

Description

This invention relates to escalators and more particularly to curved escalators which have a stairway path that is curved in plan.

5 Circular or curved escalators have been proposed in US—A—3878931 (Luna) and Japanese patent publication 48—25559. Previously proposed circular or curved escalators have a stairway path along which a series of steps travel, the path having a constant radius of curvature or circular in plan throughout its entire length including the horizontally-moving landing sections at the upper and lower ends of the escalator. The stairway path is defined by guide tracks that support and guide various rollers mounted on
10 the steps. The guide track on the outer side of the circular stairway path and the guide track on the inner side of the circular stairway path are different in gradient. Therefore, with guide tracks of a constant radius of curvature as in the escalator described above, the distance between the axes of step axles that connect the step to the driving chain must be variable in order that the angular velocities of the step at the outer and inner side of the step be equal even in locations where the angle of slope changes, such as in the transient
15 portions between the load-bearing inclined portion and the upper or lower horizontal landing portion. This requires a complex and expensive driving and guiding arrangement in the escalator.

Accordingly, the chief object of the present invention is to provide a curved escalator which is simple in structure, less expensive, and free from the above discussed problem.

Another object of the present invention is to provide a curved escalator simple and compact in
20 structure.

Still another object of the present invention is to provide a curved escalator that has simple and compact turn-around portions.

With the above objects in view, the present invention resides in a curved escalator comprising an endless belt, a plurality of segment steps attached to the endless belt, driving means for driving the endless
25 belt in a loop disposed along a stairway path along which the steps travel, and guide means for guiding and supporting the endless belt about said loop including a plurality of guide wheels rotatably mounted on the steps and a guide track disposed along the stairway path and guiding the wheels therealong. The stairway path along which the escalator extends is inclined and curved in plan along, for example, an arc. The stairway path has an upper and a lower horizontal landing section, an intermediate section that has a
30 predetermined, constant slope, and transient sections between the upper and lower landing sections and the intermediate slope section. The radius of curvature of the guide track when viewed in plan is inversely proportional to the slope of the various sections of the stairway path. Thus, if the slope of a section is constant, the radius of curvature of that section is also constant, and if the slope is gradually increasing then the radius of curvature of that section gradually decreases.

35 With this arrangement, the outer and inner angular speed of the segment steps are equal to each other and there is no need to provide a step chain with a complex mechanism for changing the distance between the step axles, resulting in a simpler and less expensive curved escalator structure.

Brief description of the drawings

40 The present invention will become more readily apparent from the following description of the preferred embodiments taken in conjunction with the accompanying drawings.

Fig. 1 is a front view of a curved escalator to which the present invention is applicable;

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

Fig. 3 is a graphical representation of the various radii of curvature of the stairway path viewed in plan;

45 Fig. 4 is a graphical representation of the geometry of the steps of the present invention;

Fig. 5 is a schematic sectional view illustrating the driving and guiding mechanism of a curved escalator according to the present invention;

Fig. 6 is a side view of the steps and the guide means of a curved escalator according to the present invention;

50 Fig. 7 is a plan view of the steps and the guide means of a curved escalator according to the present invention;

Fig. 8 is a side view of the driving chain sprocket wheels of a curved escalator according to the present invention;

Fig. 9 is a view illustrating the connecting plate of a curved escalator according to the present
55 invention;

Fig. 10 is a view schematically illustrating the guiding arrangement of another embodiment of a curved escalator;

Fig. 11 is a view illustrating the steps and the driving and guiding arrangement of the embodiment shown in Fig. 10;

60 Fig. 12 is a plan view of the steps and the guide means of the embodiment of a curved escalator shown in Fig. 10;

Fig. 13 is a side view of the turn-around portion of the embodiment of the present invention shown in Fig. 10;

65 Fig. 14 is a sectional view of a third embodiment of the escalator of the present invention illustrating the driving and guiding mechanism of the escalator;

Fig. 15 is a partial side view showing the steps and guiding mechanism of the escalator shown in Fig. 14;

Fig. 16 is a partial plan view showing the steps and guiding mechanism of the escalator shown in Fig. 14;

Fig. 17 is a partial side view of the turn-around portion of the escalator shown in Fig. 14;

Fig. 19 is a partial schematic side elevation of the horizontal landing section and the turn-around section of the inner side of a fourth embodiment of a curved escalator according to the present invention;

Fig. 19 is a view similar to Fig. 18 but showing the elevation of outer side of the curved escalator shown in Fig. 18;

Fig. 20 is a sectional view taken along line XX—XX in Fig. 18 showing the driving and guiding mechanism at the turn-around section of the curved escalator of the present invention;

Fig. 21 is a sectional view taken along line XXI—XXI of Fig. 18 showing the section at the load-bearing and the return runs;

Fig. 22 is a graphical representation of the dimensions of the segment steps of a curved escalator according to the present invention;

Fig. 23 is a schematic drawing illustrating the function of the regulating track against the steps of the present invention; and

Fig. 24 is a simplified perspective view of a series of steps in the landing and turn-around sections of the curved escalator of the present invention.

Description of the preferred embodiments

Figs. 1 and 2 illustrate a typical curved escalator to which the present invention can be applied. The curved escalator has a general configuration of a spiral or has two ends that are vertically separated and connected by an arc when viewed in plan. The escalator comprises (see Figs. 1; 5—9) a frame 10 in which an endless belt 12 and driving and guiding mechanism which will be described in more detail later are installed. The escalator also comprises a plurality of steps 14 connected to the endless belt 12. The steps 14 are moved along the endless belt 12 and formed in segments. The curved escalator includes an intermediate portion 16 that is circular in plan view and inclined at a predetermined angle with respect to the horizontal. The intermediate portion 16 constitutes most of the load bearing run of the endless belt-shaped steps. Both the upper and lower ends of the intermediate portion 16 are connected through upper and lower transient portions 18 and 20, respectively, to substantially horizontal upper and lower landing portions 22 and 24, respectively. The transient portions 18 and 20 smoothly connect the inclined intermediate portion 16 to the horizontal landing portions 22 and 24, so that the transient portions 18 and 20 have inclinations or gradients that gradually change for smooth connection. The extreme end of each of the horizontal landing portions 22 and 24 is provided with a turn-around portion 26 or 28 around which the endless belt 12 changes its travel direction and changes from the load-bearing run to the return run or its reverse.

The curved escalator also comprises a balustrade 29 including a handrail 30 thereon on each side of the escalator.

Fig. 3 is a diagram illustrating the plan configuration of the escalator of the present invention. In Fig. 3, arcs $A_0-A_1-A_2-A_3-A_4-A_5-A_6-A_7$ represent the outer guide track for guiding the drive rollers on the outer periphery of the curved escalator, and arcs $B_0-B_1-B_2-B_3-B_4-B_5-B_6-B_7$ represent the inner guide track for the inner guide rollers. As will be later explained, the outer and inner guide tracks function to support and guide for rolling thereon the drive rollers mounted on the outer and inner ends of the step axles connecting the segment steps to the driving chain. Arcs A_0-A_2 and A_5-A_7 are upper and lower horizontal sections of the outer guide track having a radius of curvature of R_1 , and arcs B_0-B_2 and B_5-B_7 are upper and lower horizontal sections of the inner guide track having a radius of curvature of R_2 . The center of the upper section tracks is O and the center of the lower section tracks is O' . Arcs A_2-A_3 and A_4-A_5 are upper and lower transient portions of the outer guide track and arcs B_2-B_3 and B_4-B_5 are upper and lower transient portions of the inner guide track. These arcs have changing radii of curvature and their centers also change from O or O' to O' . Arcs A_3-A_4 and B_3-B_4 are constant gradient sections of the outer and inner guide tracks, respectively, which have a common center O' and constant radii of curvature $R_1(\theta_1)$ and $R_2(\theta_2)$, respectively. The positions of the comb plate end of the upper and lower floor panel are shown by lines A_1-B_1 and A_6-B_6 , respectively, and the segment steps turn around at the areas outside of A_0-B_0 and A_7-B_7 with the drive chain meshing with the chain sprocket into the return run extending directly below the load bearing run guide track. The radii of curvature in plan of the outer and inner guide tracks in the return run also gradually decrease from the horizontal section to the constant incline section.

