

An Actuator

This invention relates to an actuator.

5 According to the present invention there is provided an actuator comprising a series of elements each rotatable relative to the next, a housing accommodating at least part of the series of elements with one end of the series projecting freely beyond an exit of the housing, the
10 elements being guided to follow a non-linear path to the exit, means for driving the series of elements relative to the housing to vary the total length of elements projecting beyond the exit, and means for maintaining the projecting elements in linear alignment in a
15 substantially rigid, self-supporting column.

One application of the invention is in the construction of adjustable-height beds. If four such actuators were located at or near the four corners of the bed, with the
20 linearly aligned columns of projecting elements arranged vertically and serving as the legs of the bed, then by driving the four sets of elements in synchronism the bed may be raised or lowered as desired. Alternatively, by driving the actuators only at the head or foot of the bed
25 the latter may be tilted as desired. Also, the ability of the elements to follow a non-linear path means that those elements not forming part of a leg of the bed at any given time can be accommodated horizontally along the frame of the bed or in any other orientation depending on
30 the space available. However, the invention is not limited to that application.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

5 Fig. 1 is a side view of a second embodiment of the invention with certain components removed to reveal the underlying structure;

Fig. 2(a) is a diagram showing the principle of operation
10 of the drive mechanism of the second embodiment;

Fig. 2(b) is a perspective view of part of the drive mechanism;

15 Fig. 3 is an external perspective view of the drive housing of Fig. 1;

Fig. 4 is a perspective view of the inside of one half of the drive housing, the other half being a mirror image of
20 that shown;

Fig. 5 is a perspective view of one of the linked elements of the embodiment of Fig. 1;

25 Fig. 6 is a perspective view of the rotatable input guide of the embodiment of Fig. 1; and

Figs. 7(a) to 7(c) show the actuator of Fig. 1 with the input guide set at various angles.

30

Fig. 8 is a side view of a third embodiment of the invention with certain components removed to reveal the underlying structure;

In the following description the use of expressions of orientation such as top, bottom, vertical, etc., refer to the orientation of the embodiments as seen in drawings and do not constrain their orientation in use.

5

A first embodiment of the invention is shown in Figs. 1 to 7. This embodiment comprises a drive housing 400 (Figs. 1, 3 and 4) which comprises two opposite halves 400A, 400B of which the inside structure of the housing half 400A is shown in Fig. 4. The housing half 400B is a mirror image of the housing half 400A, and the two halves are secured together along their edges 400C (Fig. 4) to form the complete housing seen in Fig. 3. The drive housing 400 has an entrance 402 on one side and an exit 404 at the bottom. The drive housing 400 may be moulded from aluminium or plastics material, or cast in steel, according to its dimensions and the intended loading.

A hollow, tunnel-like input guide 406 (Figs. 1 and 6) is mounted at the drive housing entrance 402. In particular, the guide 406 has a transverse cylindrical bore 408 which is engaged by a hollow cylindrical shaft 410 extending between the opposite major walls of the drive housing 400 to allow rotation of the entire guide 406 about the axis of the shaft 410 (Fig. 7). The housing 400 contains a drive means 412 to be described later.

A series of similar rigid hollow elements 414, moulded from plastics material, are connected to one another along one edge 416 of the series of elements for rotation about substantially parallel axes 418. To this end the front of each element 414 has a short pair of arms 420 which embrace a flange 422, Fig. 2(b), on the rear of the

21 AUG 2006

preceding element, the arms and flange having aligned holes 424 through which passes a steel pivot pin (not shown). These pivot pins allow each element 414 to rotate relative to the next element such that the elements may
5 assume a linearly aligned configuration wherein each element is in registering engagement with the next across its full width, as seen for the elements at the top right and bottom of Fig. 1, or may separate from its neighbours at its outer edges to allow the elements to change
10 direction through the housing 400 as will be described. It will be understood that certain components are omitted from Fig. 1, for example the housing half 400B and some of the elements 414, in order to show the structure more clearly.

15 The pivotally connected series of elements 414 are accommodated in the drive housing 400 such that one end of the series is located within the input guide 406 and the other end of the series is outside the housing 400,
20 projecting beyond the exit 404. Between these two ends the series of elements 414 curves through a variable angle dependent on the angular position of the input guide 406.

25 In order to maintain the elements 414 which project beyond the exit 404 linearly aligned in a substantially rigid self-supporting column 440, a flexible, substantially inelastic toothed belt 426 is provided. This may be made of the same material as is used for
30 timing belts in motor vehicles. The belt 426 is fixed by staking or welding to the end element 414A and its teeth 428 engage corresponding teeth 430-Figs. 2(b) and 5 - recessed into the edges of the elements 414 along the opposite edges of the elements to the pivots 418. The

belt 426 into proper engagement with the elements 414.

