame 1 and are adapted to be rotatably driven on the wall H to permit the apparatus to travel thereon.

In the illustrated embodiment, the positioning of the wheels 2 with respect to the frame 1 in vertical direction and the length by which the seal member 5 projects from the plate 4_1 are chosen so that the wheels 2 absorb most of the vacuum suction force generated in the vacuum chamber 4 during use of the crawler in order to prevent the vacuum suction force to force the bottom of the vacuum chamber 4 into abuttment against the wall H during use of the crawler. The traveling of the crawler on the wheels 2 may take place by self-propelling operation which may be effected by connecting one of the wheels 2 to a drive motor M and the remaining wheels to the drive wheel by means of a chain or the like as is shown in Fig. 2. Alternatively, the traveling may be effected by external drive action, for example, by connecting suitable winding-up means such as a winch or the like to the frame 1 to move the crawler in vertical direction.

Now, the manner of operation of the crawler will be described.

The crawler is placed on the wall H and is activated. Then, the vacuum generating means is activated, so that the vacuum chamber 4 defined by the seal member 5 and wall H may be evacuated. This causes a pressure drops in the vacuum chamber 4 to a level below atmospheric pressure, resulting in the seal member 5 being held on the wall H by the low friction member 6 by vacuum suction, when the crawler travels on the wall H. During the time, while vacuum suction force is acting on the crawler, said force is substantially received by the wheels 2 so that the bottom of the vacuum chamber 4 is prevented from coming into abutment against the wall H. Thus, the crawler may smoothly travel on the wall while being held on the wall H by the low friction member 6 by vacuum suction.

In the illustrated embodiment, one such vacuum-suction mechanism K is arranged on the frame 1. However, a plurality of such mechanisms may be used, too. Also, a plurality of recesses 4_2 may be arranged for forming the vacuum chamber 4. Furtheron, the recess 4 and therefore the seal member 5 and the low friction member 6 are formed into a circular or annular shape. However, they may also have any suitable shape other than a circular shape such as a square shape or the like. Moreover, the wheels 23 may be arranged at the vacuum chamber 4 rather than on the frame 1.

Figs. 6 to 9 show another embodiment of a vacuum held crawler according to the present invention. In this embodiment, vacuum-suction mechanisms are arranged and mounted on a frame in a manner different from that described above.

More particularly, the apparatus of the embodiment includes a frame 11 on which working equipment S is mounted in a manner to be positioned at the central portion thereof and a plurality of vacuum-suction mechanisms K are arranged on each of the two sides of each of the front and rear portions of the frame 11. A plurality of vacuum-suction mechanisms K arranged in rows in the width or lateral direction of the frame 11 perpendicular to the longitudinal direction thereof are mounted through support members 13 on the bottom surface of a common connecting plate 12 arranged so as to extend in the lateral direction of the frame 11. Two mechanisms K each are mounted together on each of the connecting plates 12. The crawler also includes a plurality of wheels 2 mounted on both sides of the connecting plate 12 in the longitudinal direction thereof. On both sides of each of the front and rear portions of the frame 11 a pair of support beams 14 is arranged in a manner as to be opposite to each other. The connecting plates 12 which are arranged at the front and rear portions of the frame 11 are connected with both sides thereof to the support beams 14 by air cylinders 15 in a manner as to be movable in vertical direction or in a direction perpendicular to the wall H. The air cylinders 15 each may be operated in such a manner that a sensor (not

shown) sensing the passage of the vacuum-suction mechanism K across any obstacle such as a projection T on the wall H, supplies a detection signal to a control means (not shown) which is operatively connected to the air cylinder 15, to thereby actuate the control means. The positioning of the wheels 2 with respect to the connecting plates 12 and the positioning of the vacuum chamber 4 of the vacuum-suction mechanism K with respect to height or vertical direction may carried out by causing the vacuum suction force generated in the vacuum chamber to be substantially received by the wheels 2 in order to prevent the bottom of the vacuum chamber 4 from coming into abutment against or contacted with the wall H.