Fig. 4 illustrates the principles of the step formation of the present invention, in which the geometry of the steps is illustrated for the case when the step axles of the adjacent steps are directly connected by a roller chain or a link chain.

In the upper and lower horizontal sections, the step top surface can be designated by a segment of a trapezoid ABCD since there is no overlapping portion resulted from the difference in elevation between the adjacent steps. The exposed surface of the steps in the constant inclination section is AB'C'D when the angles of inclination at the portion corresponding to the outer and inner peripheries of the step are θ_1 and θ_2 , respectively. Thus, the overlapping portion between the adjacent steps is BB'C'C. Then, the exposed

surface of the connected steps is a polygon AB'EF ... DC'GH ... which is composed of a plurality of trapezoids AB'C'D placed on a plane in a side-by-side relationship. When the radius of a circumscribed circle connecting the outer points AB'EF ... of a circumscribed circle connecting the outer points AB'EF ... of the polygon is $R_1'(\theta_1')$ and the radius of a circumscribed circle connecting the inner points DC'GH ... of the same polygon is $R_2'(\theta_2')$, then the following equation holds true. When $\theta_1' = \theta_2' = 0$, the radii of the circumscribed circles on the outer and inner peripheries of the above polygon are R_1' and R_2' , respectively, and arc AB= l_1 and arc CD= l_2 .

$$R_1'\delta = \widehat{AB} \cos \theta_1' = l_1 \cos \theta_1'$$

$$\delta = \frac{l_1}{R_1'} \cos \theta_1' \quad (1)$$

If $\angle DAB' = \alpha$, $\angle AB'C' = \beta$, $\angle OB'C' = \gamma$ and $\angle B'OA = \delta$,

$$\beta = \alpha - \gamma = \alpha - \frac{R_2'\delta - l_2 \cos \theta_2'}{R_1' - R_2'}$$

$$\alpha = \frac{\pi - \delta}{2}$$

$$\alpha + \beta = \frac{\pi R_1' - l_1 \cos \theta_1'}{R_1'} - \frac{R_2' l_1 \cos \theta_1' - R_1' l_2 \cos \theta_2'}{R_1'(R_1' - R_2')} \quad (2)$$

$$R' \cos \frac{\alpha + \beta}{2} = R_1' \sin \frac{\delta}{2} \quad (3)$$

$$R_1'(\theta_1') = \frac{R_1' \sin \left(\frac{l_1}{2R_1'} \cos \theta_1' \right)}{\cos \left(\frac{\pi R_1' - l_1 \cos \theta_1'}{2R_1'} - \frac{R_2' l_1 \cos \theta_1' - R_1' l_2 \cos \theta_2'}{2R_1'(R_1' - R_2')} \right)}$$

$$R_1'(\theta_1') = \frac{R_1' (R_1' - R_2') \cos \theta_1'}{R_1' \cos \theta_1' - R_2' \cos \theta_2'} \quad (4)$$

Although the steps between equations (3) and (4) is omitted, equation (4) expresses an approximate value at an accuracy of about 0.01 %.

Similarly,

$$R_2'(\theta_2') = \frac{R_2' - (R_1' - R_2') \cos \theta_2'}{R_1' \cos \theta_1' - R_2' \cos \theta_2'}$$

Therefore, the radius of the outer guide track should be

$$R_1(\theta_1) = \frac{R_1 (R_1 - R_2) \cos \theta_1}{R_1 \cos \theta_1 - R_2 \cos \theta_2} \quad (5)$$

and the radius of the inner guide track should be

$$R_2(\theta_2) = \frac{R_2(R_1 - R_2) \cos \theta_2}{R_1 \cos \theta_1 - R_2 \cos \theta_2} \quad (6)$$

Thus, when the gradients or the inclinations of the outer and the inner guide tracks are θ_1 and θ_2 respectively, and the steps are to be supported and guided in the intermediate constant inclination section, the circular guide tracks should have radii of curvature $R_1(\theta_1)$ and $R_2(\theta_2)$ and a center O' . When the steps are to be guided in the upper and lower horizontal sections, the guide tracks for guiding the steps should have a center O or O'' with radii of curvature R_1 and R_2 . Since the inclination is constant in the intermediate constant inclination section, the radii of curvature of the guide tracks are also constant, and the radii of curvature of the guide tracks in the upper and lower transient sections vary according to equations (5) and (6) with varying θ_1 and θ_2 .

Figs. 5 to 9 illustrate one embodiment of the curved escalator of the present invention. The escalator comprises an outer drive chain 32 and an inner drive chain 34 which constitute the endless belt 12 shown in Fig. 1. The outer and inner chains 32 and 34 are connected to a step axle 36 mounted on each of the steps 14, and each end of the step axle 36 has mounted thereon a rotatable drive roller 38. The drive rollers 38 are supported and guided on outer and inner guide tracks 40 and 42 fixedly mounted on the truss or frame 10 of the escalator. The step 14 also has another axle on which follower rollers 44 are rotatably mounted. The follower rollers 44 are also supported and guided by guide tracks 46 and 48 secured on the frame 10.

As shown in Figs. 5 to 7, the step axle 36 supporting the segment step 14 through an attachment that is not illustrated is constructed to have staggered end portions so that the outer drive roller 38 is positioned higher than the inner drive roller 38 in the load bearing run. Therefore, the guide tracks 40 and 42 for supporting and guiding the respective drive rollers 38 are also positioned at differing levels. The outer and inner chains 32 and 34 driven by a drive mechanism, which will be described in detail later, causes the steps 14 to be driven along the guide tracks 40 and 42. The follower rollers 44 on the guide tracks 46 and 48 are disposed below and interior to the drive rollers 38 and function, in cooperation with the guiding function of the drive rollers 38 and the guide tracks 40 and 42, to maintain a desired horizontal position of the steps 14 while they are travelling in the load bearing run and the return run of the endless belt. The outer guide tracks 40 and 46, and the inner guide tracks 42 and 48 are arranged according to the previously described relationship between the radius of curvature and the inclination of the escalator, i.e. the radii of curvature of the guide tracks are inversely proportional to their inclination, whereby the step axles 36 can be directly connected to the outer and inner drive chains 32 and 34. The steps 14 also have on their reverse side a guide shoe 50 or a wheel in engagement with a guide track 52 centrally disposed and rigidly mounted on the frame 10 of the escalator. The guide shoe 50 moves along the track 52 to limit lateral movements of the steps 14.

As shown in Fig. 6, each step 14 has formed thereon a tread 54 and a riser 56 which include a plurality of cleats (not shown) extending perpendicular to the surface of the tread part 54 and meshing with the cleats (not shown) on the tread part 54.

The drive mechanism for driving the endless belt of the escalator comprises an electric motor 58 for driving, through a drive chain 60, chain sprockets 62 and 64 as shown in Fig. 8 in which the turn-around portion of the endless belt is illustrated together with the driving mechanism. As illustrated, the outer and inner drive chains 32 and 34 are wound around the larger and the smaller chain sprockets 62 and 64, respectively. The pitch circle of the larger sprocket 62 which engages the outer chain 32 is larger than that of the smaller sprocket 64 engaging the inner chain 34 by an amount that is determined by the ratio of the radii of curvature R_1'' and R_2'' of the chains in the horizontal landing portion of the endless belt, so that the outer and the inner chains 32 and 34 are assured to be driven at the same constant angular velocity.

