

ESCALATOR APPARATUS AND METHOD OF OPERATION

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The present invention relates to escalator apparatus which may be used not only by general
5 passengers but also by a person on a wheelchair or by a handcart.

Escalator apparatus adapted to carry a wheelchair in addition to general passengers are
10 disclosed in Japanese Utility Model Publication No. 1-9828, Japanese Unexamined Patent Publication No. 2-8190 and US Patent No. 4,681,207.

The escalator apparatus disclosed in the Japanese Utility Model Publication No. 1-9828 must be of
15 an increased height along its entire length for a special truck to horizontally maintain a plurality of steps and for a rail exclusively used to run such a truck. Thus, there has been a problem that it is impossible to modify an existing escalator apparatus to
20 carry a wheelchair.

The escalator apparatus disclosed in the Japanese Unexamined Patent Publication No. 2-8190 has a plurality of steps horizontally arranged from the outset. Thus, in the case where the sloping angle, of
25 the escalator apparatus is relatively gentle and the

apparatus is to be installed for the same height, its installation size becomes relatively large.

Furthermore, in the escalator apparatus disclosed
5 in US Patent No: 4,681,207, a wheelchair carrying surface is formed by two steps. It is thus difficult for this escalator to carry a large size wheelchair or handcart.

According to the present invention there is
10 provided an escalator apparatus including steps having bases movable on a guide rail and movable step boards which are supported by said bases and can be raised to provide a surface for carrying a wheelchair, wherein said movable step boards are those of at least two
15 adjacent steps and are arranged to be movable upwardly and/or downwardly together with a further step board of an upper step adjacent to said at least two adjacent steps, and an inclination suppressing means is provided between said bases and said movable step
20 boards for suppressing inclination of said movable step boards when the latter step boards are in their raised positions.

In this way, the present invention can permit an escalator apparatus to carry a large size wheelchair
25 or a handcart.

The present invention may permit an escalator apparatus to carry a wheelchair without changing the conventional installation size thereof.

With the construction as described above, it is

possible to secure a large horizontal surface for carrying a wheelchair. As a result, it is easy to carry a large size wheelchair or a handcart. At the
5 same time, since ascent and descent of the step boards is performed by the raising/lowering mechanism provided in

1 the steps, it is not necessary to increase the installation size of the escalator apparatus compared with the conventional size.

In the drawings:

5 Fig. 1 is a partially sectional side view of a part of an escalator apparatus according to the present invention with the apparatus shown in operation;

Fig. 2 is a schematic side view of the escalator apparatus according to the present invention
10 showing entire operative modes thereof;

Fig. 3 shows in perspective view a coupling mechanism for a special step group of the escalator apparatus according to the present invention;

Fig. 4 is a top plan view showing a power
15 transmission mechanism for the special step group of the escalator apparatus according to the present invention;

Fig. 5 is a side view showing the power transmission mechanism of the special step group of the escalator apparatus according to the present invention;

20 Fig. 6 is a side view of a part of the escalator apparatus according to the present invention with a wheelchair on the special step group of the apparatus;

Fig. 7 is a perspective view showing respective mechanisms of the special step group at the sloping
25 portion of the escalator apparatus according to the present invention;

1 Fig. 8 is a perspective view of the special
step group and a wheelchair thereon at the sloping
portion of the escalator apparatus according to the
present invention;

5 Fig. 9 is a schematic side view showing the
entire modes of operation of the escalator apparatus
according to another embodiment of the present invention;

 Fig. 10 is a schematic side view of a lower
entrance/exit section of the apparatus according to the
10 other embodiment of the present invention;

 Fig. 11 is a schematic side view of an upper
entrance/exit section of the escalator apparatus of the
other embodiment of the present invention; and

 Fig. 12 is a schematic side view of a wheel-
15 chair carried by the escalator apparatus of the other
embodiment of the present invention.

