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(54) Running gear assembly with minimum play for a rail vehicle with radial adjustment of wheel pairs or wheel sets

(57) The invention relates to a running gear assembly (1) for a rail vehicle comprising a plurality of two-wheeled running gears (2,3), at least one of which is radially steerable using steering levers (6) mutually connecting the running gears (2,3), wherein at least the one steerable running gear (2,3) comprises a ring assembly system formed by at least a first and a second ring, the first of which is connected to a sub-frame forming part of the relevant running gear (2,3) and at least the second ring is connected to one of the steering levers connecting the running gear (2,3) to other running gears (2,3) and that the running gear (2,3) comprises coupling means for mutually coupling the rings and steering

levers such that the wheels forming part of the running gear (2,3) are directed substantially radially.

There is a completely free choice of coupling of the four elements, first, second lever, sub-frame and wheel pair/wheel set, to the three concentric moving rings or groups of rings, the sole proviso being that the forced radial adjustment of the wheel pair/wheel set is achieved.

As a result of these steps the use of hinges is eliminated as far as possible so that the danger of play occurring is as small as possible.

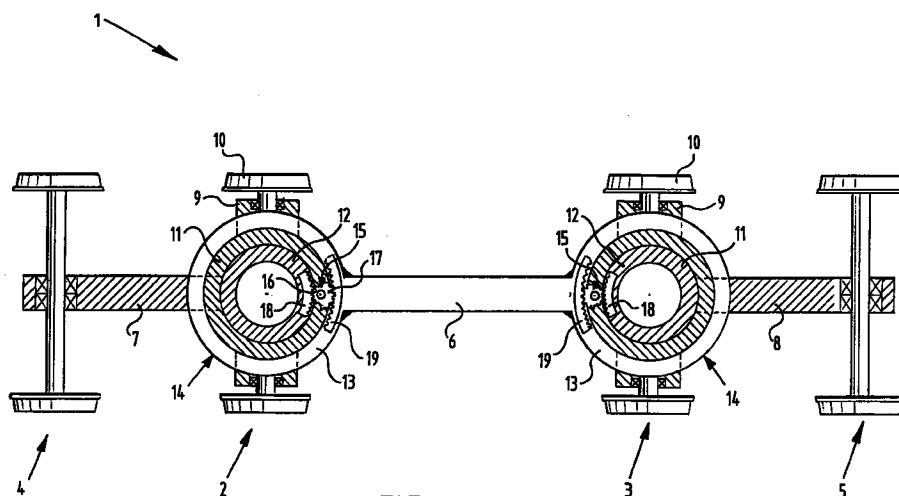


FIG. 1

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Description

The invention relates to a running gear assembly for a rail vehicle comprising a plurality of two-wheeled running gears, at least one of which is radially steerable using steering levers mutually connecting the running gears.

Such a running gear assembly is known from the Netherlands patent application number 8401549.

In this known running gear assembly use is made of a system of rods for radial adjustment of the running gears. As a result thereof a large number of hinges is present so that such a system is sensitive to play and elastic deformation and once a play has occurred it may be enlarged with use, which results in deterioration of the travel characteristics and therewith the comfort of the passengers in the rail vehicle.

The object of the present invention is to provide a rail vehicle wherein the plays are minimized and wherein they are not enlarged during use.

This object is achieved in that at least the steerable running gear comprises a ring assembly system formed by at least a first and a second ring assembly, the first of which is connected to a sub-frame forming part of the relevant running gear and the second is connected to both steering levers connecting the running gear to other running gears, and comprises coupling means for mutually coupling the ring assemblies and levers such that the wheels forming part of the running gear are adjusted substantially radially.

There is a completely free choice of coupling of the four elements, first, second steering lever, sub-frame and wheel pair/wheel set, to the three concentric moving rings or groups of rings, the sole proviso being that the forced radial adjustment of the wheel pair/wheel set is achieved.

As a result of these steps the use of hinges is eliminated as far as possible so that the danger of play occurring is as small as possible.

Ring assembly systems seem generally to have minimum play and this favourable characteristic is enhanced when ring assembly systems are used in the form of ball ring assembly systems.

According to another preferred embodiment the ring assembly system comprises two ring assemblies which are located concentrically above each other, and in which at least two of the four rings of said two ring assemblies are mutually connected.

As required by the construction, both inner, both outer or even one inner and one outer ring are mutually connected. Three independent rings or pairs of rings then remain, which are coupled with the four elements: the first, the second steering lever, subframe and pair of wheels/wheel set by means of a gear connection, rod system or simple leave spring elements (with very small rotation angles).

According to again another preferred embodiment the ring assembly system comprises a first, a second and a third ring. The first ring is connected to the sub-

frame and the second and third ring are connected to both levers connecting the running gear to the other running gears and the coupling means comprise a pinion which is arranged on one of the rings and which is in engagement with connections fixed to both other rings.

These steps likewise minimize play.