It is to be noted that the lower turn-around portion of the curved escalator has a set of larger and smaller follower chain sprockets that are similarly dimensioned to those just described to guide the outer and inner driving chains, respectively. The lower set of follower chain sprockets are mounted on a movable platform that is movable along articulated tracks in accordance with the elongation of the chains so that a predetermined necessary tension is provided in the chains. Such a chain tensioner arrangement may be a conventional one known in the art.

In the turn-around portion of the endless belt, the step axles 36 turn about the sprocket shaft (not shown) in a truncated conical surface.

The vertical distance h between the positions of the ends of the step axles 36 is expressed by the following equations when the radii of the outer and inner chain sprockets 62 and 64, respectively, are r_1 and r_2 , and the radii of curvature of the outer and inner chains in the horizontal section are R_1'' and R_2'' , respectively:

$$h = r_1 - r_2 \frac{r_1}{r_2} = \frac{R_1''}{R_2''}$$

As shown in Fig. 7 and 9, the endless belt includes an outer connecting plate 66 and an inner connecting plate 68 mounted on the outer and the inner end portions of the step axle 36, respectively. The connecting plates 66 and 68 are of similar construction except that their lengths measured in the direction of the chain extension is different. As best seen in Fig. 9, the connecting plate 68 has through holes 70 at opposite ends thereof through which a pin 72 between chain links 74 at the end of the chain 34 extends. It is to be noted that each of the through holes 70 in the ends of the connecting plate 68 is defined by an

inwardly convex curve which is rotated about the axis of the hole 70. Also the distance a between the centers of the through holes 70 in the connecting plate 68 is selected so that it is not equal to a pitch p of the outer or inner chain multiplied by an integer. The reason that this distance should not be equal to an integral multiplicity of the chain pitch p is that, in the actual design of the escalator, the ratio l_1/l_2 of the distances between the adjacent step axles of the outer and the inner driving chains must be selected to equal the radius ratio r_1/r_2 of the chain sprockets in the horizontal section of the endless belt, and if the distance a is selected to be np (p multiplied by an integer), the distance in the width-wise direction between the outer and the inner driving chains 32 and 34 must be considerably large in order to obtain a practical design. On the other hand, if the distance a between the centers of the through holes 70 is not equal to the chain pitch p , the width-wise dimension w between the outer and the inner driving chains 32 and 34 can be any desired value.

Although not illustrated, the moving handrail is driven by a drive force from the chain sprocket wheels disposed in the turn-around portion of the escalator. This arrangement enables a continuous handrail to be driven without an angular velocity differential and without the need for a variable speed moving handrail.

As apparent from the foregoing description, in the escalator of the present invention, the radii of curvature when viewed in plan of the guide track in various sections including the horizontal landing section, the transient section, and the constant slope intermediate section are inversely proportional to the slope angle at their position. Also the guide tracks of the above arrangement support and guide the driving rollers mounted on the step axle of the steps. Therefore, the step axles can be directly connected to the driving chains for the travel of the steps, resulting in a simple structure, an easy limitation of the dimensional relationship between the adjacent steps, and a reliable, less expensive structure which is easily manufactured because the step axles are arranged in symmetry with respect to a horizontal axis in the load-bearing and the return runs.

Figs. 10 to 13 illustrate another embodiment of the curved escalator of the present invention in which a new and improved arrangement is employed for a compact turn-around of the escalator. The curved escalator of the second embodiment comprises a plurality of steps 80 having a tread 82, a riser 84 and side face 86. Each of the steps 80 mounted thereon a step axle 88 projecting at its opposite ends from the side faces 86 of the step 80 and includes at its extremities a drive roller 90. The drive rollers 90 are supported and guided by an outer guide track 92 and an inner guide track 94 fixedly mounted on an escalator frame 96. Also fixedly mounted on the frame 96 are outer and inner guide tracks 98 and 100 for supporting and guiding the follower rollers 102 mounted on the step 80. It can be seen from Fig. 10, that the follower rollers 102 and therefore the follower roller guide tracks 98 and 100 are positioned on the lower and inner side of the driving roller guide tracks 92 and 94.

It is to be noted that a control lever arm 104 is rotatably mounted on the step axle 88 at its outer end portion, and a shorter end of the arm 104 is connected to an outer driving chain 106 through a connecting pin 108, and a longer end of the arm 104 has mounted thereon a control roller 110 that travels along a control guide track 112 disposed closely to the follower roller outer guide track 98. An inner chain 114 is connected to each of the step axles 88.

Fig. 13 illustrates a turn-around portion of the escalator of the present invention. The turn-around portion includes a larger and a smaller chain sprockets 116 and 118 around which the outer and the inner chains 106 and 114, respectively, are wound. It is also seen that a drive mechanism including an electric motor, a drive chain, and chain sprockets is disposed for driving the sprockets 116 and 118.

As described previously, the steps 80 are connected at the inner side of the curved stairway path to the inner endless chain 114 via the step axle 88 and the outer side of the curved stairway path of the escalator is connected to the outer endless chain 106 via the connecting pin 108, the lever arm 104, and the step axle 88. Therefore, when the drive mechanism shown in Fig. 13 is energized, the outer and the inner driving chains 106 and 114 drive the steps 80 along the guide tracks on which the steps 80 are supported and guided through various guide rollers. It is to be noted that since the step axle 88 that is connected to the outer chain 106 is connected through the lever arm 104, the position of the outer driving chain 106 with respect to the step 80 at the outer side of the stairway path is higher than the position of the driving chain 114 on the inner side of the step 80 by a distance A which is expressed by the following equation:

$$A = r_2 \cdot \left(\frac{R_1}{R_2} - 1 \right)$$

where,

r_2 : is the pitch circle radius of the smaller sprocket 118,

R_1 : is the radius of curvature of the center line of outer driving chain 106, and

R_2 : is the radius of curvature of the center line of the inner driving chain 114.

As seen from Figs. 10 and 13, the outer chain 106 turns around about the larger diameter sprocket 116 and the inner chain 114 turns around about the smaller sprocket 118 so that it may be said that a straight line connecting a point on the outer and the inner chains turns to describe a truncated conical surface at the turn-arounds. According to the present invention, however, the steps 80 are rotatably connected to the

outer and the inner driving chains 106 and 114, and the follower rollers 102 mounted on the step 80 are supported and guided by the guide tracks 98 and 100 so that the steps 80 in the turn-around portion of the escalator are regulated to move along a cylindrical plane rather than a conical surface. Also as the steps 80 moves along the stairway path, the regulating roller 110 is also guided by the regulating track 112 to regulate the positional relationship of the lever arm 104 with respect to the side face 86 of the step 80.

Although the guide tracks 92, 94, 98 and 100 must be formed in an accurate spiral form and positioned in exact positions, particularly in the load bearing run, and if there is any displacement of the guide tracks the steps 80 tend to interfere with each other or create clearances between the steps 80, the proper positioning of the regulating track 112 to suitably move the lever arm 104 with respect to the step 80 enables the steps 80 to travel with a proper positional interrelationship maintained between the steps 80.