Reference numeral 16 designates fitting members provided on the front face of the frame 11 so as to project in forward direction therefrom. A lifting rope extends through the fitting member 16 between a winch and the frame 11. The movement of the apparatus may be effected in the same manner as in the embodiment described with reference to Figs 1. to 5. More particularly, the crawler is pulled by means of the winch. Alternatively, the crawler is moved by self-propelling operation by connecting part of the wheels 2 to a drive motor and connecting the remaining wheels to the drive wheel by means of a chain or the like. The working equipment S may be mounted on the frame 11 so that the entire equipment S or a part thereof which is arranged adjacent to the wall H, is spaced from the wall H by a distance sufficient to avoid any obstacle on the wall H.

When the crawler of the illustrated embodiment travels on the wall H, while being suctionally held thereon, only the particular vacuum-suction mechanism(s) K encountering the projection T on the wall H is lifted by means of the air cylinders 15 from the wall H to pass the obstacle. concurrently, the working equipment S will likewise avoid the projection T. During this time, the rest of the vacuum-suction mechanisms still move on the wall H while being held thereon by suction, so that the crawler continuously travels on the wall H. When the vacuum-suction mechanism K which was lifted to avoid the projection T has passed the projection T, it is again lowered down to the wall H by means of the air cylinder 15, being held thereon by suction. Correspondingly, the working equipment S is likewise lowered to the wall H for further operation.

In the embodiment shown in Figs. 6 to 9, one vacuum-suction mechanism K is arranged on each side of each connecting plate 12. However, a plurality of vacuum-suction mechanisms K may be arranged on each side of each connecting plate 12. The vacuum chambers 4 may be formed at the connecting plates 12, wherein a suitable number of recesses 4_2, seal members 5 and members 6 are provided on the bottom of each of the connecting plates 12. Further, the vacuum chambers 4 may rather be arranged in a manner other than the above-described manner of the first embodiment, wherein the chamber 4 together are mounted in groups on the connecting plates 12. For example, they may be mounted on the frame 11 being vertically movable by the air cylinders 15. Moreover, any suitable lifting or spacing means other than the air cylinder 15 may be conveniently used in the present invention as far as it can enable the wall vacuum-suction mechanism K to avoid the projection T on the wall H.

As can be seen from the foregoing, the crawler of the present invention constructed as described above substantially decreases frictional resistance between the apparatus and the wall of a building or the like, and thereby improves the efficiency of the crawler and reduces the power required for driving the crawler, as compared with the conventional crawler. More particularly, in the conventional apparatus, the trumpet-shaped seal member provided on the lower peripheral edge of the bowl-like sucker is in close contact with the wall by vacuum suction, thus substantially increasing frictional resistance between the seal member and the wall. In contrast thereto, the flexible seal member in the present invention provided so as to surround the recess of the vacuum chamber is arranged so that it projects vertically by a suitable length from the bottom of the vacuum chamber and the low friction member is mounted on the distal end of the seal member. The seal member and low friction member are thin-walled parts. Such construction permits the flexible seal member to come into close contact by means of the low friction member with the wall while being held on the wall by the low friction member by vacuum suction, thereby preventing the bottom of the vacuum chamber from coming into contact with the wall. This is more efficiently accomplished when the positioning of the wheels with respect to the frame and the position of the vacuum chamber in vertical direction of the crawler is suitably chosen. Thus, the apparatus of the present invention highly reduces frictional resistance and can smoothly travel on the wall by means of the low friction member while being held thereto by the low friction member.

The crawler of the present invention also continuously and positively travels on the wall irrespective of any obstacle such as a projection on the wall, and thereby enables the working equipment to safely and efficiently carry out dangerous operations at an elevation. More particularly, the conventional crawler is constructed so as to travel on the wall by means of one single large-size sucker, and thereby fails to continuously travel across a projection on the wall so that it is required to stop

the movement and to remove the entire crawler from the wall in order to enable the crawler to pass the projection and then to again place it on the wall for restarting the operation. In contrast thereto, a plurality of the vacuum-suction mechanisms is arranged in the present invention at the front and rear portions of the frame in a manner to be vertically movable with respect to the frame. Such construction of the present invention permits the vacuum-suction mechanisms to be lifted in order to avoid a projection, only when they encounter the projection, and the remaining mechanisms are kept on the wall by suction, so that the apparatus may continuously travel on the wall irrespective of the projection while being held on the wall by suction.

