

Description

This invention relates to a curved escalator construction, and more particularly to a curved escalator having a path of travel defined by a fixed center, constant radius arc when viewed in plan.

Escalators which follow a curved path of travel from entry landing to exit landing are generally known in the prior art. There are two general approaches which have been taken in the prior art to designing an operable curved escalator. One approach involves the use of a path of travel which, in plan, is defined by an arc having varying radii of curvature and emanating from a shifting center. The other approach involves the use of a path of travel which, in plan, is defined by an arc of constant radius struck from a fixed center.

Patent publications which relate to the aforesaid first approach include: Japanese Patent Publication 48-25559 of July, 1973; German patent publication 3,441,845, June 13, 1985; U.S. patent No. 4,662,502, Nakatani et al, granted May 5, 1987; and U.S. Patent No. 4,746,000, Nakatani et al, granted May 24, 1988.

Patent publications which relate to the aforesaid second approach include: U.S. Patents Nos. 685,019, October 22, 1901; 723,325, March 24, 1903; 727,720, May 12, 1903; 782,009, February 7, 1905; 967,710, August 16, 1910; 2,695,094, November 23, 1954; 2,823,785, February 18, 1958; 3,878,931, April 22, 1975; 4,726,460, February 23, 1988; 4,730,717, March 15, 1988; 4,739,870, April 26, 1988; British Patent No. 292,641, June 22, 1928; and Japanese Patent Disclosure No. 58-220077, 1983.

Japanese Patent Disclosure No. 58-220077, dated December 21, 1983 discloses a curved escalator which has a constant radius, fixed center arcuate path of travel when viewed in plan. When the treads of the escalator move from the horizontal landing to the constant slope intermediate zone, they are properly repositioned by accelerating and decelerating their inside edges in the transition zones adjacent the landings. The differential movement of the inside tread edges is accomplished with pivoting links which interconnect the step axes of adjacent steps and which are joined at pivot points provided with rollers that traverse a track. The step axes also have rollers at their inside ends which travel over another track vertically spaced from the link roller track. The position of the inside edges of the steps is varied in the transition zone by varying the vertical distance between the inside step axle roller track and the link roller track beneath it. The links lengthen in the constant slope portion of the escalator and shorten in the horizontal landing and turn around zones. The steps are engaged by driving chains which connect to the step axes only in the constant slope zone where the position of the steps relative to each other remains constant. The drive chains do not contact the step axes in the transition, landing, or turn around zones. Varying the position of the inside edge of the steps requires that the connecting links be shortened in the horizontal and turn around zones of the escalator, and the use of two separate tracks for the inside step axle roller and for the adjustment link rollers, requires that the adjustment links will always be skew throughout the entire path of travel of the escalator. The use of two separate axle roller and link roller tracks also requires that the drive housing and tread reverse sprockets be vertically elongated.

Charles D. Seeberger was a turn-of-the-century inventor who obtained U.S. Patents Nos. 617,778, granted January 17, 1899; 617,779, granted January 17, 1899; 984,495, granted February 14, 1911; 984,858, granted February 21, 1911; and 999,885, granted August 8, 1911, which all relate to curved escalators. The 617,779 patent discusses the need to shorten and lengthen step chains in a curved escalator having a path of travel which has portions with different radii. The step chains are formed with segments which are threadably connected to each other. The segments are rotated by a pinion mechanism to unscrew, or tighten the threaded connections whereby the chain is lengthened or shortened when necessary. The 984,495 patent states that a curved escalator with a fixed radius, constant center cannot have both ends of adjacent step axes connected to each other by links of fixed length. A scissor connection is then made between succeeding axes, and a slight adjustment of this connection is made when the steps move from the curved horizontal track section to the inclined curved section of the track. The adjustment is described at page 3, line 119 to page 4, line 28 of the patent. The 999,885 patent describes a curved escalator having its steps connected together at their inner and outer edges, with the outer edge connection being of constant length, and the inner edge connection being variable by reason of adjustable links.

This invention relates to a step chain and track assembly for use in a curved or spiral escalator of the type having a fixed center, constant radius arcuate path of travel when viewed in plan. The assembly of this invention takes into account that in the escalator of the type specified, the steps, as they pass from the horizontal landing entry area into and through the entry transitional area to the constant slope area, will have to pivot with respect to each other in order to have their tread surfaces remain horizontal. This pivoting movement is accomplished by moving one side of the steps at a different angular velocity than the other side of the steps as the latter move through the entry transition zone and through the constant slope zone when viewed in plan. In the exit transition zone, the differential movement of the sides of the steps is reversed so that the steps then pivot back to their original orientation relative to each other. Thus the velocities of the steps and their angular positions will vary at different locations along the path of movement thereof. In order to allow the pivotal step move-

ment without binding the steps together, the step risers may be formed with a modified conical configuration, the details or specifics of which will be determined by the radius of curvature of the path of travel of the escalator, and the size of the step.

5 US-A-3878931 discloses an escalator having an arcuate path of travel defined by a constant radius derived from a fixed center as viewed in plan, the escalator including horizontal entry and exit landing zones, an intermediate constant slope zone, and entry and exit transition zones of continuously varying slope interconnecting the constant slope zone with the entry and exit landing zones respectively, said escalator comprising

10 a) inner and outer tracks extending between said landing zones and through said transition and constant slope zones for supporting movement of steps along the path of travel of the escalator; and

b) a plurality of steps, each having: an upper tread portion which remains substantially horizontal throughout a people transporting portion of the path of travel of the escalator; a step axle at inner and outer sides of each step; inner and outer step axle rollers rotatably mounted on said step axles, said step axle rollers being operable to travel over said inner and outer tracks.

15 According to one aspect, the present invention is characterised by inner and outer step chains forming a continuous connection between said step axles whereby all of said steps are connected together by the step chains throughout the entire path of travel of the escalator;

eccentric cam means connecting pairs of adjustable links in at least one of said inner and outer step chains and rotating means operable to cam the pair of adjustable links to vary the extent of overlap of said 20 adjustable links as the steps move through each of said transition zones so as to move the outer ends of the step axles of adjacent steps toward and away from each other in said transition zones, whereby the steps are continuously guided along said arcuate path of travel, and said escalator having turn around sprockets at each of said landing zones for reversing the direction of travel of the moving escalator components.