 An embodiment of the present invention will
now be described with reference to Figs. 1 to 8. As
20 shown in Fig. 2, the escalator apparatus according to
the present invention has a plurality of steps 3
connected together to form an endless loop arranged to
extend and driven to run between a lower entrance/exit 1
and an upper entrance/exit 2 which are provided on a
25 lower floor and an upper floor, respectively, of a
construction or building. A railing 4 is raised along
each of the two sides of the path of travel of the steps

- 1 3. A handrail 5 which rotates in the same direction as
the steps 3 is guided by the railing 4. Of the plurali-
ty of steps 3, specific three steps 7-9 located next to
one another are selected to form a special step group
5 6. In the special step group 6, an upper step 7 is
selected as a reference step. The respective step
boards of a middle step 8 and a lower step 9 of the
particular step group can be elevated so that a
horizontal surface is provided by the special step group
10 6 to carry a wheelchair 10.

The actual construction and operation of the
above described special step group will now be described
with reference to Fig. 1 and Figs. 3 to 8. The upper
step 7, middle step 8 and lower step 9 of the special
15 step group 6 are respectively provided with a fixed step
board 7F and vertically movable step boards 8F and 9F
and have front wheels 11A and rear wheels 11B rotatable
between and guided by guide rails 12A and 12B which are
fixed to a frame body constituting the fixed structure
20 of the escalator. Further, the step boards 8F and 9F
are supported through parallel linkages 14 and 15 on
bases 12 and 13 on which the front wheels 11A and rear
the wheels 11B are mounted. Note that the parallel
linkage 15 of the lower step 9 is formed by two sets of
25 linkages, i.e., a first parallel linkage 15A and a
second parallel linkage 15B with a middle base 13S
interposed therebetween. Furthermore, coupling mecha-
nisms 16 and 17 are provided between the step boards 7F,

1 8F and 9F to couple them together when a wheelchair is
to be carried. A coupling mechanism 18 for coupling the
base 12 of the middle step 8 and the middle base 13S of
the lower step 9 is also provided. In addition, the
5 lower step 9 is provided with a riser 19A attached to
the base 13, a riser 19B attached to the middle base 13S
and a riser 13C attached to the step board 9F, the three
risers forming a triple superposed structure. On the
other hand, the coupling mechanisms 16, 17 and 18 are
10 constructed as shown in Figs. 3 to 5. That is, when the
steps 7 to 9 are horizontally positioned, a rack rotat-
ing mechanism is rotated by a motor energized by a
built-in battery within a step or an external power
supply, or by a rack mechanism and driving means within
15 the steps, as shown in Figs. 4 and 5. Fixing hooks 20A,
20B, 21A, 21B, 22A and 22B are thus rotated to fix the
steps 7, 8 and 9 together against relative movements in
vertical and forward-rearward directions.

When the steps 7, 8 and 9 are horizontally
20 positioned at the lower portion or at the upper portion
of the escalator, the vertical load from the wheelchair
10 does not act upon the fixing hooks 20A, 20B, 21A,
21B, 22A and 22B, so that it is easy to engage the
fixing hooks. Further, the parallel linkages 14 and 15
25 which bear the moment generated by the load of the
wheelchair 10 do not receive the load and are in their
free state. Thus the load from the wheelchair 10 only
acts upon the front wheels 11A and the rear wheels 11B.

1 of the steps 7, 8 and 9 as downward loads F1-F6. The
fixing hooks 20A and 20B are pivotally supported by
shafts S1 and S2 on the lower surface of the step board
7F and are rotatable into engagement with noses 23A and
5 23B provided on the adjacent step board 8F. The fixing
hooks 21A and 21B are rotatably supported by the shafts
S3 and S4 on the lower surface of the step board 8F and
are rotatable to engage noses 24A and 24B provided on
the adjacent step board 9F. Furthermore, the fixing
10 hooks 22A and 22B are supported by means of shafts S5
and S6 on the base 12 of the step 8 and are rotatable to
engage noses 25A and 25B provided on the middle base 13S
of the adjacent step 9. It should be noted that no
jolting is caused after such engagement since the free
15 ends of the fixing hooks 20A, 20B, 21A, 21B, 22A and 22B
are engaged with the respective noses 23A, 23B, 24A,
24B, 25A and 25B while they are inserted into the
respective spaces formed between these noses and rollers
26 disposed adjacent the noses. Further, the state of
20 engagement may be constantly maintained by a stopper 27
provided at the position corresponding to the terminal
end of each fixing hook in its engaged position.