Claims

1. A vacuum held crawler comprising:
- a frame on which working equipment is to be mounted;
- a vacuum-suction mechanism mounted on said frame and wheels mounted on said frame characterized in that said vacuum-suction mechanism includes a vacuum chamber formed at the bottom thereof having an opening and being connected to vacuum generating means, a flexible seal member mounted on the bottom of said vacuum chamber in such a menner that it surrounds said bottom opening of said vacuum chamber and projects in downward direction by a suitable distance from the bottom of said vacuum chamber, and that a surface contact mechanisms including a low friction member having a low friction coefficient is mounted on the distal end of said seal member and being in close contact with a wall for receiving the vacuum suction force acting between the crawler and the wall and for traveling on the wall.

2. A crawler as defined in Claim 1, wherein a plurality of said vacuum-suction mechanisms are provided at the front and rear portions of said frame.

3. A crawler as defined in Claim 1 or 2, wherein said vacuum-suction mechanism each being arranged so as to be vertically movable by lifting means, thus avoiding any obstacle on the wall.

FIG.1

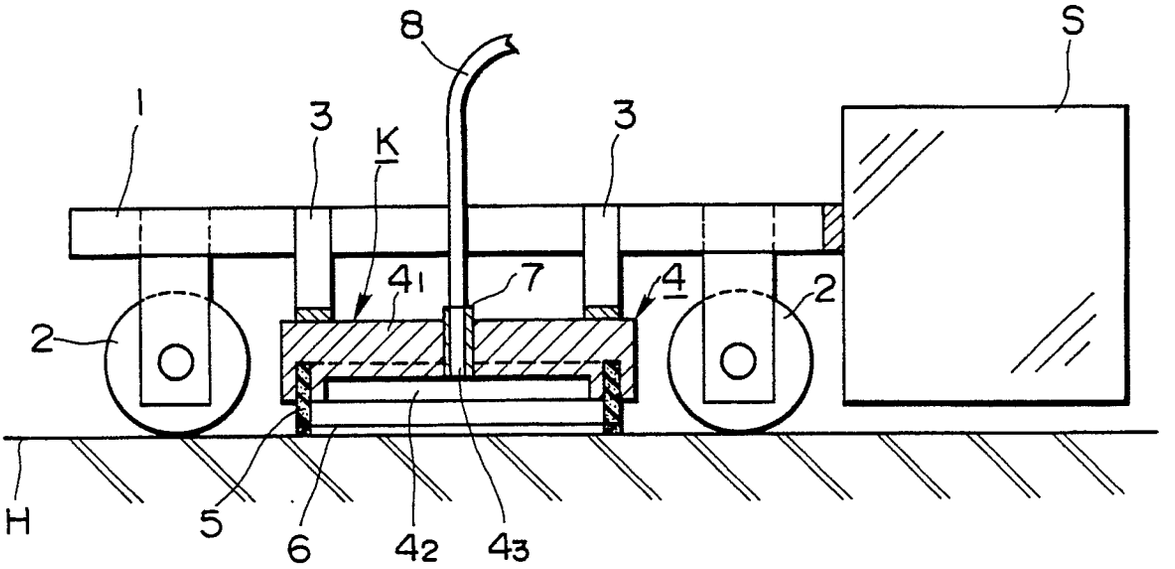


FIG.2

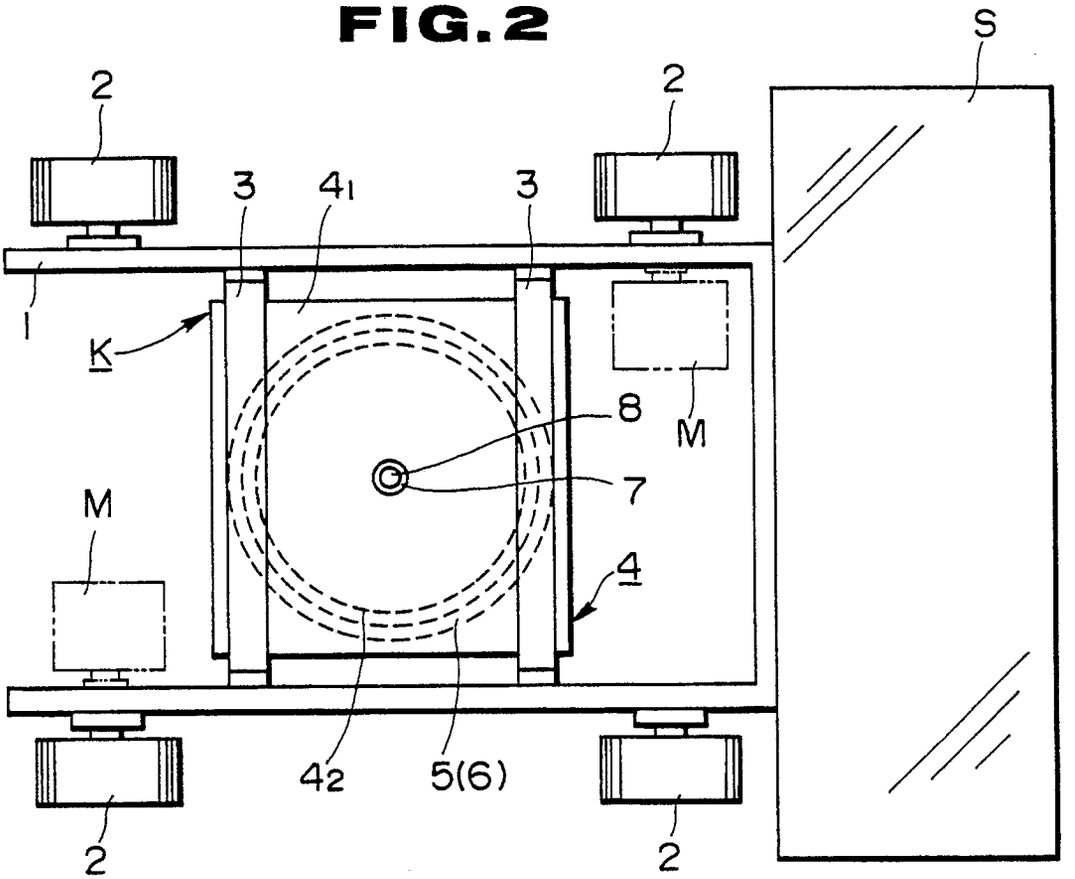


FIG. 3

FIG. 4

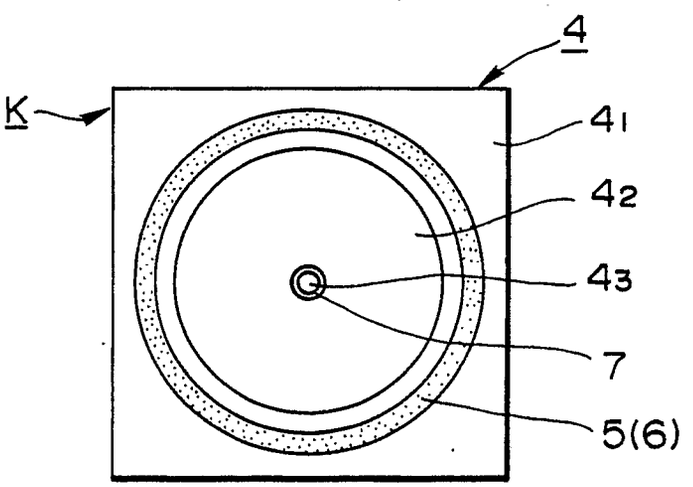