The differential velocity and pivotal movement of the steps can be accomplished in the escalator of this invention by changing the effective length of one or both of the step chains without changing the length of 25 the individual chain links. It should be noted that the actual length of the step chain is not altered, but only its effective length is changed. In performing the necessary shifting of the steps, either the inner or outer step chain can be effectively lengthened and shortened in appropriate fashion, or both the inner and outer step chains can be appropriately lengthened and shortened in a complementary manner, i.e., one will be shortened and the other simultaneously lengthened to accomplish the intended result. The step chains consist of a plurality of links which are pivotably connected together and which are also connected to the step axles on the 30 steps.

Certain of the chain link pivot connections are formed with eccentric cams means, said cam means itself being cammed and operable by an associated cam actuating roller means, as will be described in greater detail 35 hereinafter. The step roller axles carry rotating rollers which move on tracks mounted beneath the steps, in a known manner. In the assembly of this invention, the chain link pivot connections having eccentric cams are operable to shorten and lengthen the effective length of one of the inside or outside chains, or both of them. These certain length-altering link pivot connections are disposed between successive roller axle chain link joints, and utilize eccentric pivot cams to alter the effective length of the chain. The chain links at these 40 eccentric cam connections have laterally overlapping ends which may be connected together by a bearing pin. The bearing pin in turn may be connected to a pin rotational mechanism whereby the bearing pins can be selectively rotated in the ends of the inner sets of links.

The bearing pin rotational mechanism may operate on an axis which is eccentric or offset from the axis of rotation of the bearing pins, whereby rotation of the bearing pins causes an axial camming of the inner sets of 45 the certain of the links in the chain to occur. This shortens the effective length of the chains. The maximum amount of link camming shift occurs when the bearing pins are rotated through a 180° angle. Thus a 180° rotation of the bearing pins in one direction will shorten the chain and a reverse 180° rotation of the bearing pins will lengthen the chain.

The bearing pin rotation may be accomplished by the use of a lever or some other actuator which is connected to the eccentric cam so that when the lever pivots or swings, the eccentric cam is also rotated to cause 50 rotation of the bearing pins. Pivoting of the cam lever may be controlled by rollers mounted in the lever which follow actuating roller tracks in the escalator assembly. When the actuating tracks move toward or away from the chain vertically, the actuating cam lever will pivot accordingly causing the lengthening or shortening of the effective length of the chains. The cam levers can be connected to the eccentric pivot cams by means of 55 gears; chains and sprockets; or can be directly keyed to the eccentric pivot cams. The rate of change of vertical offset between the two actuating tracks determines the rate of change of the effective chain length, and thus the rate of change of the step velocity.

In an escalator constructed in accordance with this invention, in the entry transitional zone, i.e., the transitional zone between the entry landing and the constant slope portion of the escalator, the effective length

of the chain or chains may be shortened or lengthened, as the case may be, and the reverse may happen in the exit transitional zone which connects the constant slope portion of the escalator with the exit landing.

Viewed from a further aspect there is provided a step chain assembly for an escalator, as described previously, comprising inner and outer step chains adapted to connect together and drive the steps of an escalator having a curved path of travel the assembly further comprising eccentric cam means connecting pairs of adjustable links in at least one of said inner and outer step chains and operable when rotated to cam the pair of adjustable links to vary the extent of overlap of said adjustable links.

There now follows, by way of example only a detailed description of the invention taken in conjunction with the accompanying drawings in which:

Figure 1 is a plan view of the steps of the escalator as they appear in the horizontal landing zones of the escalator;

Figure 2 is a plan view similar to Figure 1 but showing the pivotal movement that the steps would undergo in the constant slope intermediate zone if the inner and outer step chains were kept at a constant effective length;

Figure 3 is a plan view similar to Figure 2, but showing the pivoted position of the steps in the intermediate zone when the effective length of the outside step chain is shortened while maintaining constant the effective length of the inside step chain;

Figures 4 and 5 are schematic views of the steps in the landing and inclined portions respectively showing how velocities can be related to step positions;

Figure 6 is a perspective fragmented view of a step chain and track assembly formed in accordance with this invention;

Figure 7 is an exploded perspective view of the assembly of Figure 6 showing the construction of the eccentric cam which operates the pivot pins;

Figure 8 is a side elevational view showing the assembly on the constant slope zone of the track illustrating how the effective length of the step chain is shortened;

Figure 9 is a side elevational view showing the assembly on a horizontal landing zone of the track illustrating how the effective length of the step chain is increased;

Figure 10 is a view similar to Figures 8 and 9 but showing the operation of the eccentric cam in a transition zone;

Figure 11 is a side elevational view of the overlapped ends of adjacent links at one of the adjustable chain link joints showing the position of the eccentric cam when the chain is at its longest effective length;

Figure 12 is a view similar to Figure 11 but showing the position of the eccentric cam as the effective length of the chain is in the process of being shortened during a transitional zone of the escalator;

Figure 13 is a view similar to Figure 11 but showing the position of the eccentric cam when the chain is at its shortest effective length;

Figure 14 is a fragmented somewhat schematic elevational view of the camming tracks in the entrance transition zone of a down escalator; and

Figure 15 is a view similar to Figure 14 of the camming tracks in the entrance transition zone of an up escalator; and

Figure 16 is an elevational view of the turn around sprocket of the step chain of Figure 6.

Referring now to Fig. 1, there are shown two steps 10 and 12 on the escalator as they would appear in plan view looking down on the treads in one of the horizontal landing zones. The steps 10, and 12 have constant arcuate inner sides of radius RS1 along which points 1, 4, 5 and 8 lie, and constant arcuate outer sides of radius RS2 along which points 2, 3, 6 and 7 lie. The radii RS1 and RS2 are struck from a fixed center C. An inner step chain has an incremental length B1 for each step 10 and 12, and an outer step chain has an incremental length B2 for each step 10 and 12.

Referring to Fig. 2, the positions of the steps 10 and 12 are illustrated as they would appear in the intermediate constant slope incline zone of the escalator if the effective incremental lengths B1 and B2 of the inner and outer step chains were kept constant. The position of the step 12 in the landings is shown in Fig. 2 in phantom and the position of the step 12 in the incline is shown in solid lines. When the steps 10 and 12 are in the inclined zone of the escalator, assuming that step 12 is the higher step, it will have pivoted up and over the step 10 so that point 6 will have moved a distance S2 and point 5 will have moved a distance S1. This movement of the step 12 will cause the apparent radius of the inner side sections of the steps 10 and 12 to decrease to R'S1 and the apparent radius of the outer side sections of the steps 10 and 12 to decrease to R'S2 both of which will be struck from a center point C' which is offset from the original center point C.