The mechanism for rotating the fixing hooks
are drivingly connected to pinions 30-32 beneath the
25 steps 7-9 by a group of power transmission gears 28, 29A
and 29B, respectively. These pinions 30-32 are adapted
to mesh with racks 34 arranged in parallel to the guide
rails 12A, 12B. The racks 34 are disposed in the upper

1 and lower horizontal portions of the escalator and
 raised into meshing engagement with the pinions 30-32
 only when a wheelchair is to be carried. It should be
 noted that, instead of the racks 34, motors 34A-34C may
 5 be provided in the steps 7 and 8 to drive the pinions.

Fig. 6 shows the state of carrying the wheel-
 chair 10 when the steps 7-9 are in their horizontal
 state at an entrance/exit. In this state, the fixing
 hooks 20A-20B of the coupling mechanism are already
 10 engaged and extend over adjacent pairs of steps 7 and 8
 and 8 and 9. Since, at this time, loads W_1 and W_2 from
 the wheelchair 10 act directly upon the front wheels 11A
 and the rear wheels 11B, but not act upon the
 above-described fixing hooks.

15 A description will now be given with respect
 to a case where the special step group carrying the
 wheelchair 10 is moved to the sloping portion of the
 escalator. As shown in Figs. 7 and 8, the upper step 7
 of the special step group receives loads W_1 and W_2 of
 20 the wheelchair 10 through the fixing hooks 20A-22B and
 the moment caused by said loads is born by the parallel
 linkages 14 and 15 to distribute the loads to the
 respective front wheels 11A and rear wheels 11B of the
 steps 7-9. Loads on the front wheels 11A and rear
 25 wheels 11B are thus lowered to an allowable level.
 Specifically, the lower step 9 is heavily loaded by the
 wheelchair 10 in the case where the wheelchair is a
 motor-operated one and is heavy and large in size.

1 Thus, the upper step 7 and the step board 8F of the middle step 8 are connected in an interlocked manner by means of the fixing hooks 20A and 20B. Further, an interlocked connection is made respectively between the

5 step board 8F and the step board 9F of the lower step 9 by fixing hooks 21A and 21B and between the base 12 and the middle base 12S by the fixing hooks 22A and 22B. In this state, when the upper step 7 is displaced upward as it is moved to the sloped portion of the escalator, the

10 steps 8F and 9F connected to the upper step 7 by the fixing hooks 20A-22B are lifted. At this time, while the step boards 8F and 9F tend to be inclined about the fixing hooks 20A, 20B and 21A, 21B, the parallel linkages 14 and 15 are provided to prevent such inclina-

15 tion. That is, a moment $M_1 = W_1 \times l_1$ is generated when the load W_1 by the wheelchair 10 acts upon the step board 9F of the lower step 9. Since this moment M_1 is transmitted to the parallel linkage 15, the moment is distributed to the front wheel 11A and the rear wheel

20 11B of the lower step 9. On the other hand, since the load W_1 is received by the fixing hooks 21A and 21B, the load W_1 acts as a load W_3 at the point of connection. Further, the load acting upon the step board 8F consists of the above-mentioned load W_3 and the load W_2 by the

25 wheelchair 10. When these loads W_2 and W_3 act upon the step board 8F, a total moment M_2 consisting of a moment $W_3 \times l_2$ and a moment $W_2 \times l_4$ is generated. The moment M_2 is distributed to the front wheel 11A and the rear

1 wheel 11B of the middle step 8. Further, the loads W_2
 and W_3 are received as a load W_4 by the fixing hooks 20A
 and 20B. The upper step 7 is subjected to the load W_4 ,
 the weight of itself and a moment M_3 consisting of $W_4 \times$
 5 l_3 . At this time, the respective front wheels 11A and
 rear wheels 11B of the steps 7-9 are subjected to loads
 F_1-F_6 (Fig. 7).