FIG. 5

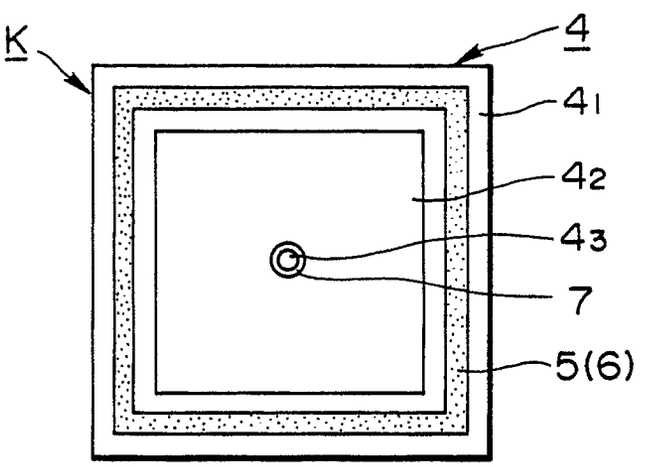


FIG.6

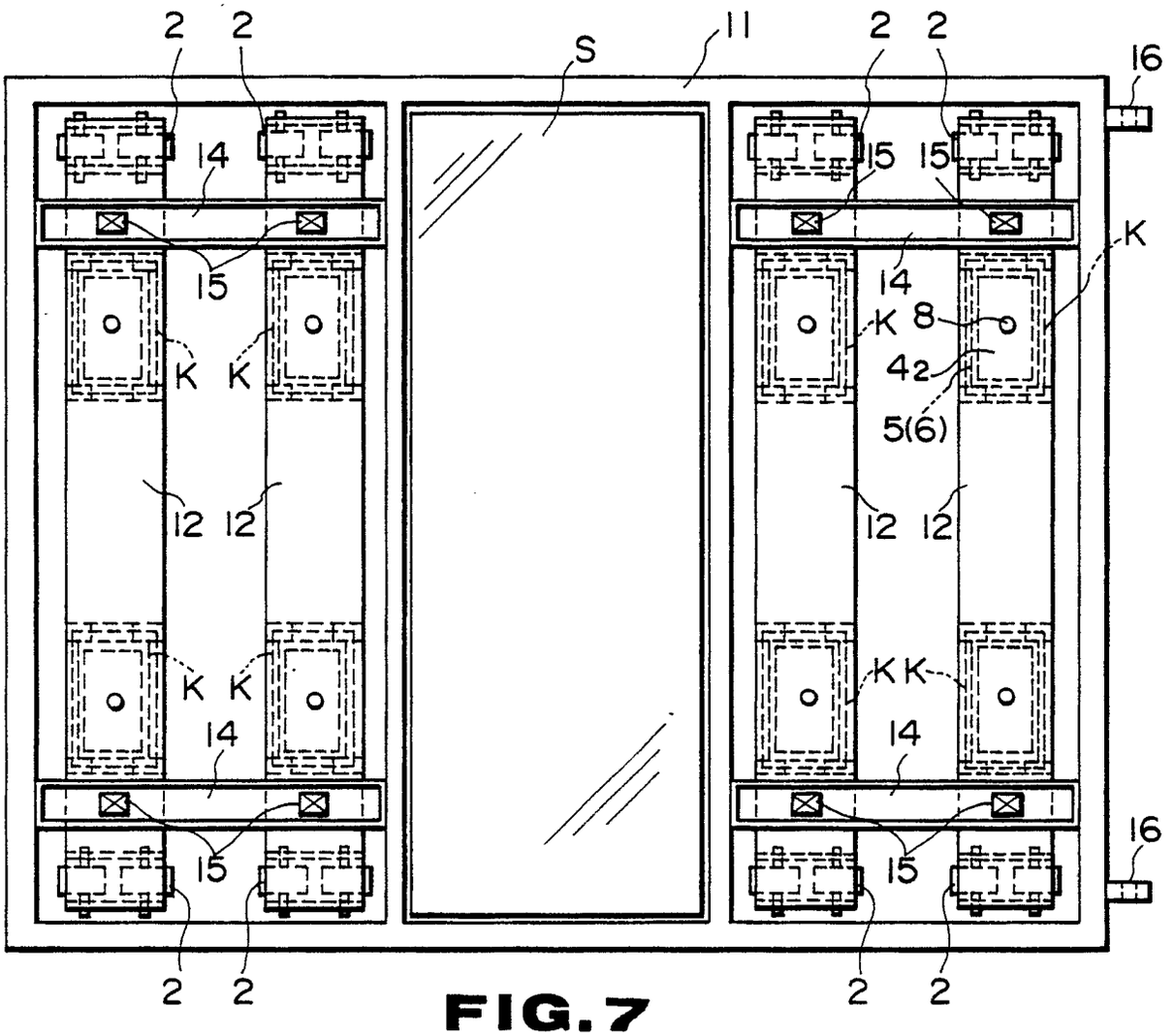

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FIG.7

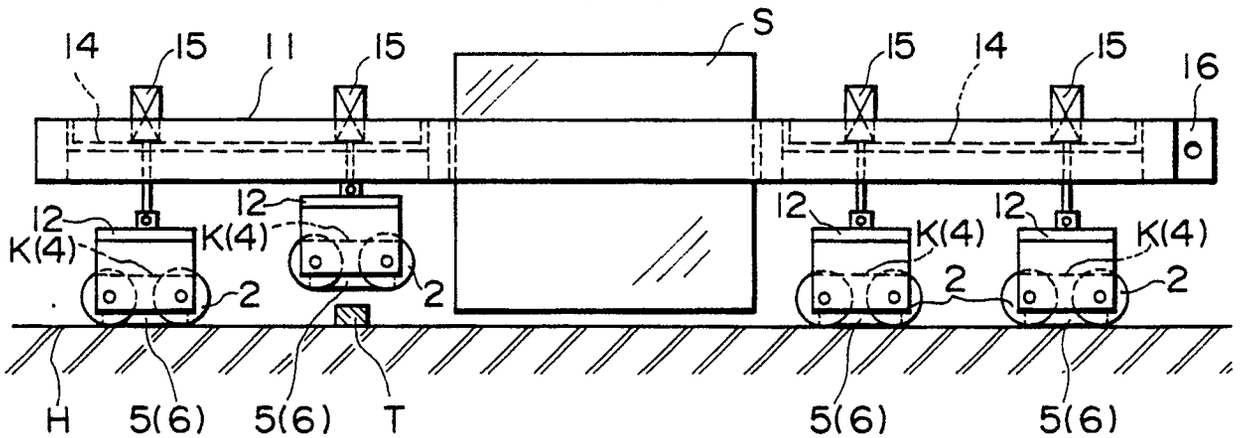
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FIG.8

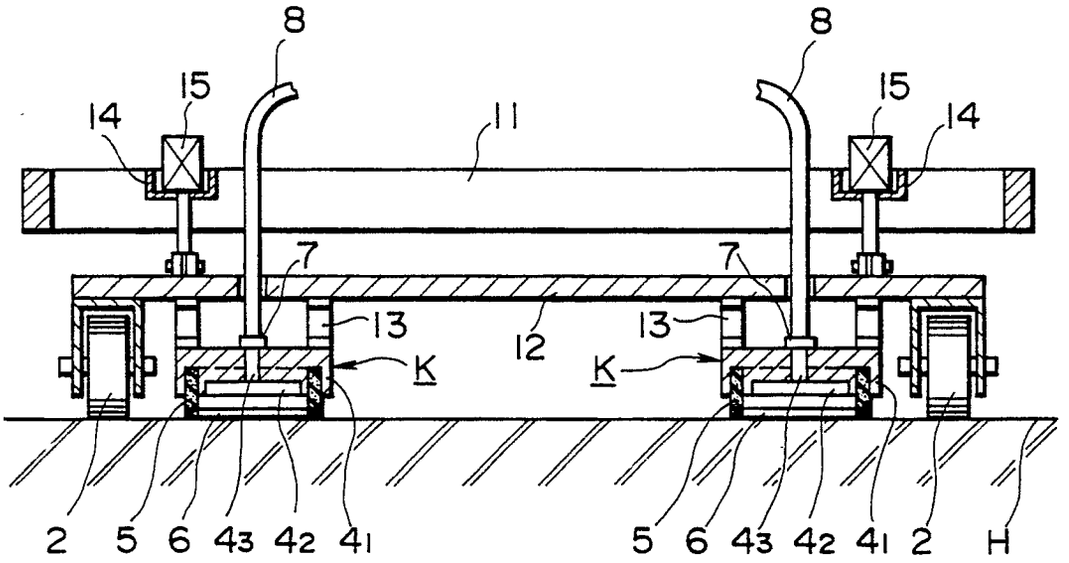
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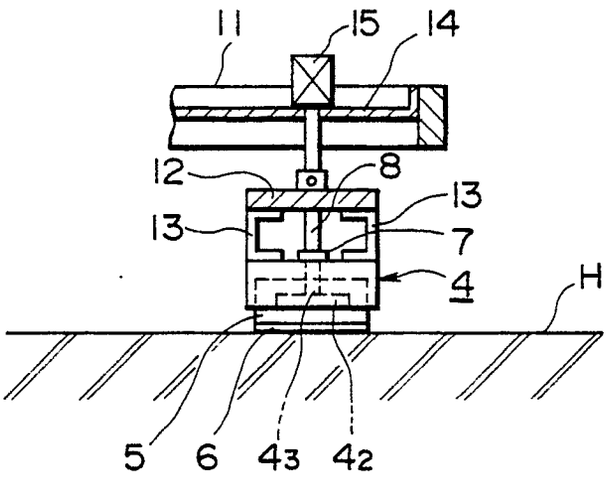
FIG.9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