In order to counter this tendency of the steps 10 and 12 to spiral into a tighter radius path of travel, and to maintain the original radial path of travel, the step 12 must be pivoted an additional increment over the step 10 when the steps are in the intermediate inclined zone of the escalator path. In Fig. 3, the position of step

12 from Fig. 2 is shown in phantom, and the desired position needed to provide the constant radius is shown in solid lines. To achieve the desired position, the outside of the step 12 is further pivoted a distance $\Delta S2$ so that the corners 6, 7 and 8 of the step 12 shift to positions 6', 7' and 8' respectively. The corner 5 of the step 12 can be considered as forming the pivot point and thus does not substantially shift its position. It will be appreciated that the radii described above are actually the step chain radii, but for purposes of explaining the step movement, they can be considered to be the radii of the path of movement of the inner and outer edges of the steps.

As noted, to make a constant plan radius curved escalator, the distance between point 2 and point 6 needs to get smaller while maintaining the distance between point 1 and point 5. A pivoting motion about point 5 is the result. This is done by shortening the length of the outer step chain as it goes through the entry transition zone. The result thereof is shown in Fig. 3.

The following equations can be used to calculate the required shortening of the outer step chain:

$$S1 = B1 (1 - \cos \alpha s1) \quad \text{eq. 1}$$

$$S2 = B2 (1 - \cos \alpha s2) \quad \text{eq. 2}$$

$$S'2 = \frac{Rs2(S1)}{Rs1} \quad \text{eq. 3}$$

$$\Delta S2 = S'2 - S2 \quad \text{eq. 4}$$

$$B'2 = \frac{B2 \cos \alpha s2 - S2}{\cos \alpha s2} \quad \text{eq. 5}$$

where

$Rs1$ = plan radius inner step track;

$Rs2$ = plan radius outer step track;

$B1$ = incremental chain length inner step;

$B2$ = incremental chain length outer step;

$B'2$ = incremental chain length outer in transition/incline section;

$\alpha s1$ = angle of inclination inner step track;

$\alpha s2$ = angle of inclination outer step track;

$S1$ = arc length projection inner step;

$S2$ = arc length projection outer step;

$S'2$ = arc length projection outer step which will pivot the step onto the constant radius; and

$\Delta S2$ = delta arc length projection outer step which will pivot the step onto the constant radius.

VELOCITY

The following equations show how the velocities will be related to the step positions as shown in Figs. 4 and 5, wherein:

$V1$ = tangential velocity inner step edge;

$V2$ = tangential velocity outer step edge;

W = angular velocity;

$Rs1$ = plan radius inner step track;

$Rs2$ = plan radius outer step track;

$\alpha s1$ = angle of inclination inner step track;

$\alpha s2$ = angle of inclination outer step track;

$B1$ = incremental chain length inner step;

$B2$ = incremental chain length outer step;

$\Delta S2$ = delta arc length projection outer step which will pivot the step onto the constant radius; and

V = delta velocity subtracted from outer step in the plan view.

For the horizontal section which is shown in Fig. 4, the following equations apply.

$$V1 = W \times Rs1$$

$$V2 = W \times Rs2$$

$$\frac{V1}{V2} = \frac{Rs1}{Rs2} = \text{constant} = K$$

$$\frac{Rs1}{Rs2} = \frac{B1}{B2}$$

For the transition section and incline section which is shown in Fig. 5, the following equations apply.

$$\frac{V1 \cos \alpha s1}{V2 \cos \alpha s2} = \frac{Rs1}{Rs2} = K$$

$$\frac{B1 \cos \alpha s1}{B2 \cos \alpha s2} \neq \frac{Rs1}{Rs2} = K$$

To vary the velocity of the outside step edge and vary the outside axle distance the following equations apply.

$$\frac{V1 \cos \alpha s1}{V2 \cos \alpha s2 - \Delta V} = \frac{Rs1}{Rs2} = \frac{B1 \cos \alpha s1}{B2 \cos \alpha s2 - \Delta S^2}$$

whereupon ΔV can be calculated as follows:

$$\Delta V = V2 \cos \alpha s2 - \frac{Rs2}{Rs1} (V1 \cos \alpha s1).$$

Referring now to Figs. 6-16, there is shown a preferred embodiment of a step chain and track assembly which is operable to effect the aforesaid changes in the effective length of the outer and/or inner step chains, and in the velocity of the outer and/or inner sides of the steps 10 and 12. Fig. 6 shows an inner and outer step chain on the intermediate constant slope portion of the escalator. Referring firstly to the outer step chain what is shown is one segment of the outer step chain that interconnects adjacent step axes 14 and 16. The step axle 14 is mounted on the step 10 and the axle 16 is mounted on the step 12. The step axes 14 and 16 carry rollers 18 and 20 respectively which roll along the track 22. The chain segment shown includes five links 24a, 24, 25, 26 and 27 which are pivotally connected directly or otherwise to the step axes 14 and 16. An eccentric pivot cam denoted generally by the numeral 35 pivotally connects the chain links 25, 26 and is operable to cam the links 25, 26. The pivot cam 35 is itself cammed and is further operably connected to camming rollers 41 and 42 by a camming lever 43. The links 24a, 24, 25, 26 and 27 are joined by spherical pin joints 30 which provide the necessary flexibility to the chain. The camming rollers 41 and 42 move along tracks transversely inwardly and outwardly offset from the path that the axle rollers 18 and 20 move along. An outer upthrust track 28 is disposed above the axle rollers 18 and 20 for engagement thereby to counter upthrust forces imparted to the chain during operation of the escalator.