The operation of the escalator constructed as
 described will now be described. If it is desired to
 10 place a wheelchair on an escalator which is being
 operated in its usual manner, it is necessary to call a
 person in charge or to push an operation button provided
 in the vicinity of an entrance/exit to switch the opera-
 tion of the escalator to an wheelchair carrying mode.
 15 When it is switched to the wheelchair carrying mode, the
 special step group 6 is stopped in front of the lower
 entrance 1. At this time, the respective step boards
 7F, 8F and 9F of the upper step 7, the middle step 8 and
 the lower step 9 are horizontally arranged so that the
 20 wheelchair 10 can be loaded thereon. Upon detecting
 that the above described special step group 6 has been
 stopped at the predetermined position, the rack 33 shown
 in Figs. 4 and 5 is raised and engaged with the pinions
 30-32 incorporated into the steps 7 and 8.

25 Next, when the escalator is operated by
 pushing the operation button of the escalator, the
 pinions 30-32 meshed with the rack 33 are rotated as the
 steps 7 and 8 are moved. Such rotation is transmitted

1 by the power transmission gear group 28, 29A and 29B to
the fixing hooks 20A-22B to cause them to rotate into
locking engagement with the noses 23A-25B of the adjoin-
ing step boards 8F and 9F and the middle base 13S. When
5 the steps 7-9 are further moved and enter the sloped
portion of the escalator, the upper step 7 is moved
upward. At this time, the step boards 8F and 9F of the
middle step 8 and the lower step 9 which are coupled to
the upper step 7 are concurrently raised upward so that
10 the parallel linkages 14 and 15 are extended. The steps
are further moved through the sloped portion while
maintaining their horizontal positions (Fig. 1, Fig. 2,
Fig. 7, Fig. 8).

In this sloped portion, the step board 9F of
15 the lower step 9 is to be raised by the amount equal to
two steps. If nothing is done, a large gap is formed
between the step board 9F and the base 13. In the
present embodiment, however, the risers 19A-19C
constructed in three-fold are provided to prevent the
20 occurrence of such gap.

When the above described special step group 6
reaches the horizontal portion at a higher entrance/
exit, the steps 7-9 are brought into the same level, so
that the parallel linkages 14 and 15 are contracted.
25 Thus, no difference in level is caused between the step
boards 7F-9F. Stopping the special step group 6 at a
predetermined position, the wheelchair 10 is moved to
the upper entrance/exit and then removed therefrom. It

1 should be noted that, after the special step group has
arrived at the predetermined position, the rack is
raised, in a similar manner as at the lower entrance/
exit 1, into engagement with the pinions 30-32 and the
5 escalator is again operated in normal mode. The fixing
hooks 20A-22B are rotated and disengaged to release the
interlocking. This rising of the upper rack may be
performed simultaneously with the rising of the lower
rack at the lower entrance/exit. After the above
10 described interlocking is released, the rack is lowered
to assure that the rack is disengaged from the pinions
30-32 during normal operation of the escalator.

Many movable components are incorporated in
the steps 7-9 to raise and lower the step boards 8F and
15 9F. If, among such movable components, the fixing hooks
20A-22B for example are not securely moved to their
predetermined positions, the step boards 8F and 9F are
displaced at the time of carrying a wheelchair to
receive an excessive stress. In order to detect that
20 each of the fixing hooks is displaced to its predeter-
mined position, it is thus desirable to provide a motion
confirming member which is movable with each fixing
hook. A sensor is provided for example on the frame of
the escalator at a position corresponding to the
25 displaced position of the motion confirming member to
check the reliability of motion to perform safe
operation.