In summary, according to the second embodiment of the present invention, the inner side of the steps disposed in a stairway path curved in plan and inclined is connected to the inner driving endless chain via the step axle rotatably mounted on the step and the outer side of the steps is connected to the outer chain via the connecting pin carried on the lever arm pivotally mounted on the step axle at the position higher than the inner chain. Also, the position of the lever arm with respect to the step is regulated by the regulating roller and the regulating track which support and guide the regulating roller, and a turn-around mechanism is provided which allows the steps to be turned around along a cylindrical surface whereas the outer and the inner driving chain are wound around chain sprockets of differing diameter. With this arrangement of the second embodiment of the present invention, the turn-around mechanism of the curved escalator is simple and compact in structure, decreasing the frame size. Also, since the abnormalities such as interference of the steps and creation of clearances between the steps due to the manufacturing and assembling error of the steps can be corrected by the regulating track and the regulating roller through the lever arm, the curved escalator is accurate and reliable.

Figs. 14 to 17 illustrate the third embodiment of the curved escalator of the present invention which is similar to the second embodiment described in conjunction with Figs. 10 to 13. The curved escalator shown in Figs. 14 to 17 is different from that shown in Figs. 10 to 13 in the arrangement of the regulating lever arm 120. The lever arm 120 is rigidly mounted at its one end on the inner side of the step axle 88 of the step 80 and rotatably carries at the other end a regulating roller 122 which is supported and guided by a regulating track 124. It is to be noted that the inner driving chain 114 is connected to the midpoint of the lever arm 120 through a connecting pin 126 at a level lower than the outer driving chain 106 by an amount A just as in the previous embodiment. With this arrangement in which the lever arm is disposed on the inner side of the curved stairway path, an additional advantage is obtained in that the depth of the step 80 can be made small due to the step axle 88 being disposed close to the tread 82 of the step 80, enabling the depth of the truss or frame to be small. Also, since the driving rollers 90 on the step axle 88 are positioned outside of the driving chains 106 and 114, access to the driving rollers 90 for exchange or maintenance can be easily gained in the turn-around portion of the escalator.

Figs. 18 to 24 illustrate a fourth embodiment of the curved escalator constructed in accordance with the present invention. Fig. 18 schematically shows the turn-around portion on the inner side of the escalator while Fig. 19 shows the same portion as Fig. 18 on the outer side of the curved escalator. Fig. 20 illustrates a section taken along the line XX—XX in Fig. 18 showing the turn-around mechanism, and Fig. 21 illustrates a section of the escalator at the line XXI—XXI in Fig. 18. In these figures, it is seen that the curved escalator comprises a frame 128 which supports various guide tracks including an outer guide track 130, an inner guide track 132, and a pair of follower roller guide tracks 134 and 135. These guide tracks support and guide their respective rollers including driving rollers 138 and follower rollers 140 to maintain proper position of a plurality of segment steps 142 that rotatably mount the driving rollers 138 by a step axle 144. It is seen that outer and inner endless driving chains 146 and 148 are connected to the step axle 144. The driving chain 146 is wound around a larger chain sprocket wheel 150 (radius r_1) as shown in Fig. 19 and the inner driving chain 148 is wound around a smaller sprocket wheel 152 (radius r_2) shown in Fig. 18. This relationship is also shown in Fig. 20. The larger and smaller sprockets 150 and 152 are connected by a rotatable shaft 154 which is driven by a drive mechanism similar to those described in conjunction with the previous embodiments.

As shown in Figs. 18 and 19, the guide tracks 134 and 135 for guiding the follower rollers 140 on the step 142 have regulating sections 156 and 158, respectively. The sections 156 and 158 are integral parts of the guide tracks 134 and 135, respectively, and are rigidly supported by the frame 128. The track sections 156 and 158 function to displace the follower rollers 134 and 135 in the upper direction or in the direction away from the center line of the truss frame 128. The track sections 156 and 158 terminate at positions just beyond the shaft of the sprocket wheels 150 and 152 after partially encircling the shaft and other bank tracks 160 and 162 which are integral parts of the return run guide tracks 134 and 135 are disposed to subsequently support and guide the follower rollers 134 and 135 for the smooth travel of the steps.

As best shown in Fig. 23, each step 142 includes a tread 160 and a riser 162, and the riser 162 includes a plurality of cleats 164 which mesh with cleats 166 formed on the opposite end of the adjacent step 142. These cleats 164 and 166 are kept in meshing relationship in the upper and lower runs of the escalator with a gap G between the adjacent steps. When the steps 142 are in the turn-around portion of the stairway path, the follower rollers 140 are lifted with respect to the guide rollers 138 by a predetermined angle θ by the regulating tracks 156 and 158 to rotate the step 142 about the rollers 138. This rotation of the step 142

causes the gap G between the steps 142 to increase by a distance g, the turn around portion becomes G plus g and the meshing relationship between the cleats is not maintained as shown in Fig. 23.

In order to smoothly move the steps 142 along a truncated conical surface as shown in Figs. 24 in the turn-around portion of the endless belt of the escalator, the following relationship should be maintained:

$$r_1 \cdot R_2 = R'_1 \cdot R'_2$$

where,

R'_1 : radius of curvature in plan of the inner chain 148 in the intermediate and horizontal sections of the stairway path

R'_2 : radius of curvature in plan of the outer chain 146 in the intermediate and horizontal sections of the stairway path

r_1 : radius of the smaller chain sprocket 152

r_2 : radius of the larger chain sprocket 150.

As illustrated in Fig. 22, in the horizontal section of the endless belt, the inner chain 148 has a radius of curvature of R'_1 , and the outer chain 146 has a radius of curvature of R'_2 , and in the turn-around section of the endless belt, since the inner side edge of the steps 142 moves downward or toward the center line of the frame 128, the inner chain 148 has a radius of curvature in plan of R_1 which is smaller than R'_1 , and the outer chain 146 has a radius of curvature in plan of R_2 which is smaller than R'_2 .

According to the fourth embodiment of the curved escalator of the present invention, the cleats of the steps that engage in the intermediate and the horizontal sections disengage in the turn-around section of the endless belt, thereby allowing the steps to smoothly turn around along a compact conical surface with a simple turn-around mechanism.

Claims

1. A curved escalator, comprising:
an endless belt (12);

a plurality of segment steps (14) attached to said endless belt;

means (60, 62, 64) for driving said endless belt in a loop disposed along a stairway path, said stairway path being curved in plan and having an intermediate section (16) that has a predetermined constant slope angle, upper and lower landing sections (22, 24) that have substantially zero slope angle, and transition sections (18, 20) connecting said intermediate section to said upper or lower section that have changing slope angles for the smooth connection of the sections; and

means for guiding said belt about said loop including a plurality of guide wheels (38, 44) rotatably mounted on said steps and a guide track (A_1-A_7 , B_1-B_7 ; 40, 42, 46, 48) disposed along said stairway path, characterised in that the guide track has radii of curvature in plan ($R_1(\theta_1)$, $R_2(\theta_2)$) that are inversely proportional to the slope angles (θ_1 , θ_2) of the differing positions of said stairway path.

2. A curved escalator as claimed in claim 1, wherein said guide track includes an outer guide track (A; 40, 46) and inner guide track (B; 42, 48), characterised in that the relationship between said radii of curvature of said guide tracks and said slope angle of said stairway path is

$$R_1(\theta_1) = \frac{R_1 (R_1 - R_2) \cos \theta_1}{R_1 \cos \theta_1 - R_2 \cos \theta_2},$$

$$R_2(\theta_2) = \frac{R_2 (R_1 - R_2) \cos \theta_2}{R_1 \cos \theta_1 - R_2 \cos \theta_2},$$

where

$R_1(\theta_1)$: radius of curvature of the outer guide track at an arbitrary position

$R_2(\theta_2)$: radius of curvature of the inner guide track at an arbitrary position

R_1 : radius of curvature of the outer guide track at the upper and lower landing sections

R_2 : radius of curvature of the inner guide track at the upper and lower landing sections

θ_1 : slope angle of the outer guide track

θ_2 : slope angle of the inner guide track.