Providing the pinion with two sectors each having a different radius, wherein the ratio of the radii corresponds to the ratio of the length of the relevant steering levers coupled to the other ring assemblies, causes the relevant running gear to obtain the correct angular setting, also in the case of unequal distances between the running gears.

In another embodiment there is coupling of two pinions with segments having different radii which are placed one above the other. When angular displacements are very small it is also possible to operate with a coupling by means of rod-like elements; no toothing occurs herein, although this embodiment does however give a small kinematic error.

Such a running gear assembly is not only suitable as running gear assembly for trains but also for subways, express trams and trams. Particularly in these latter categories of vehicle there is a trend in recent years toward so-called depressed-floor vehicles, wherein the floor of these vehicles lies as low as possible in order to facilitate entry and exit.

It was initially attempted here to arrange only the floor parts between the running gears as low as possible, although a trend has emerged recently of also making use of a depressed floor at the position of the running gears and raising the floor only at the position of the wheels and the construction associated therewith, thus resulting in wheel casings there on which seats can be arranged.

The present invention also takes account of this latter possibility in that according to a preferred embodiment the wheels of the running gear are fixed to separate shafts and the ring assemblies are fixed between the wheels.

This preferred embodiment makes it possible for the depressed floor to extend continuously between the wheels.

The advantages of the steps of other sub-claims will become apparent from the following description.

The present invention will subsequently be elucidated with reference to the annexed figures, in which:

fig. 1 shows a schematic top view of an embodiment of a running gear assembly according to the invention provided with three-part ring assemblies; fig. 2 shows a schematic top view of a detail of an embodiment of a running gear according to the invention provided with a two-part ring assembly, wherein the wheels of the running gear are separately rotatable on a vertical shaft; fig. 3 shows a schematic top view of another embodiment of a running gear assembly according to the present invention;

fig. 4 shows a perspective schematic view of a part of the running gear assembly shown in fig. 1;

fig. 5 shows a perspective schematic view of a transition between a first driven running gear and the steering lever connecting thereto; and

fig. 6 is a perspective view of a variant of the embodiment shown in fig. 4.

Formed in fig. 1 is a running gear assembly 1 comprising two running gears 2,3 as well as two running wheel assemblies 4,5. The running gear 2 is connected to the running gear 3 by means of a steering lever 6, while running gear 2 is connected to running wheel assembly 4 by means of a steering lever 7 and the running gear 3 is connected to running wheel assembly 5 by means of a steering lever 8.

The running gear 2 is formed by a sub-frame 9, inside which is mounted a wheel set 10. Running gear 2 can be embodied with individual wheels as well as with wheels mounted on a fixed shaft (a so-called wheel set), with separate wheels mounted on a stationary, continuous shaft, with separate wheels connected via an assembly of cardan shafts, with or without couple-influencing or amortizing elements.

The sub-frame 9 is fixedly connected to the middle ring 11 of a ring assembly 14 present on the sub-frame and further comprising an inner ring 12 and an outer ring 13. The outer ring 13 is connected to the lever 6, while the inner ring 12 is connected to lever 7.

A pinion 15 is arranged rotatably on the middle ring 11. Pinion 15 comprises a first sector 16 with a small radius and a second sector 17 with a large radius. Arranged on the internal ring 12 is a first gear rack 18 which is in engagement with the teeth of the first sector 16 of pinion 15, while on the external ring 13 is arranged a second gear rack 19, the teeth of which are in engagement with the teeth of the second sector 17 of pinion 15.

By arranging the pinion 15, the teeth of which are in engagement with the first gear rack and with the second gear rack, the middle ring 11, the internal ring 12 and the external ring 13 are mutually coupled for rotation in the horizontal plane. This coupling is such that when the vehicle which rests on the associated running gear assembly 1 travels into a bend, the running wheel assembly 4 will initially be laterally displaced, which causes the internal ring 12 to rotate whereby the middle ring 11 will likewise rotate, albeit over a smaller angle, as will the sub-frame 9 and the wheel set 10 mounted therein, so that it will assume the correct radial angular position.

The same components are also to be found in the second running gear 3.

It will be apparent that fig. 1 is only shown in order to explain the operation of the construction in the horizontal plane.

It is also conceivable to couple one or more running gears of the basic type 2 or 3 of fig. 1 over the levers 7 and 8 with bogies instead of with single shafts; in this

case there is an extra rotation point with a vertical axis between the bogie and one of the levers 7 or 8.

In fig. 2 is shown another embodiment of a running gear according to the invention wherein use is made of a two-part ring assembly with two auxiliary steering levers and wherein the wheels are rotatable on a vertical axis.

The running gear 20 depicted in fig. 2 comprises a sub-frame 21 in which are mounted two bearings 24 rotatable on a vertical axis. Two wheels 22 are fixed to shafts 23 which are mounted at one of their ends in bearings 24 rotatable on a vertical axis. At their other end the shafts are mounted in floating bearings 25 which are connected by means of steering levers 25' to a ring assembly 26.