1 Further, since the steps 8 and 9 provided with
the movable step boards 8F and 9F are reversed in their
high and low relationship on the returning side of the
escalator. It is thus possible that the step boards 8F
5 and 9F are separated from the bases 12 and 13 due to
their own weight and are damaged upon their collision
against the bottom of the frame body. Therefore, it is
desirable to provide a holding mechanism which holds the
step boards 8F and 9F at their predetermined positions
10 during normal operation and releases them from the
predetermined positions when a wheelchair is to be
carried.

As has been described, according to the above
embodiment, the three step boards 7F, 8F and 9F are
15 maintained horizontally even at the sloped portion by
the coupling mechanism for coupling the upper step 7 of
the special step group 6 to the respective step boards
8F and 9F of the two remaining steps 8 and 9. It is
thus possible to carry a large wheelchair without
20 changing the construction of a conventional escalator.

Another embodiment of the present invention
will now be described with reference to Figs. 9-11,
wherein the reference numerals same as in Figs 1-8
indicate identical components and a repetitive descrip-
25 tion thereof will be omitted. This embodiment is
similar to the foregoing embodiment in that the respec-
tive step boards 37F and 38F of middle and lower steps
37 and 38 of a special step group 35 are raised to the

1 same level as the step board of an upper step 36 when
carrying a wheelchair to secure a surface for supporting
the wheelchair and that the raising/lowering mechanisms
for the step boards 37F and 38F are incorporated in the
5 steps 37 and 38 to make it possible to transport a large
size wheelchair or a handcart without changing the
installation size of the escalator.

In the embodiment, the respective mechanisms
for raising/lowering the step boards 37F and 38F are
10 provided independently from each other in the steps 37
and 38. That is, the step boards 37F and 38F are
provided on bases (not shown) equivalent to those in the
foregoing embodiment and cross linkages 39 and 40 are so
constructed as to be expanded/contracted by power from
15 power transmission gear 41 and 42. The transmission
gears 41 and 42 are to be driven by an external driving
means. That is, when an instruction for wheelchair
carrying operation is given, racks 45A and 45B located
respectively at the upper and lower portions of the
20 escalator between the sloped portion and the respective
horizontal portions are raised in the direction of the
arrows so that the rack 45A is engaged with the pinions
43 and 44 at the lower entrance/exit 1. If the
escalator is operated in this state, since the rack 45A
25 is not moved, the pinions 43 and 44 are rotated and the
rotating force thereof causes the cross linkages 39 and
40 to be raised through the power transmission gears 41
and 42 so that the step boards 36F-38F of the steps

1 36-37 are placed in the same level. The steps 37 and 38
after being disengaged from the rack 45A are continued
to be moved with the cross linkages 39 and 40 in their
raised state. When the pinions 43 and 44 are engaged
5 with the rack 45B at the upper portion, the cross
linkages 39 and 40 are lowered as shown in Fig. 11.
Before the normal operation is restored, the racks 45A
and 45B are lowered to their regular positions.

It should be noted that a wheel stopper 46
10 projects from the step board 38F of the step 38 and is
vertically movable by a power transmission gear 47
incorporated into the step 38. The lower portion of the
power transmission gear 47 is engaged by a rack raised
from its regular position or by driving chains 48A and
15 48B. At the side of the lower entrance/exit, therefore,
after a wheelchair 10 is placed on the special step
group, the wheel stopper 46 is caused to protrude by the
operation of the power chain 48A and the escalator is
operated in this state. On the other hand, at the upper
20 entrance/exit 2, the power chain 48B is operated after
the wheelchair 10 is removed from the escalator to lower
the wheel stopper 46. Further, when a wheelchair 10 is
to be loaded at the upper entrance/exit 2, the wheel
stopper 46 is caused to protrude before the loading.
25 During the movement of the escalator, a stopper is
formed by the wheel stopper 46 and a riser 3R of an
upper step 3U which is adjacent to the special step
group 35. It is thus possible to safely carry the

1 wheelchair 10 by retaining it within the range of the
special step group 35.