Referring now to Figure 7, details of the construction of the preferred form of the eccentric pivot cam mechanism 35 are shown. As shown in Figure 7, the components of the link 26 are inwardly adjacent to and overlap components of the link 25. A pivot pin 1 has opposite end bearing bosses 3 which are telescoped into socket holes 5 in the components of the link 26. Pinion gears 7 are fixed to the opposite ends of the pivot pin 1, with the axis of the pinion gears 7 being offset from the axis of the pivot pin 1. The camming levers 43 have inner internal ring gears 9 affixed thereto which ring gears 9 each have bearing bosses 11 which telescope into socket holes 13 in the components of the link 25. The ring gears 9, bearing bosses 11, and link holes 13 are all shown coaxial with the link holes 5, bearing bosses 3 and pivot pin 1. The bosses 3 and 11 are rotatably secured to the link components 26 and 25 respectively by means of snap rings (not shown) which engage suitable grooves (not shown) formed on the bosses 3 and 11. The pinion gears 7 are so positioned as to mesh with the ring gears 9 and a pinion idler gear 15 which pairs with each pinion gear 7 to maintain proper meshing of the latter with the ring gears 9 during operation of the eccentric pivot cam 35. It will be appreciated that when the cam levers 43 are rotated vertically, the ring gears 9 will also rotate about their axes. Rotation of the ring gears 9 results in concurrent planetary movement of the pinion gears 7 which in turn causes the pivot pin 1 to be cammed about the axis of the pinion gears 7 and out of coaxial registry with the ring gears 9. Using a three-to-one gear ratio, a 60° angle rotation of the ring gears 9 will result in a 180° orbital displacement of the pinion gear 7 with a resultant shift of the pivot pin 1 and the chain link 26 as will be more clearly illustrated hereinafter.

Referring back to Figure 6, an inner step chain 32 connects inner ends of the step axes 14 and 16. The inner step chain 32 may be of relatively conventional construction and have a constant effective length which equals its actual length, or it may be equipped with an eccentric pivot cam 35, as shown in Figure 6. A bracket 34 is mounted on the inner end of each step axle 14, 16, the bracket 34 carrying inner step axle rollers 36 which ride on an inner track 38. The bracket 34 also carries a side thrust roller 40 which rides on the outer side surface 37 of the inner track 38. The side thrust roller 40 is operable to counter inwardly directed side thrust forces imparted to the chains and steps during operation of the escalator. An inner upthrust track 39 is disposed above the inner step axle rollers 36 to counter upthrust forces imparted to the assembly during operation of the escalator. It will be understood that the outer step chain may be shortened when in the entry transition zone and relengthened in the exit transition zone; or the inner step chain may be lengthened in the entry transition zone and reshortened in the exit transition zone; or the effective length of both of the chains can be concurrently altered to effect the necessary shifting of the steps.

Referring now to Figures 8-13, the mode of operation of the invention in the flat, transitional, and constant incline zones of the escalator is illustrated. Figures 8 to 10 show the variation in length of an outer chain over varying incline zones as controlled by cam levers 43. When the steps 10, 12 are in a horizontal landing area, as shown in Figure 9, if the outer chain is adjustable then it will be at its greatest effective length (as shown),

and if the inside chain is adjustable then it will be at its smallest effective length. If both chains are adjustable, then both will be as noted previously, but the amount of length adjustment of each chain will be one half of that needed when only one chain is adjustable. When the steps 10, 12 are in the constant incline zone of the escalator as shown in Figure 8, the lengths of the chains will be the reverse of that specified for the horizontal zone such that the outer chain will be at its shortest (as shown), if adjustable, and the inner chain will be at its longest. Figure 10 shows the elements in a transition region. As shown in Figures 14 and 15, the cam rollers 41, 42 of an outer chain are guided by cam tracks 50 and 51 which converge and diverge in the transitional zones to cause the cam levers 43 to pivot appropriately. Arrows A and B indicate the direction of movement of the escalator in Figures 14 and 15, respectively. Figures 11-13 illustrate how the planetary gear 7 orbits in the ring gear 9 responsive to pivoting of the lever 43 to cam the chain links 25 and 26 from their shortened condition shown in Figure 11 to their lengthened condition shown in Figure 13 with the middle of the transition zone being shown in Figure 12. It will be appreciated that the orbiting of the gear 7 may proceed in both directions, i.e., from 3 o'clock to 9 o'clock, and return.

As seen from Fig. 16, when the chain links 24a; 24, 25, 26, 27 are all aligned in the horizontal landing zones, they will pass easily over the turn around sprocket 53 at the entry and exit of the escalator. The sprocket 53 is mounted on a driven shaft 55 and is disposed at one of the landing ends of the escalator. It will be appreciated that the escalator is thus of conventional construction wherein the return path of the steps lies beneath the passenger-carrying path. The sprocket 53 is formed with circumferential recesses 57 which are sized so as to receive and carry the spherical joints of the step chains. The camming levers 43 and rollers 41, 42 pass on either side of the sprocket 53 as the chain and steps reverse their path of travel. It will be appreciated that there will be two reversing sprockets, one at each end of the escalator, but only one of which will be a drive sprocket. The other sprocket will be formed as shown but will serve as an idler sprocket which merely guides the chain but does not drive it.

It will be readily understood that the step chain and track assembly of this invention allows the escalator path of travel to be defined by a constant radius arc derived from a fixed center point. This in turn allows for greater control of step-to-step, and step-to-skirt gaps in the escalator. Balustrades, tracks and skirts can be more easily formed and accurately installed. Additionally, the step pivoting feature of the invention assures a relatively simple mechanical form which eliminates the complex step connections described in the aforesaid prior art. The movement of the steps is completely controlled at all points in the path of travel of the escalator, and may be customized to accommodate different sweep angles, angles of inclination, and rise distances for the escalator.

It will be appreciated that the adjustments in effective chain lengths may be made in the outer step chain, the inner step chain, or both step chains, and will allow the chain and steps to smoothly pass over the turn around sprockets without drastically altering the latter. By using the chain adjustment of this invention to change the position of the steps, a compact envelope is established for housing the drive assembly for the escalator.

Since many changes and variations of the disclosed embodiments of the invention may be made without departing from the inventive concept, it is not intended to limit the invention otherwise than as required by the claims as interpreted by the description and drawings.