The ring 26 forms together with ring 27 a ring assembly, wherein the outer ring 27 is fixed to the sub-frame 21. The outer ring 27 is also connected rotatably in the horizontal plane to two steering levers 28,29 extending to adjoining running gears, wherein lever 28 is extended into the region of the internal ring 26. The lever 28 is further connected for rotation at its end to the internal ring 26 by means of an auxiliary lever 30, while lever 29 is connected to the internal ring 26 by means of an auxiliary lever 30'.

The auxiliary steering levers 30,30' ensure that when the lever 28 turns in the horizontal plane the external ring 27 moves therewith, whereby the shafts 23 and therewith wheels 22 will assume the correct angular position, as in the first embodiment.

Although the combination is shown of a ring assembly system provided with two rings and a sub-frame, wherein the wheels are each rotatable separately relative to the sub-frame, the two construction variants do not necessarily have to be applied in combination. It is for instance possible to combine a sub-frame having wheels not mounted on a vertical axis with a ring assembly provided with more than two rings, as well as a combination of a sub-frame having wheels mounted on a vertical axis with a ring assembly system provided with three ring assemblies.

It will likewise be apparent that other mechanisms can be used for radial adjustment of the separately adjustable shafts.

Fig. 3 shows a running gear assembly provided with three running gears. The construction and configuration of this running gear assembly correspond largely with the construction of the running gear assembly shown in fig. 1, with the difference that the running wheel assemblies are omitted. In this running gear assembly a second coupling is provided between the individual running gears above the coupling by levers already shown in fig. 1. One embodiment has rigid triangular constructions 31,32 which start from the sub-frames and which meet each other in the middle between two adjoining running gears in a kind of ball joint 33. During turning the length of the coupled "triangles" becomes greater; this is taken up in that the ball joint 33 can slide on one side in lengthwise direction as

a result of a system of biased springs between the ball joints and the levers.

The running gear 2 is shown in more detail in fig. 4. As already stated with reference to fig. 1, the running gear comprises a sub-frame 9 which is formed by a base plate 34 on which the ring assembly 14 is fixed. Arranged in the interior of the ring assembly is a schematically shown air spring 35 which can be used to support the bodywork to be arranged on the running gear assembly. On the base plate is arranged an extension 36 on which is mounted a traction motor 37. A traction motor 37 is also mounted on the other side of base plate 34. It is also possible however to arrange elsewhere on the sub-frame one or more air springs or other springs fulfilling the secondary spring function.

On the outside of traction motor 37 is fixed a gearbox 38 which can rotate with the traction motor 37 on an axis parallel to the axis of rotation of the motor shaft. The gearbox 38 has a dual function: it functions not only as gearbox but also as support and bearing mounting for the wheel shaft 40 to which the wheel 41 is attached. It is important herein that gearbox 38 is rotatable relative to shaft 39.

Opposite both extensions 36 a bracket 42 is fixed to the base plate 34 which extends to a position above the end of gearbox 38. Received between the relevant end and bracket 42 is a spring element 43 which can take the form of a helical spring or a rubber spring and which fulfills the primary spring function.

In the present embodiment each shaft is driven separately by a traction motor. In this configuration both wheels of the running gear are not mutually coupled. This is possible however in this configuration; it is also possible to mutually couple both traction motors with one shaft so that both wheels 41 are mutually coupled for rotation. When running shafts are not used such a coupling of both wheels is necessary to obtain good running and travel characteristics.

The lever 7 shown in fig. 1 takes the form in the present embodiment of a box 44 which is fixedly mounted to the inner ring 12. The box 44 is connected to a tube 49 in the form of a torsion bar which is connected to a steel girder 50.

The steel girder 50 is connected at its forward side to a bearing 51 inside which is mounted a shaft 52 of the running wheel assembly 4. The bearing permits a rotation such that in the present embodiment it is possible to radially adjust the shaft 52. Present for this purpose is an adjusting mechanism formed by auxiliary bearings 54 which are arranged on shaft 52 and which are connected via a triangle 55 to a stabilisation unit 56 which can move in transverse direction over the girder 50. Stabilisation unit 56 is controlled from the running gear 2 by means of the triangle 57 connected to the base plate 34 of running gear 2. This results in a kinematic coupling. Such a stabilisation unit 56 forms part of the prior art and consists of a ball joint mounted under bias. In a possible embodiment the construction can be embodied such that a threshold force is required to obtain a rota-

tion in the xy-plane between running wheel assembly and first wheel pair.

At the position of bearing 51 a spring, for instance an air spring, can be arranged to support the bodywork at that position.