3. A curved escalator as claimed in claim 1 or 2 characterised in that said segment steps (14) each have an outer and an inner side edge that are concentric arcs expressed by

$$\frac{l_1}{l_2} = \frac{R_1'}{R_2'}$$

where



causes the gap G between the steps 142 to increase by a distance g , the turn around portion becomes G plus g and the meshing relationship between the cleats is not maintained as shown in Fig. 23.

In order to smoothly move the steps 142 along a truncated conical surface as shown in Figs. 24 in the turn-around portion of the endless belt of the escalator, the following relationship should be maintained:

$$r_1:R_2=R'_1:R'_2$$

where,

R'_1 : radius of curvature in plan of the inner chain 148 in the intermediate and horizontal sections of the stairway path

R'_2 : radius of curvature in plan of the outer chain 146 in the intermediate and horizontal sections of the stairway path

r_1 : radius of the smaller chain sprocket 152

r_2 : radius of the larger chain sprocket 150.

As illustrated in Fig. 22, in the horizontal section of the endless belt, the inner chain 148 has a radius of curvature of R'_1 and the outer chain 146 has a radius of curvature of R'_2 , and in the turn-around section of the endless belt, since the inner side edge of the steps 142 moves downward or toward the center line of the frame 128, the inner chain 148 has a radius of curvature in plan of R_1 which is smaller than R'_1 , and the outer chain 146 has a radius of curvature in plan of R_2 which is smaller than R'_2 .

According to the fourth embodiment of the curved escalator of the present invention, the cleats of the steps that engage in the intermediate and the horizontal sections disengage in the turn-around section of the endless belt, thereby allowing the steps to smoothly turn around along a compact conical surface with a simple turn-around mechanism.

Claims

1. A curved escalator, comprising:

an endless belt (12);

a plurality of segment steps (14) attached to said endless belt;

means (60, 62, 64) for driving said endless belt in a loop disposed along a stairway path, said stairway path being curved in plan and having an intermediate section (16) that has a predetermined constant slope angle, upper and lower landing sections (22, 24) that have substantially zero slope angle, and transition sections (18, 20) connecting said intermediate section to said upper or lower section that have changing slope angles for the smooth connection of the sections; and

means for guiding said belt about said loop including a plurality of guide wheels (38, 44) rotatably mounted on said steps and a guide track (A_1-A_7 , B_1-B_7 ; 40, 42, 46, 48) disposed along said stairway path, characterised in that the guide track has radii of curvature in plan ($R_1(\theta_1)$, $R_2(\theta_2)$) that are inversely proportional to the slope angles (θ_1 , θ_2) of the differing positions of said stairway path.

2. A curved escalator as claimed in claim 1, wherein said guide track includes an outer guide track (A; 40, 46) and inner guide track (B; 42, 48), characterised in that the relationship between said radii of curvature of said guide tracks and said slope angle of said stairway path is

$$R_1(\theta_1) = \frac{R_1 (R_1 - R_2) \cos \theta_1}{R_1 \cos \theta_1 - R_2 \cos \theta_2}$$

$$R_2(\theta_2) = \frac{R_2 (R_1 - R_2) \cos \theta_2}{R_1 \cos \theta_1 - R_2 \cos \theta_2}$$

where

$R_1(\theta_1)$: radius of curvature of the outer guide track at an arbitrary position

$R_2(\theta_2)$: radius of curvature of the inner guide track at an arbitrary position

R_1 : radius of curvature of the outer guide track at the upper and lower landing sections

R_2 : radius of curvature of the inner guide track at the upper and lower landing sections

θ_1 : slope angle of the outer guide track

θ_2 : slope angle of the inner guide track.

3. A curved escalator as claimed in claim 1 or 2 characterised in that said segment steps (14) each have an outer and an inner side edge that are concentric arcs expressed by

$$\frac{l_1}{l_2} = \frac{R_1'}{R_2'}$$

where



l_1 : length of the arc of the outer side edge of the step
 l_2 : arc length of the inner side edge of the step
 R_1' : radius of curvature of the outer side edge of the step at upper and lower landing sections,
 R_2' : radius of curvature of the inner side edge of the step at upper and lower landing sections,

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a riser (56) that is a portion of a truncated cone surface having a radius of curvature of l_1 at the outer side edge of the step and a radius of curvature of l_2 at the inner side edge of the step.

4. A curved escalator as claimed in any one of claims 1 to 3 characterised in that each step (14) is supported on said guide track through a step axle (36) that has a first end that is higher in level than the second end in the load-bearing side of the endless belt.

5. A curved escalator as claimed in claim 4 characterised in that said belt includes an outer and an inner chain (32, 34) and the difference in the levels of said ends of said step axle (36) is expressed by

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$$h = r_1 - r_2, \quad \frac{r_1}{r_2} = \frac{R_1''}{R_2''}$$

where

h : level difference
 r_1 : radius of a chain sprocket (62) for the outer chain
 r_2 : radius of a chain sprocket (64) for the inner chain
 R_1'' : radius of curvature of the outer chain in the landing section
 R_2'' : radius of curvature of the inner chain in the landing section.

25 6. A curved escalator as claimed in claim 4 or 5 characterised in that said outer and inner chains are wound around a larger and a smaller sprocket (62, 64), respectively, in the turn-arounds of the stairway path, said steps being travelled by the driving of said chain sprocket.

30 7. A curved escalator as claimed in any one of the preceding claims characterised in that said step axle (36) has mounted thereon a connecting plate (68) connected at its opposing ends to chain links (74) of said chain, the connecting ends of said connecting plate having formed therein a circular hole (70) for receiving therein a pin (72) of the chain link, said circular hole having a surface formed by rotating about the axis of the hole an arc which is convex towards the axis of the hole.

35 8. A curved escalator as claimed in claim 7, characterised in that the distance between the axes of said circular holes (70) in said connecting plate is a value not equal to the pitch of the chain pins multiplied by an integer.

40 9. A curved escalator as claimed in any one of the preceding claims characterised in that said endless belt includes an endless inner chain (114) disposed along the inner side of said curved stairway path and an endless outer chain (106) disposed along the outer side of said curved stairway path, wherein said drive means includes a turn-around mechanism having a large chain sprocket (116) around which said outer chain is wound and a small chain sprocket (118) around which said inner chain is wound, and wherein said guide means comprise a step axle (88) mounted on each of said steps extending in the widthwise direction of the step, drive wheels (90) mounted on said step axle and guided by said guide track (92, 94), guide wheels (102) mounted on said step and guided by said guide track (98, 100), said guide wheels being positioned farther from the top face of the step than said drive wheels, a lever arm (104) pivotally mounted on said step axle at the outer side of said stairway path at its intermediate portion, said lever arm having a connecting pin (108) secured on an end closer to the step top face, a regulating roller (110) rotatably mounted on the other end of said lever arm, and a regulating track (112) disposed along said stairway path for guiding said regulating roller to displace said lever arms with respect to said step, whereby said segment steps are turned around along a substantially cylindrical surface.