The engagement of the belt teeth 428 with the element teeth 430 all along the length of the projecting column of elements prevents these from pivoting relative to one

5 another and maintains them tight up against one another.

Each element 414 has a helically-threaded bore 436 whose axis, when the element is in linear alignment with other such elements in the projecting column 440, is coaxial with the other such bores in the column 440 to form a

10 continuous helical thread along the centre of the column.

The drive means 412 comprises a worm gear 438 disposed at the free end of a drive shaft 442 whose rotational axis is coaxial with that of the bores in the column 440. The

worm gear 438 meshes with at least one element 414 in the

15 column 440 at any one time such that rotation of the worm

gear progressively drives the elements out of the housing

400, or draws them into the housing 400, thereby

increasing or decreasing the length of the column 440,

according to the direction of rotation of the worm gear.

20

The belt 426, which passes out of the drive housing 400 through a hole 448 (Fig. 4), is accommodated on a take-up spool 444 which is biased by a coil spring (not shown)

for rotation in a direction which maintains the belt 426

25 under slight tension and tends to wind the belt on the

spool, as indicated by the arrow in Fig. 1. As the

projecting column 440 increases in length the belt 426 is

pressed by the roller assembly 432 progressively into

engagement with consecutive elements 414 as they emerge

30 from the housing exit 404, against the bias of the coil

spring. When the column 440 is decreasing in length the

belt 426 progressively disengages the elements 414 and is

wound onto the spool 444 by the coil spring. A fin-like

element 446 in the housing 400 ensures that the belt 426 separates cleanly from the elements 414.

Within the housing 400 the elements 414 follow a non-
5 linear path between the entrance 402 to the exit 404.
This path is defined by a first, straight guide rail 450
near the exit 404 which is contiguous with a second,
part-circular guide rail 452 whose centre of curvature is
10 coaxial with the shaft 410 (it will be understood that
due to the mirror image construction of the housing
halves 400A and 400B the guide rails 450,452 shown in
Fig. 4 are duplicated on the inside surface of the
opposite housing half so as to form a pair of guide rails
in each case). Each element has a groove 454 along each
15 opposite side and these are engaged in the housing 400 by
the guide rails 450 and 452 to direct the element along
the desired path between the entrance 402 and exit 404.
The pair of straight guide rails 450 resists the turning
torque produced on the element 414 by the worm gear 438
20 so as to keep each element 414 straight as the belt 426
engages or disengages.

To allow each element 414 to join or leave the column 440
by rotation relative to the next element as it follows
25 the pair of curved guide rails 452, each element 414 has
a side opening 456 for passage of the drive shaft 442,
see especially Fig. 2 (b). The width of the opening 456
is preferably such as to leave at least 80% of the
circumference of the threaded bore 436.

30

The input guide 406 also has a pair of guide rails 458
extending continuously through the length of the guide.
In the main body of the guide 406 the guide rails are
straight, as indicated by the dashed line in Fig. 6, but

the portions 458A at the front of the guide are part-circular and concentric with the axis of the shaft 410. The radius of the portions 458A is slightly less than that of the guides 452 so that the latter ride over the
5 former as seen in Fig. 1, the degree of overlap depending on the angle of the input guide 406 relative to the drive housing 400. Thus the pairs of guides 450, 452 and 458 form a continuous guide for the elements 414 from the drive housing exit 404 to the rear end of the input guide
10 406.

In Fig. 1 the shaft 442 is shown being driven by an electric motor 460 via a gearbox 462, but any other suitable arrangement may be used. For example, the shaft
15 442 may be driven by a belt.

As mentioned previously, the input guide 406 is rotatable relative to the drive housing 400 to permit the angle of the input guide to be varied relative to the column 440.
20 In this embodiment the angle can be varied between about 60 and 180 degrees, as seen in Fig. 7. Fig. 7 also shows a variation of the embodiment shown in Fig. 1 where the toothed belt 426 is not attached to a take-up spool but is instead fed round loosely in the drive housing 400 to
25 re-engage the elements 414 where they emerge from the input guide 406 into the housing. From that point the belt extends along and in engagement with all the elements 414 in the guide 406 and beyond the free end of the guide 406 to the end element 414B, Fig. 7 (a), to
30 which the belt is fixed. This ensures that the elements are maintained in linear alignment prior to entering the guide 406.

A third embodiment of the invention is shown in Fig. 8.