Further, since the steps 37 and 38 are
independent from the step 36, the arrangement of the
5 preceding embodiment may be incorporated into the
present embodiment, if necessary, to assure a safe
operation.

Fig. 12 shows another embodiment according to
the present invention, in which only a middle step 37 of
10 the special step group 35 is provided with a raising/
lowering mechanism 49 for raising/lowering a step board
37F. A step board 38F of a lower step 38 is raised/
lowered by a supporting rod 50 which projects from the
step board 37F.

15 As has been described, the present invention
provides an escalator apparatus which can carry a large
size wheelchair of a handcart and which can be installed
in a conventional installation size.



CLAIMS

1. An escalator apparatus including steps having bases movable on a guide rail and movable step boards which are supported by said bases and can be raised to provide a surface for carrying a wheelchair, wherein said movable step boards are those of at least two adjacent steps and are arranged to be movable upwardly and/or downwardly together with a further step board of an upper step adjacent to said at least two adjacent steps, and an inclination suppressing means is provided between said bases and said movable step boards for suppressing inclination of said movable step boards when the latter step boards are in their raised positions.
2. An escalator apparatus according to Claim 1, wherein the step boards of said at least two adjacent steps and said further step board are upwardly movable at the same speed.
3. An escalator apparatus according to Claim 1, wherein the step boards of said at least two adjacent steps are so constructed as to be raised following said further step board.
4. An escalator apparatus according to Claim 1, said steps having said movable step boards accommodate a raising/lowering mechanism for raising said movable step boards of said at least two adjacent steps together with said further step board.
5. An escalator apparatus according to Claim 1, further including coupling means for coupling together the step

9. An escalator apparatus according to Claim 1, wherein



said at least two adjacent steps and said upper step adjacent thereto cooperate together to form a special step group, and said special step group accommodates a movable component element for actuating a sensor provided on a fixed member of said escalator apparatus for confirming motion of said escalator apparatus.

10. An escalator apparatus according to Claim 1, wherein one of said at least two adjacent steps comprises a first riser integral with the movable step board of said one step, a second riser movable upwardly following an upward movement of the last-mentioned movable step board, and a third riser attached to said base.

11. An escalator apparatus according to Claim 1, wherein one of said at least two adjacent steps comprises a middle base supported on the base of said one step through a first inclination suppressing means, and the movable step board of said one step is supported on said middle base through a second inclination suppressing means.

12. An escalator apparatus according to Claim 1, wherein one of said at least two adjacent steps has its movable step board supported on said base through an inclination suppressing means and held by a holding mechanism at a fixed position on said base.

13. An escalator apparatus according to Claim 1, wherein each of said at least two adjacent steps has a raising/lowering mechanism for independently raising/lowering the step board of the step.

14. An escalator apparatus according to Claim 1, wherein said at least two adjacent steps accommodate a



raising/lowering mechanism for raising the step boards of said at least two adjacent steps and said raising/lowering mechanism is actuated by a relative movement between said at least two adjacent steps and a fixed member of said escalator apparatus.

15. An escalator apparatus according to Claim 1, further including coupling means for coupling together the movable step boards of said at least two adjacent steps and for coupling together said further step board and adjacent one of the movable step boards of said at least two adjacent steps.

16. An escalator apparatus according to Claim 15, further including a coupling force imparting mechanism provided on a fixed part of said escalator apparatus for imparting a coupling force to each of said coupling means when the movable step boards of said at least two adjacent steps are at a predetermined position in an entrance of said escalator apparatus and a disengaging force imparting mechanism provided on another fixed part of said escalator apparatus for imparting an uncoupling force to each of said coupling means when the step boards of said at least two adjacent steps are at a predetermined position in an exit of said escalator apparatus.