50 10. A curved escalator as claimed in any one of claims 1 to 8 characterised in that said endless belt includes an endless inner chain (114) disposed along the inner side of said curved stairway path and an endless outer chain (106) disposed along the outer side of said curved stairway path, wherein said drive means include a turn-around mechanism having a large chain sprocket (116) around which said outer chain is wound and a small chain sprocket (118) around which said inner chain is wound, and wherein said guide means comprise a step axle (88) mounted on each of said steps extending in the widthwise direction of the step, drive wheels (90) mounted on said step axle and guided by said track (92, 94), guide wheels (102) mounted on said step and guided by said guide track (98), said guide wheels being positioned farther from the top face of the step than said drive wheels, a lever arm (120) pivotally mounted on said step axle at the inner side of said curved stairway path at its one end, said lever arm having a connecting pin (126) secured on its intermediate portion, and connected to said inner chain (114), a regulating roller (122) rotatably mounted on the other end of said lever arm, and a regulating track (124) disposed along said stairway path for guiding said regulating roller to displace said lever arm with respect to said step, whereby said segment steps are turned around along a substantially cylindrical surface.

65 11. A curved escalator as claimed in any one of the claims 1 to 8, characterised in that said endless belt includes an endless inner chain (148) disposed along the inner side of said curved stairway path and an



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endless outer chain (146) disposed along the outer side of said curved stairway path, wherein said drive means include a turn-around mechanism having a larger chain sprocket (150) around which said outer chain wound and a smaller chain sprocket (152) around which said inner chain is wound, and wherein said guide means comprise a step axle (144) mounted on each of said steps extending in the widthwise direction of the step, guide and trailing wheels (138, 140) mounted on said step axle and guided by said guide track, said guide tracks guiding said guide and trailing wheels such that said steps are horizontally positioned while they are in the load bearing run and that said steps are moved along a truncated conical surface in the turn-around position of said stairway path.

12. A curved escalator as claimed in claim 11, characterised in that said guide track means further include a guide track section (156, 158) which lifts the trailing rollers with respect to the leading rollers of the step by an amount sufficient to disengage the cleats formed on the adjacent steps.

Patentansprüche

1. Bogenrolltreppe,
mit einem endlosen Band (12);
mit einer Vielzahl von Segmentstufen (14), die an dem endlosen Band befestigt sind;
mit einer Einrichtung (60, 62, 64) zum Antreiben des endlosen Bandes in einer Schleife, die längs einer Treppenstrecke angeordnet ist, wobei die Treppenstrecke im Grundriß bogenförmig ist und einen mittleren Bereich (16), der einen vorgegebenen konstanten Neigungswinkel besitzt, obere und untere Landungsbereiche (22, 24), die im wesentlichen einen Neigungswinkel von Null besitzen, und Übergangsbereiche (18, 20) aufweist, welche den mittleren Bereich mit dem oberen bzw. dem unteren Bereich verbinden und für die gleichmäßige Verbindung der Bereich sich ändernde Neigungswinkel besitzen;
und mit einer Einrichtung zur Führung des Bandes längs der Schleife, die eine Vielzahl von Führungsrädern (38, 44), die drehbar an den Stufen montiert sind, und eine Führungsschiene (A1—A7, B1—B7; 40, 42, 46, 48) aufweist, die längs der Treppenstrecke angeordnet ist, dadurch gekennzeichnet, daß die Führungsschiene im Grundriß Krümmungsradien ($R_1(\theta_1)$, $R_2(\theta_2)$) besitzt, die umgekehrt proportional zu den Neigungswinkeln (θ_1 , θ_2) der verschiedenen Positionen der Treppenstrecke sind.
2. Bogenrolltreppe nach Anspruch 1, wobei die Führungsschiene eine äußere Führungsschiene (A; 40, 46) und eine innere Führungsschiene (B; 42, 48) aufweist, dadurch gekennzeichnet, daß der Zusammenhang zwischen den Krümmungsradien der Führungsschienen und dem Neigungswinkel der Treppenstrecke gegeben ist durch

$$R_1(\theta_1) = \frac{R_1 (R_1 - R_2) \cos \theta_1}{R_1 \cos \theta_1 - R_2 \cos \theta_2}$$

und

$$R_2(\theta_2) = \frac{R_2 (R_1 - R_2) \cos \theta_2}{R_1 \cos \theta_1 - R_2 \cos \theta_2}$$

wobei

$R_1(\theta_1)$ = Krümmungsradius der äußeren Führungsschiene in einer beliebigen Position,

$R_2(\theta_2)$ = Krümmungsradius der inneren Führungsschiene in einer beliebigen Position,

R_1 = Krümmungsradius der äußeren Führungsschiene in den oberen und unteren Landungsbereichen;

R_2 = Krümmungsradius der inneren Führungsschiene in den oberen und unteren Landungsbereichen,

θ_1 = Neigungswinkel der äußeren Führungsschiene,

θ_2 = Neigungswinkel der inneren Führungsschiene.

3. Bogenrolltreppe nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Segmentstufen (14) jeweils eine äußere und eine innere Seitenkante haben, die konzentrische Bogen bilden, die sich ausdrücken lassen durch

$$\frac{l_1}{l_2} = \frac{R'_1}{R'_2}$$

wobei

l_1 = Bogenlänge der äußeren Seitenkante der Stufe,

l_2 = Bogenlänge der inneren Seitenkante der Stufe,

R'_1 = Krümmungsradius der äußeren Seitenkante der Stufe in den oberen und unteren Landungsbereichen,

R'_2 = Krümmungsradius der inneren Seitenkante der Stufe in den oberen und unteren Landungsbereichen,



sowie eine Stufenhöhe (56) aufweisen, die ein Bereich einer Kegelstumpffläche mit einem Krümmungsradius von l_1 an der äußeren Seitenkante der Stufe und einem Krümmungsradius von l_2 an der inneren Seitenkante der Stufe ist.

4. Bogenrolltreppe nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß jede Stufe (14) von der Führungsschiene über eine Stufenachse (36) getragen ist, die ein erstes Ende aufweist, das ein höheres Niveau hat als das zweite Ende in der Last tragenden Seite des endlosen Bandes.

5. Bogenrolltreppe nach Anspruch 4, dadurch gekennzeichnet, daß das Band eine äußere und eine innere Kette (32, 34) aufweist und daß die Niveaudifferenz der Enden der Stufenachse (36) sich ausdrücken läßt durch

$$h = r_1 - r_2 \text{ und } \frac{r_1}{r_2} = \frac{R''_1}{R''_2}$$

15 wobei

h = Niveaudifferenz

r_1 = Radius eines Kettenrades (62) für die äußere Kette,

r_2 = Radius eines Kettenrades (64) für die innere Kette,

R''_1 = Krümmungsradius der äußeren Kette im Landungsbereich,

20 R''_2 = Krümmungsradius der inneren Kette im Landungsbereich.

6. Bogenrolltreppe nach Anspruch 4 oder 5, dadurch gekennzeichnet, daß die äußeren und die inneren Ketten um ein größeres bzw. ein kleineres Kettenrad (62, 64) in den Umlenkbereichen der Treppenstrecke herumgelegt sind, wobei die Stufen durch den Antrieb des Kettenrades bewegt werden.

- 25 7. Bogenrolltreppe nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß an der Stufenachse (36) eine Verbindungsplatte (68) angebracht ist, die an ihren gegenüberliegenden Enden mit Kettengliedern (74) der Kette verbunden ist, daß in den Verbindungsenden der Verbindungsplatte ein kreisförmiges Loch (70) ausgebildet ist, um darin einen Stift (72) des Kettengliedes aufzunehmen, und daß das kreisförmige Loch eine Oberfläche besitzt, die dadurch gebildet ist, daß ein Bogen, der zur Achse des

30 Loches hin konvex ausgebildet ist, um die Achse des Loches rotiert.

8. Bogenrolltreppe nach Anspruch 7, dadurch gekennzeichnet, daß der Abstand zwischen den Achsen der kreisförmigen Löcher (70) in der Verbindungsplatte ein Wert ist, der ungleich dem Abstand der Kettenstifte multipliziert mit einer ganzen Zahl ist.