In one embodiment the levers are suspended from the bodywork by means of suspension elements 58 which permit a horizontal movement. An alternative provides an embodiment wherein the bodywork is suspended from a steering lever which in that case takes a rigid form in the vertical plane. To the running gear part drawn in fig. 4 the lever 60 is now connected by a flat, hinged girder which is joined on the one side to the lever and on the other side to one of the rings. The hinges used are clamped leaf spring elements which allow only a movement in the zx-plane. This flat girder is necessary as connecting part to enable a vertical springing of the running gear sub-frame. A tube 49 is also arranged as connecting part which fulfills a roll stability function in respect of the rolling movement of the bodywork on an x-axis. If there is a middle running gear it is necessary to stabilize this running gear between two adjacent levers in the xz-plane. For this purpose two flat hinged girders are present as connecting pieces to the levers. Through a height displacement both pieces form together with the sub-frame a lemniscate which is as it were clamped between both adjacent levers.

It will be apparent that the torsion tube 49 can be used to resiliently absorb the rolling of the vehicle. The rod can then easily be extended by causing it to extend in the interior of the girders 50,60.

It will be clear that the carriage will be in the direction of movement by the steering lever 30. The connection between these elements is such that the carriage can, however, move in the vertical direction.

In the embodiment shown in fig. 4 the running shaft is adjusted radially; this is not necessary when the distance between the running shaft and the first running gear is small.

Fig. 5 shows a following construction of a running gear 2. This construction corresponds largely with the construction of the running gear shown in fig. 4 but differs therefrom in a number of points.

Both traction motors 37 in fig. 4 are substituted by a single traction motor 61 which in the present case is suspended from the lever. Rotation of this motor is carried over to a transmission box 63 by means of a cardan shaft 62. This box is connected by means of a shaft 64 to gearbox 38 on the one side and connected by means of a short shaft (not shown) to gearbox 38 on the other side. It is possible, though not essential, to make use for this transmission box 63 of an hydraulic transmission box which ensures that, while both output shafts substantially take over the movement of the driving shaft 62, vibrations between both output shafts are not transmitted mutually or to the driving shaft.

A connecting lever 66 is arranged on the girder 50 to transmit longitudinal forces between the supported bodywork and the relevant lever.

It will otherwise be apparent that the traction motor 61 does not have to be fixed to the lever; it is possible to fix this motor in longitudinal direction to the bodywork.

The running gear depicted in fig. 5 shows a running gear to be arranged in the middle of a running gear assembly; there are levers which extend to both sides and which are not connected to a running wheel assembly.

The above described construction is an integral unit kinematically connected by mechanical elements. In particular embodiments it may be found that either due to lack of construction space or great spanning lengths the rigidity of the elements for coupling, with an eye to correct steering, is not adequately ensured. It is then possible using hydraulic or electrical "detectors" and "receivers" to strengthen the kinematic signal without altering the essence of the operation.

In the constructions described in the patent application the running gears are connected in kinematically correct manner. In particular cases it can nevertheless be recommended to connect the assembly of motor and transmission on one side to the assembly of motor and transmission on the other side and to connect this whole in strictly lateral sense over a determined elastic element to the sub-frame of the running gear. In such an embodiment the rotations on z-axes of the running gears are strictly kinematic and mutually coupled with minimal plays. Each wheel set or wheel pair can make a determined movement strictly laterally (y-direction) and controlled by forces in relation to the kinematic assembly.

Finally, fig. 6 shows an embodiment which substantially corresponds with the embodiment shown in fig. 4, but wherein the construction of the ring assembly is different.

In the embodiment depicted in fig. 4 the ring assembly is formed by three ring assemblies 13, 11, 12 lying in one plane. As is generally known in the relevant art, these are mutually connected by a ball circulation.

In the embodiment depicted in figure 6 there is question of two concentric ring assemblies located above each other and each comprising two rings. In the shown embodiment both inner rings are mutually connected and form a unit with a base plate 71, on which for instance a carrying spring can be located. In the embodiment shown both mutually connected inner rings and the base plate form one unit with the steering lever 48. The upper outer ring 74 is connected with the steering lever 50 and the lower outer ring with the sub-assembly of sub-frame, pairs of wheels/wheel set. The mutually coupled pinions 79 and 81 which are journaled in the base plate 71 engage respective racks of the outer rings. This leads to a relative mutually independent rotation of the sub-assemblies: inner rings and base plate, upper outer ring, lower outer ring.

The thus described construction has a much greater rigidity than the construction shown in fig. 4. This rigidity is brought about particularly by plate 71

which extends over the whole surface of the ring assembly.

In this embodiment the function of the steering lever is executed by the carriage. There is still question of a full correct cinematically coupling between the sets of wheels; the carriage and the wheel sets can execute a lateral movement, that is in the y-direction, controlled by forces; in the case of a rotation around the z-axis, there is question of a coupling between the movement of the carriage and the cinematic unit of the wheel sets. When the whole lateral possibility of movement between carriage and wheel sets is taken over at the location of the primary suspension, the hangers 58 can be eliminated.

It is of course equally possible in this embodiment to implement other forms of kinematic coupling, for instance by means of levers.