Claims

1. An escalator having an arcuate path of travel defined by a constant radius (Rs1, Rs2) derived from a fixed center (C) as viewed in plan, the escalator including horizontal entry and exit landing zones, an intermediate constant slope zone, and entry and exit transition zones of continuously varying slope interconnecting the constant slope zone with the entry and exit landing zones respectively, said escalator comprising
 - a) inner and outer tracks (22,38) extending between said landing zones and through said transition and constant slope zones for supporting movement of steps (10,12) along the path of travel of the escalator; and
 - b) a plurality of steps (10,12), each having: an upper tread portion which remains substantially horizontal throughout a people transporting portion of the path of travel of the escalator; a step axle (14,16) at inner and outer sides of each step; inner and outer step axle rollers (18,20,36) rotatably mounted on said step axles, said step axle rollers being operable to travel over said inner and outer tracks, characterised by inner and outer step chains (24a,25,25, 26,27,32) forming a continuous connection between said step axles (14,16) whereby all of said steps are connected together by the step chains throughout the entire path of travel of the escalator;
- eccentric cam means (35) connecting pairs of adjustable links (25,26) in at least one of said inner



and if the inside chain is adjustable then it will be at its smallest effective length. If both chains are adjustable, then both will be as noted previously, but the amount of length adjustment of each chain will be one half of that needed when only one chain is adjustable. When the steps 10, 12 are in the constant incline zone of the escalator as shown in Figure 8, the lengths of the chains will be the reverse of that specified for the horizontal zone such that the outer chain will be at its shortest (as shown), if adjustable, and the inner chain will be at its longest. Figure 10 shows the elements in a transition region. As shown in Figures 14 and 15, the cam rollers 41, 42 of an outer chain are guided by cam tracks 50 and 51 which converge and diverge in the transitional zones to cause the cam levers 43 to pivot appropriately. Arrows A and B indicate the direction of movement of the escalator in Figures 14 and 15, respectively. Figures 11-13 illustrate how the planetary gear 7 orbits in the ring gear 9 responsive to pivoting of the lever 43 to cam the chain links 25 and 26 from their shortened condition shown in Figure 11 to their lengthened condition shown in Figure 13 with the middle of the transition zone being shown in Figure 12. It will be appreciated that the orbiting of the gear 7 may proceed in both directions, i.e., from 3 o'clock to 9 o'clock, and return.

As seen from Fig. 16, when the chain links 24a; 24, 25, 26, 27 are all aligned in the horizontal landing zones, they will pass easily over the turn around sprocket 53 at the entry and exit of the escalator. The sprocket 53 is mounted on a driven shaft 55 and is disposed at one of the landing ends of the escalator. It will be appreciated that the escalator is thus of conventional construction wherein the return path of the steps lies beneath the passenger-carrying path. The sprocket 53 is formed with circumferential recesses 57 which are sized so as to receive and carry the spherical joints of the step chains. The camming levers 43 and rollers 41, 42 pass on either side of the sprocket 53 as the chain and steps reverse their path of travel. It will be appreciated that there will be two reversing sprockets, one at each end of the escalator, but only one of which will be a drive sprocket. The other sprocket will be formed as shown but will serve as an idler sprocket which merely guides the chain but does not drive it.

It will be readily understood that the step chain and track assembly of this invention allows the escalator path of travel to be defined by a constant radius arc derived from a fixed center point. This in turn allows for greater control of step-to-step, and step-to-skirt gaps in the escalator. Balustrades, tracks and skirts can be more easily formed and accurately installed. Additionally, the step pivoting feature of the invention assures a relatively simple mechanical form which eliminates the complex step connections described in the aforesaid prior art. The movement of the steps is completely controlled at all points in the path of travel of the escalator, and may be customized to accommodate different sweep angles, angles of inclination, and rise distances for the escalator.

It will be appreciated that the adjustments in effective chain lengths may be made in the outer step chain, the inner step chain, or both step chains, and will allow the chain and steps to smoothly pass over the turn around sprockets without drastically altering the latter. By using the chain adjustment of this invention to change the position of the steps, a compact envelope is established for housing the drive assembly for the escalator.

Since many changes and variations of the disclosed embodiments of the invention may be made without departing from the inventive concept, it is not intended to limit the invention otherwise than as required by the claims as interpreted by the description and drawings.

Claims

1. An escalator having an arcuate path of travel defined by a constant radius (R_{s1}, R_{s2}) derived from a fixed center (C) as viewed in plan, the escalator including horizontal entry and exit landing zones, an intermediate constant slope zone, and entry and exit transition zones of continuously varying slope interconnecting the constant slope zone with the entry and exit landing zones respectively, said escalator comprising
 - a) inner and outer tracks (22,38) extending between said landing zones and through said transition and constant slope zones for supporting movement of steps (10,12) along the path of travel of the escalator; and
 - b) a plurality of steps (10,12), each having: an upper tread portion which remains substantially horizontal throughout a people transporting portion of the path of travel of the escalator; a step axle (14,16) at inner and outer sides of each step; inner and outer step axle rollers (18,20,36) rotatably mounted on said step axles, said step axle rollers being operable to travel over said inner and outer tracks, characterised by inner and outer step chains (24a,25,25, 26,27,32) forming a continuous connection between said step axles (14,16) whereby all of said steps are connected together by the step chains throughout the entire path of travel of the escalator;
- eccentric cam means (35) connecting pairs of adjustable links (25,26) in at least one of said inner



and outer step chains and rotating means operable to cam the pair of adjustable links (25,26) to vary the extent of overlap of said adjustable links as the steps move through each of said transition zones so as to move the outer ends of the step axles (14,16) of adjacent steps (10,12) toward and away from each other in said transition zones, whereby the steps are continuously guided along said arcuate path of travel; and

said escalator having turn around sprockets (53) at each of said landing zones for reversing the direction of travel of the moving escalator components.