9. Bogenrolltreppe nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß das endlose Band eine endlose innere Kette (114), die längs der Innenseite der bogenförmigen Treppenstrecke angeordnet ist, und eine endlose äußere Kette (106) aufweist, die längs der Außenseite der bogenförmigen Treppenstrecke angeordnet ist, daß die Antriebseinrichtung einen Umlenkmechanismus mit einem großen Kettenrad (116), um das die äußere Kette herumgelegt ist, und ein kleines Kettenrad (118) aufweist, um das die innere Kette herumgelegt ist, daß die Führungseinrichtung eine Stufenachse (88), die an jeder der
- 40 Stufen angebracht ist und sich in Breitenrichtung der Stufe erstreckt, Antriebsräder (90), die an der Stufenachse angebracht und von der Führungsschiene (92, 94) geführt sind, Führungsräder (102), die an der Stufe angebracht und von der Führungsschiene (98, 100) geführt sind, wobei die Führungsräder von der Oberseite der Stufe weiter entfernt sind als die Antriebsräder, einen Hebelarm (104), der an der Stufenachse an der Außenseite der Treppenstrecke in seinem mittleren Bereich drehbar angebracht ist,
- 45 wobei der Hebelarm einen Verbindungsstift (108) besitzt, der an einem dichter an der Stufenoberseite gelegenen Ende befestigt ist, eine Steuerrolle (110), die drehbar am anderen Ende des Hebelarmes montiert ist, und eine Steuerschiene (112) aufweist, die längs der Treppenstrecke angeordnet ist, um die Steuerrolle zu führen, um die Hebelarme bezüglich der Stufe zu verschieben, so daß die Segmentstufen längs einer im wesentlichen zylindrischen Fläche umgelenkt werden.

10. Bogenrolltreppe nach einem der Ansprüche 1 bis 8, dadurch gekennzeichnet, daß das endlose Band eine endlose innere Kette (114), die längs der Innenseite der bogenförmigen Treppenstrecke angeordnet ist, und eine endlose äußere Kette (106) aufweist, die längs der Außenseite der bogenförmigen Treppenstrecke angeordnet ist, daß die Antriebseinrichtung einen Umlenkmechanismus mit einem großen Kettenrad (116), um das die äußere Kette herumgelegt ist, und mit einem kleinen Kettenrad (118) aufweist, um das die innere Kette herumgelegt ist, und daß die Führungseinrichtung eine Stufenachse (88), die an jeder der Stufen angebracht ist und sich in Breitenrichtung der Stufe erstreckt, Antriebsräder (90), die an der Stufenachse montiert und von der Führungsschiene (92, 94) geführt sind, Führungsräder (102), die an der Stufe montiert und von der Führungsschiene (98) geführt sind, wobei die Führungsräder von der Oberseite der Stufe weiter entfernt positioniert sind als die Antriebsräder, einen Hebelarm (120), der an der Stufenachse an der Innenseite der bogenförmigen Treppenstrecke an seinem einen Ende drehbar montiert ist, wobei der Hebelarm einen Verbindungsstift (126) besitzt, der in seinem mittleren Bereich befestigt ist und mit der inneren Kette (114) verbunden ist, eine Steuerrolle (122), die am anderen Ende des Hebelarmes drehbar montiert ist, und eine Steuerschiene (124) aufweist, die längs der Treppenstrecke zur Führung der Steuerrolle angeordnet ist, um den Hebelarm bezüglich der Stufe zu verschieben, so daß die
- 60 Segmentstufen längs einer im wesentlichen zylindrischen Fläche umgelenkt werden.



11. Bogenrolltreppe nach einem der Ansprüche 1 bis 8, dadurch gekennzeichnet, daß das endlose Band eine endlose innere Kette (148), die längs der Innenseite der bogenförmigen Treppenstrecke angeordnet ist, und eine endlose äußere Kette (146) aufweist, die längs der Außenseite der bogenförmigen Treppenstrecke angeordnet ist, daß die Antriebseinrichtung einen Umlenkmechanismus mit einem größeren Kettenrad (150), um das die äußere Kette herumgelegt ist, und ein kleineres Kettenrad (152) aufweist, um das die innere Kette herumgelegt ist, und daß die Führungseinrichtung eine Stufenachse (144), die an jeder der Stufen montiert ist und sich in Breitenrichtung der Stufe erstreckt, Führungs- und Hinterräder (138, 140) aufweist, die an der Stufenachse angebracht und von der Führungsschiene geführt sind, wobei die Führungsschienen die Führungs- und Hinterräder so führen, daß die Stufen horizontal positioniert sind, während sie sich auf der Last aufnehmenden Strecke befinden, und daß die Stufen in der Umlenkposition der Treppenstrecke längs einer kegelstumpfförmigen Fläche bewegt werden.

12. Bogenrolltreppe nach Anspruch 11, dadurch gekennzeichnet, daß die Führungsschienen-einrichtung außerdem einen Führungsschienenbereich (156, 158) aufweise, der die Hinterräder in Bezug auf die Vorderräder der Stufe um einen ausreichenden Betrag anhebt, um die an den benachbarten Stufen ausgebildeten Halteleisten außer Eingriff zu bringen.

Revendications

1. Escalier roulant courbe, comprenant:
 20 une bande sans fin (12);
 un certain nombre de marches en segments (14) attachées à ladite bande sans fin;
 des moyens (60, 62, 64) pour entraîner ladite bande sans fin en une boucle disposée le long d'un passage d'escalier, ledit passage d'escalier étant courbé en plan et ayant une section intermédiaire (16) qui a un angle prédéterminé et constant de pente, des sections de palier supérieur et inférieur (22, 24) qui ont
 25 un angle de pente sensiblement nul, et des sections de transition (18, 20) reliant ladite section intermédiaire à ladite section supérieure ou inférieure qui ont des angles changeants de pente pour la connexion sans à-coup des sections; et

un moyen pour guider ladite bande autour de ladite boucle comprenant un certain nombre de roues de guidage (38, 44) montées rotatives sur lesdites marches et une voie de guidage (A₁—A₇, B₁—B₇; 40, 42, 46, 48) disposée le long dudit passage d'escalier, caractérisé en ce que la voie de guidage a des rayons de courbure en plan (R₁(θ₁), R₂(θ₂)) qui sont inversement proportionnels aux angles de pente (θ₁, θ₂) des différentes positions dudit passage d'escalier.

2. Escalier roulant courbe selon la revendication 1 où ladite voie de guidage comprend une voie externe de guidage (A; 40, 46) et une voie interne de guidage (B; 42, 48) caractérisé en ce que la relation
 35 entre lesdits rayons de courbure desdites voies de guidage et ledit angle de pente dudit passage d'escalier est

$$R_1(\theta_1) = \frac{R_1 (R_1 - R_2) \cos \theta_1}{R_1 \cos \theta_1 - R_2 \cos \theta_2},$$

$$R_2(\theta_2) = \frac{R_2 (R_1 - R_2) \cos \theta_2}{R_1 \cos \theta_1 - R_2 \cos \theta_2},$$

45 dans laquelle

R₁(θ₁): rayon de courbure de la voie externe de guidage en une position arbitraire
 R₂(θ₂): rayon de courbure de la voie interne de guidage en une position arbitraire
 R₁: rayon de courbure de la voie externe de guidage aux sections de palier supérieur et inférieur
 R₂: rayon de courbure de la voie interne de guidage aux sections supérieur et inférieur de palier
 50 θ₁: angle de pente de la voie externe de guidage
 θ₂: angle de pente de la voie interne de guidage

3. Escalier roulant courbe selon la revendication 1 ou 2 caractérisé en ce que lesdites marches en segments (14) ont chacune un bord latéral interne et externe qui sont des arcs concentriques exprimés par

$$\frac{l_1}{l_2} = \frac{R_1'}{R_2'}$$

où

60 l₁: longueur de l'arc du bord latéral externe de la marche
 l₂: longueur de l'arc du bord latéral interne de la marche
 R₁': rayon de courbure du bord latéral externe de la marche aux sections de palier supérieur et inférieur,
 R₂': rayon de courbure du bord latéral interne de la marche aux sections de palier supérieur et
 65 inférieur,



(18)

une contremarche (56) qui est une partie d'une surface de cône tronqué ayant un rayon de courbure de l_1 au bord latéral externe de la marche et un rayon de courbure de l_2 au bord latéral interne de la marche.