It is likewise possible to select a different configuration of the rings, for instance with a fixed outer ring and inner rings movable relative thereto, wherein it is of course also possible to connect each of the three components to be mutually connected by the ring assembly, i.e. the pair of wheels and both levers, to each of the rings. This likewise applies to the "flat" embodiment described for instance with reference to fig. 4, wherein all rings are bounded at top and bottom by the same plane.

Claims

1. Running gear assembly for a rail vehicle comprising a plurality of two-wheeled running gears, at least one of which is radially steerable using steering levers mutually connecting the running gears, **characterized in that** at least the one steerable running gear comprises a ring assembly system formed by at least a first and a second ring, the first of which is connected to a sub-frame forming part of the relevant running gear and at least the second ring is connected to one of the steering levers connecting the running gear to other running gears and that the running gear comprises coupling means for mutually coupling the rings and steering levers such that the wheels forming part of the running gear are directed substantially radially.
2. Running gear assembly as claimed in claim 1, **characterized in that** the ring assemblies are formed by ball ring assemblies each comprising two concentric rings.
3. Running gear assembly as claimed in claim 1 or 2, **characterized in that** the two ring assemblies are located in one plane, that the outer ring of the inner ring assembly is formed integrally with the inner ring of the outer ring assembly.
4. Running gear assembly as claimed in claim 1 or 2, **characterized in that** the ring assembly system comprises two ring assemblies which are located

concentrically above each other, and that at least two of the four rings of said two ring assemblies are mutually connected.

5. Running gear assembly as claimed in claim 4, **characterized in that** the two ring assemblies are placed one above the other, wherein one of the rings of the upper ring assembly is connected to one of the rings of the inner ring assembly. 5
6. Running gear assembly as claimed in claim 5, **characterized in that** the ring assemblies are separated by a plate which also extends between the other rings of the ring assemblies. 10
7. Running gear assembly as claimed in claim 6, **characterized in that** the plate is connected with the mutually connected rings. 15
8. Running gear assembly as claimed in claim 6, **characterized in that** the inner rings of each of the ring assemblies are mutually connected. 20
9. Running gear assembly as claimed in claim 6 or 7, **characterized in that** both inner rings are at least partially provided with a toothing which is in engagement with a pinion mounted on an auxiliary shaft. 25
10. Running gear assembly as claimed in claim 1, 2 or 3, **characterized in that** the ring assembly system comprises a first, a second and a third ring assembly, of which the second and the third are connected to both steering levers connecting the running gear to the other running gears and that the coupling means comprise a pinion fixed on one of the ring assemblies which is in engagement with gear racks fixed to both other rings. 30 35
11. Running gear assembly as claimed in claim 10, **characterized in that** the pinion comprises two sectors each having a different radius, wherein the ratio of the radii corresponds to the ratio of the lengths of the relevant levers coupled to the second and the third ring assembly. 40 45
12. Running gear assembly as claimed in claim 1, 2 or 3, **characterized in that** the ring assembly system comprises two ring assemblies of which the first is coupled to both levers connecting the running gear to the other running gears, that the coupling means comprise an auxiliary set of levers connecting both levers and the second ring assembly and that one of both ring assemblies is connected to the sub-frame forming part of the relevant running gear. 50 55
13. Running gear assembly as claimed in any of the foregoing claims, **characterized in that** the wheels

of at least one of the running gears are mounted for free rotation on a single shaft.

14. Running gear assembly as claimed in claim 13, **characterized in that** the wheels arranged on a shaft are mutually coupled for rotation via a separate shaft.
15. Running gear assembly as claimed in claim 13 or 14, **characterized in that** the wheels arranged on a shaft are coupled via an elastic or amortizing connection.
16. Running gear assembly as claimed in claim 13, 14 or 15, **characterized in that** each of the wheels arranged on a shaft is separately drivable by a motor.
17. Running gear assembly as claimed in any of the claims 1-12, **characterized in that** the wheels of the running gear are fixed to separate shafts and that the ring assemblies are fixed in between the wheels.
18. Running gear assembly as claimed in claim 13, **characterized in that** the ring assemblies enclose a spring device for bodywork for supporting by the running gear assembly.
19. Running gear assembly as claimed in any of the claims 1-13, 17 or 18, **characterized in that** the wheels forming part of the running gear are separately rotatable on a vertical axis relative to the sub-frame and that steering means are provided for radially adjusting the wheels.
20. Running gear assembly as claimed in any of the foregoing claims, **characterized in that** the running gears present on the ends of the running gear assembly are each formed by a running wheel assembly mounted on a shaft and that each lever is connected to both adjacent running gears and that the other running gears are provided with a driving member.
21. Running gear assembly as claimed in any of the claims 1-19 **characterized in that** the wheels of the running gears present on the ends of the running gear assembly are mutually coupled for rotation and that two of the ring assemblies of the running gear are connected to the adjoining respectively following running gear forming part of the running gear assembly.
22. Running gear assembly as claimed in any of the foregoing claims, **characterized in that** the wheels forming part of a running gear are driven by the same drive device.