This embodiment comprises a sprocket wheel 470 with rounded teeth 471 positioned in the housing 400, coaxial with the shaft 410 (not shown). The teeth 471 of the sprocket wheel engage with curved edge sections 472 of the elements 414. The sprocket wheel 470 is thus indirectly driven by the worm gear 438 via the elements 414. The sprocket wheel acts to help reduce the friction between the elements 414 and the guide rails in the housing and the input guide (not shown), by imparting a guiding force to the elements as they are rotated through the angle between the entrance 402 and the exit 404. The guide rails ensure that contact is maintained between the sprocket wheel and the elements, while the elements are being rotated. With the sprocket wheel, any back pressure on the elements due to friction between the elements and the guide rails is alleviated, and the elements move more freely.

In one embodiment, the elements 414 could follow a helical path within the drive housing 400, up to the point where they emerge from the exit 404.

In a further variation of the embodiment shown in Fig. 1 the belt 426 can be omitted entirely. In that case the elements 414 can be manually secured to one another as they emerge from the housing exit 404. For example, the elements could have cooperating formations, similar to the arms 420 and flanges 422 shown in Fig. 2(b). Then, as each element 414 emerges from the housing exit 404 and lines up with the preceding element the flange on one element would come to lie between the arms of the other element and a pin could be manually inserted into the aligned holes in these components thus locking them together face-to-face. Similarly, upon withdrawal of the

elements into the housing, the pins could be removed one by one. It is also possible to devise a mechanism whereby the pins are inserted and removed automatically.

5 In use of the actuator the drive housing 400 is fixed to the frame of a bed or other apparatus for which lifting and/or other mechanical action is required. The drive housing 400 can be bolted rigidly and non-rotatably to the frame by bolts passing through holes 464.

10 Alternatively, the drive housing 400 can be rotatably fixed to the frame by a single bolt passing through the hollow shaft 410. This latter fixing arrangement would be desirable, for example, where the column 440 constitutes the leg of a bed and the drive housing is fixed to the side frame of the bed. In such a case, if
15 the head of the bed is lifted or lowered relative to the foot and the side frame becomes sloped, the rotation of the drive housing 400 allows the leg to remain vertical. Although the term "actuator" has been used in the description to describe the device of the invention, it
20 is to be understood that the term "articulator" could also be applied to the device.

The invention is not limited to the embodiments described herein which may be modified or varied without departing
25 from the scope of the invention.

Claims

1. An actuator comprising a series of elements each rotatable relative to the next, a housing accommodating at least part of the series of elements with one end of the series projecting freely beyond an exit of the housing, the elements being guided to follow a non-linear path to the exit, drive means for driving the series of elements relative to the housing to vary the total length of elements projecting beyond the exit, and means for maintaining the projecting elements in linear alignment in a substantially rigid, column, characterised in that the elements are hollow and the drive means includes at least one gear wheel located inside the elements as they pass through the housing and which drivingly engages an inside surface of the elements, the elements having an opening on one side which allows passage of a support means for the gear wheel.
2. An actuator as claimed in claim 1, wherein the maintaining means comprises a flexible, substantially inelastic toothed belt which is brought progressively into positive engagement with the elements as they rotate into alignment with the column.
3. An actuator as claimed in claim 2, wherein the elements are pivotally coupled each to the next along one edge of the series of elements and the belt is brought into engagement with the elements along the opposite edge.
4. An actuator as claimed in claim 1, wherein each element has a helically-threaded bore whose axis, when the element is in the linearly aligned column, is coaxial

with other such bores in the column to form a continuous helical thread along the column, and wherein the gear wheel comprises a worm gear disposed at the free end of a drive shaft whose rotational axis is coaxial with that of the bores in the column, the worm gear increases or decreases the length of the column according to the direction of rotation of the worm gear, each element having a side opening for passage of the drive shaft to allow each element to join or leave the column.

10

6. An actuator as claimed in any preceding claim, wherein the series of elements enters the housing through an input guide which is rotatable relative to the housing over a range of angles relative to the linearly aligned column.

15

7. An actuator as claimed in claim 6 when directly or indirectly dependent on claim 2, wherein the elements are engaged by the belt in the input guide whereby the elements are maintained in linear alignment prior to entering the guide.

20

8. An actuator as claimed in any preceding claim, wherein the actuator further comprises a sprocket wheel which engages with and guides the elements.

25

9. A device for moving a load comprising a base portion and a load bearing portion and means for moving the load bearing portion, the means for moving the load bearing portion comprising an actuator according to any preceding claim.

30