4. Escalier roulant courbe selon l'une quelconque des revendications 1 à 3 caractérisé en ce que chaque marche (14) est supportée sur ladite voie de guidage par un arbre (36) qui a une première extrémité qui est à un plus haut niveau que la seconde extrémité du côté de support de la charge de la bande sans fin.

5. Escalier roulant courbe selon la revendication 4 caractérisé en ce que ladite bande comprend une chaîne externe et une interne (32, 34) et la différence des niveaux desdites extrémités dudit arbre (36) de la marche est exprimée par

$$h = r_1 - r_2 \cdot \frac{r_1}{r_2} = \frac{R_1''}{R_2''}$$

où

h : différence de niveau

r_1 : rayon d'un pignon de chaîne (62) pour la chaîne externe

r_2 : rayon d'un pignon de chaîne (64) pour la chaîne interne

R_1'' : rayon de courbure de la chaîne externe dans la section de palier

R_2'' : rayon de courbure de la chaîne interne dans la section de palier.

6. Escalier roulant courbe selon la revendication 4 ou 5 caractérisé en ce que lesdites chaînes externe et interne sont enroulées sur un plus grand et un plus petit pignon (62, 64), respectivement, dans les tournants du passage d'escalier, lesdites marches étant déplacées par l'entraînement dudit pignon de chaîne.

7. Escalier roulant courbe selon l'une quelconque des revendications précédentes caractérisé en ce que sur ledit arbre (36) de la marche est montée une plaque de connexion (68) qui est connectée à ses extrémités opposées à des maillons de chaîne (74) de ladite chaîne, dans les extrémités de connexion de ladite plaque de connexion étant formé un trou circulaire (70) pour la réception d'un fuseau (72) de maillon de chaîne, ledit trou circulaire ayant une surface formée par rotation autour de l'axe du trou d'un arc qui est convexe vers l'axe du trou.

8. Escalier roulant courbe selon la revendication 7 caractérisé en ce que la distance entre les axes desdits trous circulaires (70) dans ladite plaque de connexion est une valeur qui n'est pas égale au pas des fuseaux de chaîne multiplié par un nombre entier.

9. Escalier roulant courbe selon l'une quelconque des revendications précédentes caractérisé en ce que ladite bande sans fin comprend une chaîne interne sans fin (114) disposée le long du côté interne dudit passage d'escalier courbe et une chaîne externe sans fin (106) disposée le long du côté externe dudit passage d'escalier courbe, où ledit moyen d'entraînement comprend un mécanisme tournant ayant un grand pignon de chaîne (116) autour duquel est enroulée ladite chaîne externe et un petit pignon de chaîne (118) autour duquel est enroulée ladite chaîne interne, et où lesdits moyens de guidage comprennent un arbre (88) de la marche, monté sur chacune desdites marches, s'étendant en direction de la largeur de la marche, des roues d'entraînement (90), montées sur ledit arbre de la marche et guidées par ladite voie de guidage (92, 94), des roues de guidage (102) montées sur ladite marche et guidées par ladite voie de guidage (98, 100), lesdites roues de guidage étant placées plus loin de la face supérieure de la marche que lesdites roues d'entraînement, un bras de levier (104) monté pivotant sur ledit arbre de la marche du côté externe dudit passage d'escalier en sa partie intermédiaire, ledit bras de levier ayant une broche de connexion (108) fixée à une extrémité plus proche de la face supérieure de la marche, un galet régulateur (110) monté rotatif à l'autre extrémité dudit bras de levier, et une voie régulatrice (112) disposée le long dudit passage d'escalier pour guider ledit galet régulateur pour déplacer lesdits bras de levier par rapport à ladite marche, pour qu'ainsi lesdites marches en segments puissent tourner le long d'une surface sensiblement cylindrique.

10. Escalier roulant courbe selon l'une quelconque des revendications 1 à 8 caractérisé en ce que ladite bande sans fin comprend une chaîne interne sans fin (114) disposée le long du côté interne dudit passage d'escalier courbe et une chaîne externe sans fin (106) disposée le long du côté externe dudit passage d'escalier courbe, où ledit moyen d'entraînement comprend un mécanisme tournant ayant un grand pignon de chaîne (116) autour duquel est enroulée ladite chaîne externe et un petit pignon de chaîne (118) autour duquel est enroulée ladite chaîne interne, et où lesdits moyens de guidage comprennent un arbre (88) de marche monté sur chacune desdites marches et s'étendant en direction de la largeur de la marche, des roues d'entraînement (90), montées sur ledit arbre de la marche et guidées par ladite voie (92, 94), des roues de guidage (102) montées sur ladite marche et guidées par ladite voie de guidage (98), lesdites roues de guidage étant placées plus loin de la face supérieure de la marche que lesdites roues d'entraînement, un bras de levier (120) monté pivotant sur ledit arbre de la marche du côté interne dudit passage d'escalier courbe à sa première extrémité, ledit bras de levier ayant une broche de connexion (26) fixée à sa partie intermédiaire et connectée à ladite chaîne interne (114), un galet régulateur (122) monté rotatif à l'autre extrémité dudit bras de levier et une voie régulatrice (124) disposée le long dudit passage d'escalier pour guider ledit galet régulateur pour déplacer ledit bras de levier par rapport à ladite marche, pour qu'ainsi lesdites marches en segments tournent le long d'une surface sensiblement cylindrique.



11. Escalier roulant courbe selon l'une quelconque des revendications 1 à 8 caractérisé en ce que ladite bande sans fin comprend une chaîne interne sans fin (148) disposée le long du côté interne dudit passage d'escalier courbe et une chaîne externe sans fin (146) disposée le long du côté externe dudit passage d'escalier courbe, où lesdits moyens d'entraînement comprennent un mécanisme tournant ayant un plus grand pignon de chaîne (150) autour duquel est enroulée ladite chaîne externe et un plus petit pignon de chaîne (152) autour duquel est enroulée ladite chaîne interne et où lesdits moyens de guidage comprennent un arbre (144) de marche monté sur chacune desdites marches, s'étendant en direction de la largeur de la marche, des roues de guidage et porteuse arrière (138, 140) montées sur ledit arbre de marche et guidées par ladite voie de guidage, lesdites voies de guidage guidant lesdites roues de guidage et porteuse arrière de manière que lesdites marches soient placées horizontalement tandis qu'elles sont dans le tronçon de support de la charge et que lesdites marches soient déplacées le long d'une surface conique tronquée dans la position de tournant dudit passage d'escalier.

12. Escalier roulant courbe selon la revendication 11 caractérisé en ce que lesdits moyens formant voies de guidage comprennent de plus une section de voie de guidage (156, 158) qui élève les galets arrière par rapport aux galets avant de la marche d'une quantité suffisante pour dégager les languettes formées sur les marches adjacentes.

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