23. Running gear assembly as claimed in any of the foregoing claims, **characterized in that** each of the running gears are connected to the neighbouring lever by means of a lemniscate connection allowing movements in the vertical plane.

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24. Running gear assembly as claimed in claim 23, **characterized in that** the lemniscate connection comprises hinges formed by leaf springs.

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25. Running gear assembly as claimed in claim 23 or 24, **characterized in that** between the lever and the lemniscate connection is arranged a torsion bar extending in the travel direction.

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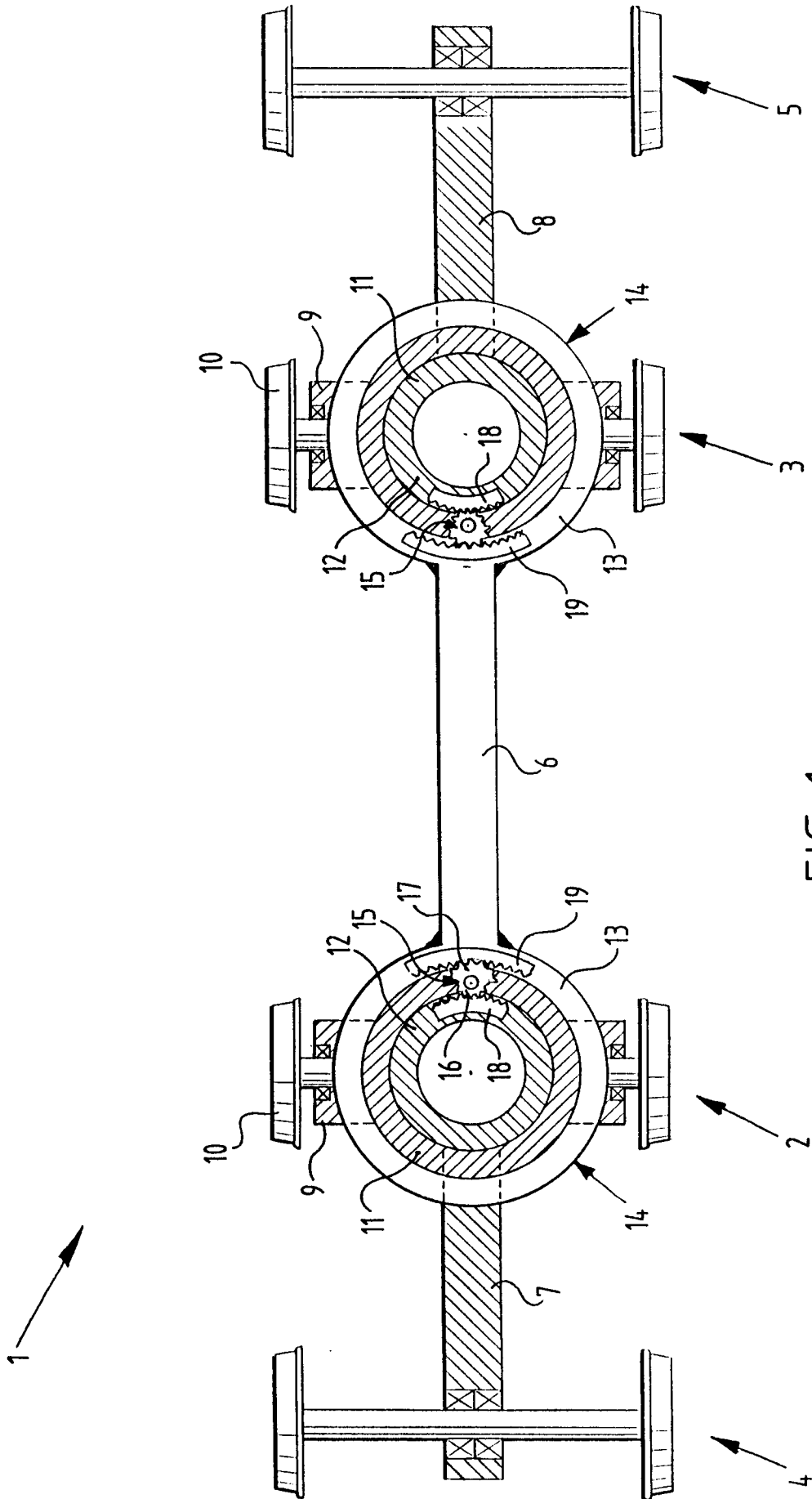