2. The escalator of claim 1 wherein said eccentric cam means includes first rotatable means (43) mounted on one of each pair of said adjustable links and second rotatable means (1) mounted on the other of each pair of said adjustable links, said first and second means being rotatable about respective eccentric axes, and means (7, 9,15) interconnecting said first and second means whereby rotation of said first rotatable means induces concurrent rotation of said second rotatable means operable to shift said adjustable links toward and away from each other.
3. The escalator of claim 2 further comprising lever means (43) connected to said first rotatable means and operable when pivoted to rotate said first rotatable means.
4. The escalator of claim 3 further comprising roller means (42) on said lever means (43), and cam tracks (50,51) for controlling the path of travel of said roller means (42) such that said lever means is cammed and whereby deflections of said roller means (43) by said cam tracks are operable to pivot said lever means.
5. The escalator of any of claims 2 to 4 wherein said interconnecting means comprises a set of meshing gears (7,9), one mounted on said first rotatable means (43) and another mounted on said second rotatable means (1).
6. The escalator of claim 5 wherein one of said meshing gears is a ring gear (9) and the other is a pinion gear (7) which orbits about the center of said ring gear (9) when the latter is rotated.
7. The escalator of claim 6 further comprising an idler pinion gear (15) mounted in said ring gear (9) for orbital movement therein which mirrors orbital movement of said pinion gear (7).
8. The escalator of any preceding claim wherein said eccentric cam means (35) is operable so as to maintain linear alignment of said adjustable links (25, 26) at the maximum and minimum effective lengths of the chain.
9. A step chain for an escalator according to any preceding claim, which escalator moves along a curved path of travel when viewed in plan, said step chain comprising:
 - a) a plurality of serially connected links (24a,24, 25,26,27) having overlapping ends;
 - b) means for connecting escalator step axles (14,16) to spaced apart ones of said links; and
 - c) rotatable eccentric camming means (35) connecting adjacent adjustable links (25,26) intermediate said spaced apart ones of said links for varying the extent of overlap of said adjustable links to selectively increase and decrease the effective length of said chain while maintaining linear alignment of said adjustable links at the maximum and minimum effective lengths of the chain.
10. The step chain of claim 9 wherein each of said rotatable eccentric camming means comprises: a bearing pin (1) mounted in an end of an inner one of each of said adjustable links, said bearing pins being rotatable in said inner links about a first rotational axis; rotary actuators (43) mounted on an outer one of each of said adjustable links adjacent each end of said bearing pins (1), said actuators being rotatable on said outer links about second rotational axis which is eccentric from said first rotational axis; and camming means connecting said bearing pins (1) and said rotary actuators (43), said camming means being operable to cam said bearing pins (1) about said second rotational axis responsive to rotation of said rotary actuators (43) to shift said inner and outer links relative to each other whereby the effective length of the step chain is shortened or lengthened.
11. The step chain of claim 9 or 10 wherein said rotary actuators include first rotatable gear means (9), and said camming means comprise second rotatable gear means (7) meshing with said first rotatable gear means.



12. The step chain of claim 11 wherein said first rotatable gear means is a ring gear (9) and said second rotatable gear means includes a pinion gear (7) mounted for orbital movement within said ring gear (9).

13. The step chain of claim 12 wherein said second rotatable gear means further includes an idler pinion gear (15) mounted in said ring gear (9) for orbital movement therein which mirrors orbital movement of said pinion gear (7).

Patentansprüche

1. Fahrtreppe mit einer gekrümmten Bewegungsbahn, die - von oben betrachtet - durch einen konstanten, von einem festen Mittelpunkt (C) ausgehenden Radius (Rs1, Rs2) bestimmt ist, wobei die Fahrtreppe eine horizontale Eintritt- und eine horizontale Austrittslandezone, eine mittlere Zone konstanter Neigung sowie, die Zone konstanter Neigung mit der Eintritt- bzw. Austrittslandezone verbindend, eine Eintritt- und eine Austrittsübergangszone mit sich kontinuierlich ändernder Neigung aufweist, und wobei die Fahrtreppe aufweist:

a) eine innere und eine äußere Bahn (22,38), die sich zwischen den Landezonen und durch die Übergangszonen und durch die Zone konstanter Neigung erstrecken, zum Abstützen der Bewegung der Stufen (10,12) entlang der Bewegungsbahn der Fahrtreppe; und

b) eine Mehrzahl von Stufen (10,12), jede mit einem oberen Trittbereich, der in dem Personenbeförderungsbereich der Bewegungsbahn der Fahrtreppe im wesentlichen horizontal bleibt; einer Stufenachse (14,16) an der inneren und der äußeren Seite jeder Stufe; sowie einer inneren und einer äußeren Stufenachsenrolle (18,2,36), die an den Stufenachsen drehbar angebracht sind, wobei sich die Stufenachsenrollen über die innere und über die äußere Bahn bewegen können,

gekennzeichnet durch

eine innere und eine äußere Stufenkette (24a,25,25,26,27,32), die eine durchgehende Verbindung zwischen den Stufenachsen (14,16) bilden, wodurch alle Stufen durch die Stufenketten in der gesamten Bewegungsbahn der Fahrtreppe miteinander verbunden sind;

Exzenter-Steuerflächeneinrichtungen (35), die Paare von verstellbaren Gliedern (25,26) mindestens in der inneren oder in der äußeren Stufenkette verbinden, und Dreheinrichtungen, die im Betrieb das Paar von verstellbaren Gliedern (25,26) verlagern können, um das Ausmaß der Überlappung der verstellbaren Glieder zu variieren, wenn sich die Stufen durch jede der Übergangszonen bewegen, um in den Übergangszonen die äußeren Enden der Stufenachsen (14,16) benachbarter Stufen (10,12) aufeinander zu und voneinander weg zu bewegen, wodurch die Stufen entlang der gekrümmten Bewegungsbahn durchgehend geführt sind;

und wobei die Fahrtreppe Umdrehkettenräder (53) an jeder der Landezonen zum Umkehren der Bewegungsrichtung der sich bewegendenden Fahrtreppenkomponenten besitzt.

2. Fahrtreppe nach Anspruch 1, bei der die Exzenter-Steuerflächeneinrichtung eine erste drehbare Einrichtung (43), die an einem von jedem Paar von verstellbaren Gliedern angebracht ist, und eine zweite drehbare Einrichtung (1) aufweist, die an dem anderen von jedem Paar von verstellbaren Gliedern angebracht ist, wobei die erste und die zweite Einrichtung um ihre jeweilige exzentrische Achse drehbar sind, und eine Einrichtung (7,9,15) zum Verbinden der ersten und der zweiten Einrichtung aufweist, wodurch die Drehung der ersten drehbaren Einrichtung eine gleichzeitige Drehung der zweiten drehbaren Einrichtung induziert, was im Betrieb die verstellbaren Glieder aufeinander zu und voneinander weg verschieben kann.

3. Fahrtreppe nach Anspruch 2, die außerdem eine Hebeleinrichtung (43) aufweist, die mit der ersten drehbaren Einrichtung verbunden ist und im Betrieb, wenn sie geschwenkt wird, die erste drehbare Einrichtung dreht.

4. Fahrtreppe nach Anspruch 3, die außerdem eine Rolleneinrichtung (42) an der Hebeleinrichtung (43) und Steuerbahnen (50,51) zum Steuern der Bewegungsbahn der Rolleneinrichtung (42) aufweist, so daß die Hebeleinrichtung verlagert wird und wodurch im Betrieb Auslenkungen der Rolleneinrichtung (43) durch die Steuerbahnen die Hebeleinrichtung schwenken können.

5. Fahrtreppe nach einem der Ansprüche 2 bis 4, bei der die Verbindungseinrichtung einen Satz ineinandergreifender Zahnräder (7,9) aufweist, von denen eines an der ersten drehbaren Einrichtung (43) und ein anderes an der zweiten drehbaren Einrichtung (1) montiert ist.



6. Fahrtreppe nach Anspruch 5, bei der eines der ineinandergreifenden Zahnräder ein Zahnkranz (9) und das andere ein Ritzel (7) ist, das um den Mittelpunkt des Zahnkranzes (9) umläuft, wenn der letztere gedreht wird.
7. Fahrtreppe nach Anspruch 6, die außerdem ein leerlaufendes Ritzel (15) aufweist, das in dem Zahnkranz (9) für eine umlaufende Bewegung angebracht ist, welche die umlaufende Bewegung des Ritzels (7) widerspiegelt.
8. Fahrtreppe nach einem der vorhergehenden Ansprüche, bei der die Exzenter-Steuerflächeneinrichtung (35) im Betrieb die lineare Ausrichtung der verstellbaren Glieder (25,26) bei der maximalen und der minimalen Effektivlänge der Kette beibehält.
9. Stufenkette für eine Fahrkette nach einem der vorhergehenden Ansprüche, wobei sich die Fahrtreppe - von oben betrachtet - entlang einer gekrümmten Bewegungsbahn bewegt und wobei die Stufenkette aufweist:
 - a) eine Mehrzahl in Reihe verbundener Glieder (24a,24,25,26,27) mit überlappenden Enden;
 - b) Mittel zum Verbinden der Fahrtreppe Stufenachsen (14,16) mit davon beabstandeten Gliedern; und
 - c) drehbare Exzenter-Steuerflächeneinrichtungen (35), die benachbarte verstellbare Glieder (25,26), die zwischen den beabstandeten Gliedern liegen, verbinden zum Variieren des Ausmaßes der Überlappung der verstellbaren Glieder, um die Effektivlänge der Kette wahlweise zu vergrößern und zu verkleinern, während die lineare Ausrichtung der verstellbaren Glieder bei der maximalen und bei der minimalen Effektivlänge der Kette beibehalten wird.
10. Die Stufenkette nach Anspruch 9, bei der jede der drehbaren Exzenter-Steuerflächeneinrichtungen aufweist: einen Lagerungsbolzen (1), der in einem Ende eines inneren von jedem der verstellbaren Glieder angebracht ist, wobei die Lagerungsbolzen in den inneren Gliedern um eine erste Drehachse drehbar sind; Drehbetätiger (43), die an einem äußeren jedes der verstellbaren Glieder nahe jedem Ende der Lagerungsbolzen angebracht sind, wobei die Betätiger an den äußeren Gliedern um eine zweite Drehachse drehbar sind, die zu der ersten Drehachse exzentrisch ist; und Steuerflächeneinrichtungen, welche die Lagerungsbolzen (1) und die Drehbetätiger (43) verbinden, wobei die Steuerflächeneinrichtungen im Betrieb die Lagerungsbolzen (1) in Reaktion auf die Drehung der Drehbetätiger (43) um die zweite Drehachse verlagern können, um die inneren und die äußeren Glieder relativ zueinander zu verschieben, wodurch die Effektivlänge der Stufenkette verkürzt oder verlängert wird.
11. Stufenkette nach Anspruch 9 oder 10, bei der die Drehbetätiger eine erste drehbare Zahnradeneinrichtung (9) aufweisen und die Steuerflächeneinrichtungen eine zweite drehbare Zahnradeneinrichtung (7) aufweisen, die mit der ersten drehbaren Zahnradeneinrichtung kämmt.
12. Stufenkette nach Anspruch 11, bei der die erste drehbare Zahnradeneinrichtung ein Zahnkranz (9) ist und die zweite drehbare Zahnradeneinrichtung ein Ritzel (7) aufweist, das für eine umlaufende Bewegung in dem Zahnkranz (9) angebracht ist.
13. Stufenkette nach Anspruch 12, bei der die zweite drehbare Zahnradeneinrichtung außerdem ein leerlaufendes Ritzel (15) aufweist, das in dem Zahnkranz (9) für eine umlaufende Bewegung angebracht ist, welche die umlaufende Bewegung des Ritzels (7) widerspiegelt.

Revendications

1. Un escalier roulant ayant une trajectoire courbe définie par un rayon constant (R_{s1} , R_{s2}) issu d'un centre fixe (C), dans une vue en plan, l'escalier roulant comprenant des zones de paliers horizontales d'entrée et de sortie, une zone intermédiaire à pente constante et des zones de transition d'entrée et de sortie à pente continuellement variable, qui relient respectivement la zone à pente constante aux zones de paliers d'entrée et de sortie, ledit escalier roulant comprenant :
 - a) des rails intérieur et extérieur (22, 38) qui s'étendent entre lesdites zones de palier et sur la longueur des zones de transition et à pente constante, pour supporter le mouvement de marches (10, 12) le long de la trajectoire de l'escalier roulant ; et
 - b) une série de marches (10, 12) dont chacune comprend : un giron supérieur qui reste sensiblement horizontal dans toute la partie de transport des passagers de la trajectoire de l'escalier roulant ; un axe