FIG. 1

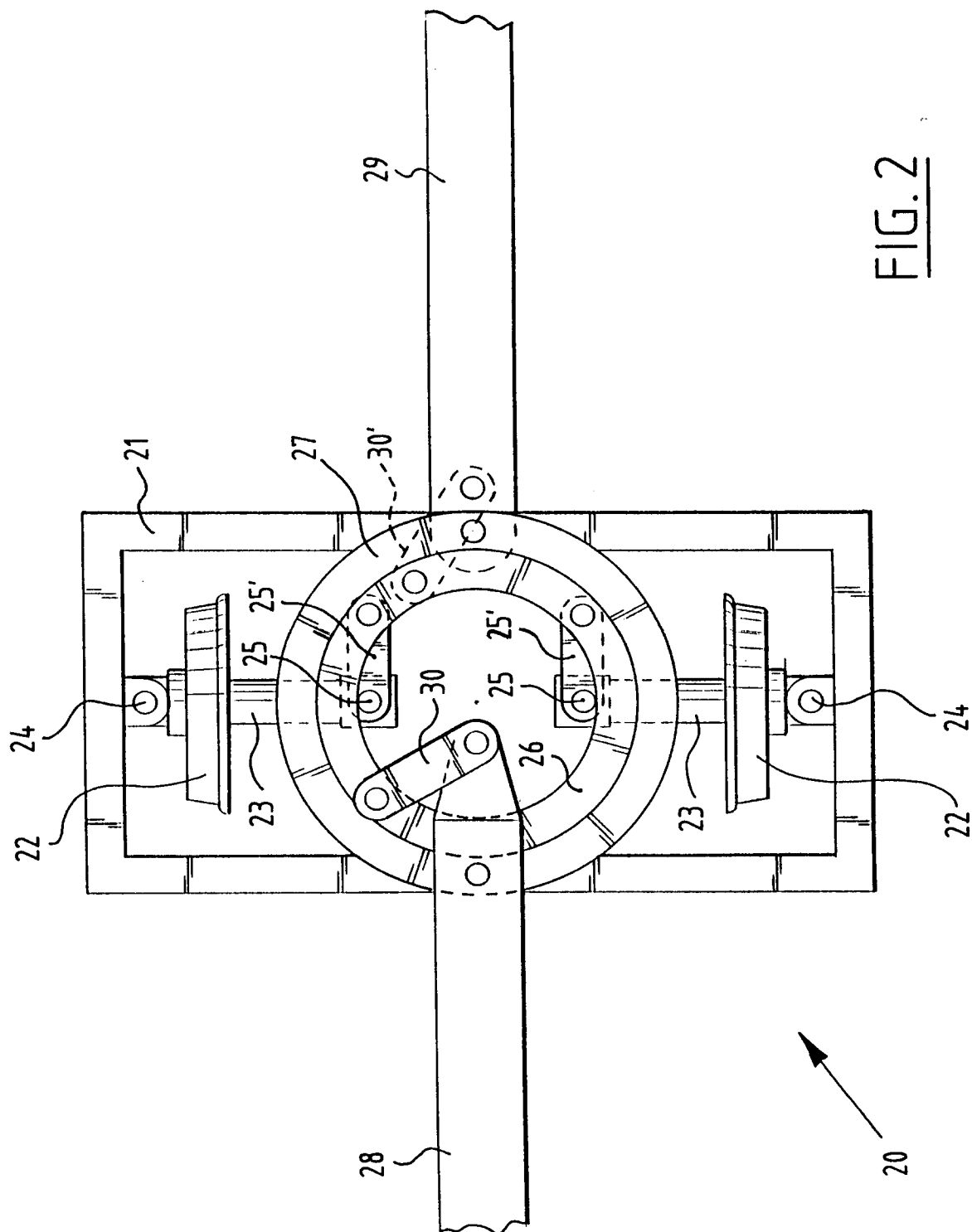


FIG. 2