- de marche (14, 16) sur chacun des côtés intérieur et extérieur de chaque marche ; des galets (18, 20, 36) intérieurs et extérieurs d'axes de marches montés rotatifs sur lesdits axes de marches, lesdits galets d'axe de marches pouvant circuler sur lesdits rails intérieur et extérieur,
- 5 caractérisé par des chaînes de marches intérieure et extérieure (24a, 25, 25, 26, 27, 32) et formant une liaison continue entre lesdits axes de marches (14, 16), de sorte que toutes les marches sont reliées les unes aux autres par les chaînes de marches sur toute la trajectoire de l'escalier roulant ;
- des moyens formant cames excentriques (35) qui relient des paires de maillons réglables (25, 26) dans au moins une desdites chaînes de marches intérieure et extérieure et des moyens rotatifs qui exercent un effet de came sur la paire de maillons réglables (25, 26) pour faire varier l'amplitude du recouvrement desdits maillons réglables lorsque les marches parcourent chacune desdites zones de transition, de manière à rapprocher et éloigner les extrémités extérieures des axes de marches (14, 16) des marches (10, 12) adjacentes les unes des autres dans lesdites zones de transition, de sorte que les marches sont continuellement guidées le long de ladite trajectoire courbe, et ledit escalier roulant ayant des roues dentées de renvoi (53) à chacune desdites zones de paliers pour renverser le sens du mouvement des composants mobiles de l'escalier roulant.
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2. Escalier roulant selon la revendication 1, dans lequel les moyens à cames excentriques comprennent des premiers moyens rotatifs (43) montés sur un maillon de chaque paire desdits maillons réglables et des deuxièmes moyens rotatifs (1) montés sur l'autre maillon de chaque paire desdits maillons réglables, lesdits premiers et deuxièmes moyens pouvant tourner autour d'axes excentriques respectifs, et des moyens (7, 9, 15) interconnectant lesdits premiers et deuxièmes moyens, de telle manière que la rotation desdits premier moyens rotatifs induisent une rotation concourante desdits deuxièmes moyens rotatifs, qui rapproche ou éloigne lesdits maillons réglables l'un de l'autre.
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3. Escalier roulant selon la revendication 2, comprenant en outre des moyens du type levier (43) reliés auxdits premiers moyens rotatifs et qui, lorsqu'on les fait pivoter, font tourner lesdits premiers moyens rotatifs.
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4. Escalier roulant selon la revendication 3, comprenant en outre des moyens formant galets (42) prévus sur lesdits moyens formant leviers (43) et des rails de cames (50, 51) servant à commander la trajectoire desdits moyens formant galets (42) de telle manière que lesdits moyens formant leviers soient mis en mouvement par effet de came, de sorte que les déviations desdits moyens formant galets (43) provoquées par lesdits rails de cames font pivoter lesdits moyens formant leviers.
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5. Escalier roulant selon l'une quelconque des revendications 2 à 4, dans lequel lesdits moyens d'interconnexion comprennent un jeu de roues dentées (7, 9) en prise entre elles, l'une étant montée sur lesdits premiers moyens rotatifs (43) et une autre étant montée sur lesdits deuxièmes moyens rotatifs (1).
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6. Escalier roulant selon la revendication 5, dans lequel une desdites roues dentées en prise est une couronne dentée (9) et l'autre roue dentée est un pignon (7) qui orbite autour du centre de ladite couronne (9) lorsque cette dernière est mise en rotation.
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7. Escalier roulant selon la revendication 6, comprenant en outre un pignon fou (15) monté dans ladite couronne (9) pour y décrire un mouvement orbital qui est symétrique du mouvement orbital dudit pignon (7).
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8. Escalier roulant selon l'une quelconque des revendications précédentes, dans lequel lesdits moyens formant cames excentriques (35) ont pour effet de maintenir l'alignement linéaire desdits maillons réglables (25, 26) aux longueurs effectives maximale et minimale de la chaîne.
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9. Chaîne de marches pour un escalier roulant selon l'une quelconque des revendications précédentes, lequel escalier roulant circule selon une trajectoire courbe, dans une vue en plan, ladite chaîne de marches comprenant :
- a) une série de maillons (24a, 24, 25, 26, 27) reliés en série et ayant des extrémités à recouvrement ;
- b) des moyens servant à relier les axes de marches (14, 16) de l'escalier roulant des maillons espacés appartenant auxdits maillons ; et
- 55 c) des moyens à effet de came excentriques rotatifs (35) qui relient les maillons réglables adjacents (25, 26) situés entre ceux desdits maillons qui sont espacés pour faire varier l'amplitude du recouvrement desdits maillons réglables, afin d'augmenter ou de diminuer sélectivement la longueur effective de ladite chaîne tout en maintenant l'alignement linéaire desdits maillons réglables aux longueurs effectives maximale et minimale de la chaîne.



- 5 10. Chaîne de marches selon la revendication 9, dans laquelle chacun desdits moyens à effet de came excentriques rotatifs comprend : une broche de portée (1) de montée dans une extrémité d'un maillon intérieur desdits maillons réglables, lesdites broches de portée pouvant tourner dans lesdits maillons intérieurs autour d'un premier axe de rotation ; des actionneurs rotatifs (43) montés sur un maillon extérieur de chacun desdits maillons réglables, à proximité de chaque extrémité desdites broches de portée (1), lesdits actionneurs pouvant tourner sur lesdits maillons extérieurs autour d'un deuxième axe de rotation qui est excentré par rapport auxdits premiers axes de rotation ; et des moyens à effet de came qui relient lesdites broches de portée (1) et lesdits actionneurs rotatifs (43), lesdits moyens à effet de came pouvant entraîner lesdites broches de portée (1) par effet de came autour dudit deuxième axe de rotation en réponse à la rotation desdits actionneurs rotatifs (43) pour déplacer lesdits maillons intérieurs et extérieurs l'un par rapport à l'autre, de telle manière que la longueur effective de la chaîne de marches soit raccourcie ou allongée.
- 15 11. Chaîne de marches selon la revendication 9 ou 10 dans laquelle lesdits actionneurs rotatifs comprennent des premiers moyens d'engrenage rotatifs (9) et lesdits moyens à effet de came comprennent des deuxièmes moyens d'engrenage rotatifs (7) qui engrènent avec lesdits premiers moyens d'engrenage rotatifs.
- 20 12. Chaîne de marches selon la revendication 11, dans laquelle lesdits premiers moyens d'engrenage rotatifs sont constitués par une couronne dentée (9) et lesdits deuxièmes moyens d'engrenage rotatifs comprennent un pignon (7) monté pour décrire un mouvement orbital à l'intérieur de ladite couronne (9).
- 25 13. Chaîne de marches selon la revendication 12, dans laquelle lesdits deuxièmes moyens d'engrenage rotatifs comprennent en outre un pignon fou (15) monté dans ladite couronne (9) pour décrire dans celle-ci un mouvement orbital qui est symétrique du mouvement orbital dudit pignon (7).
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