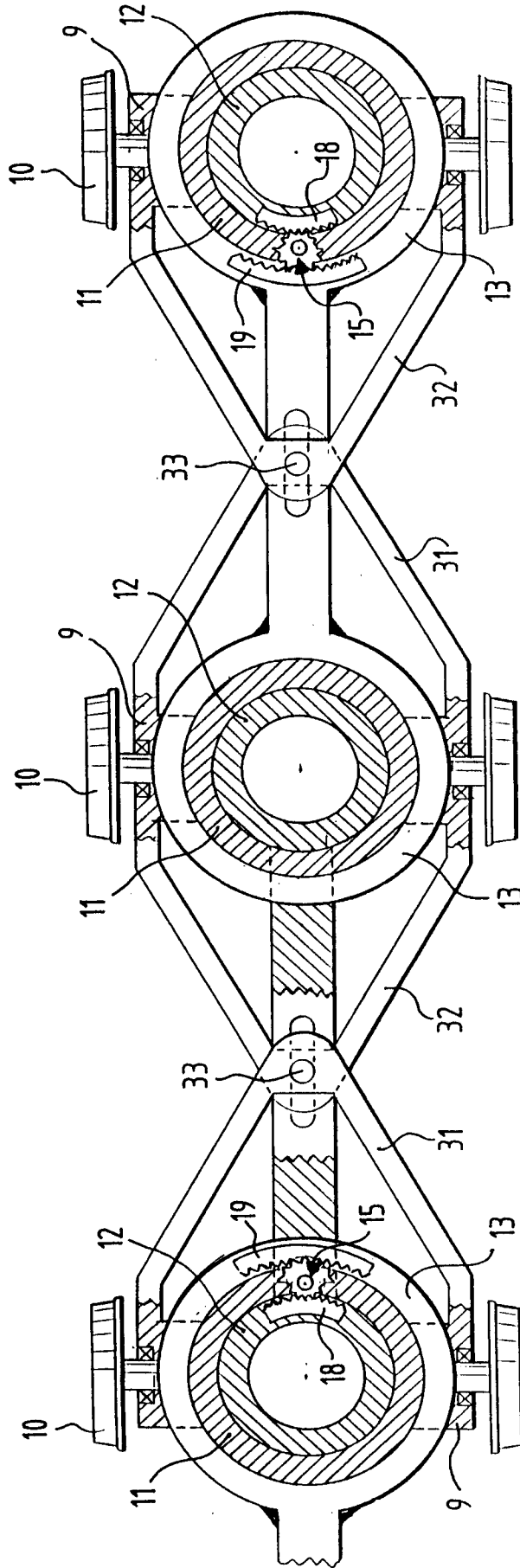
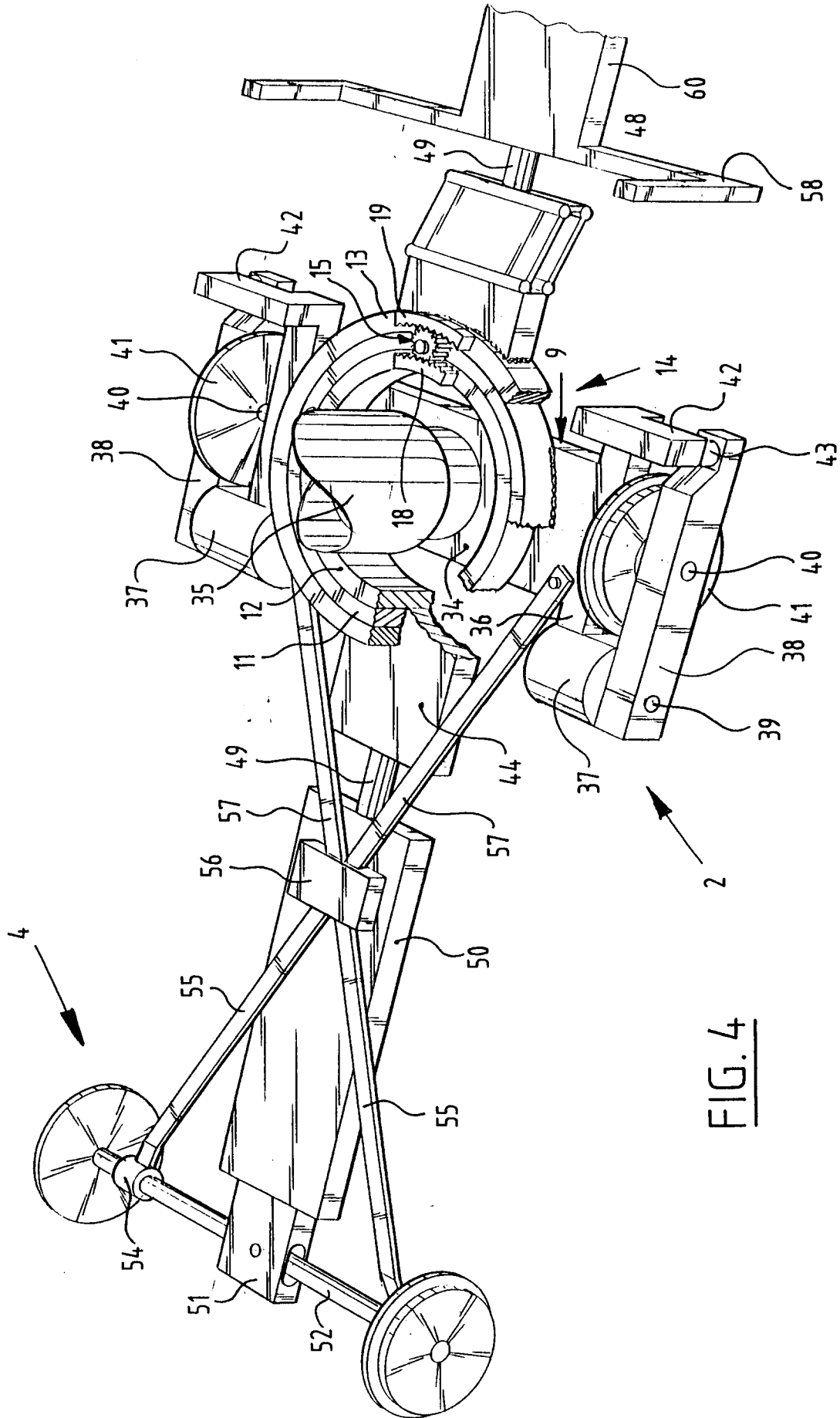


FIG. 3



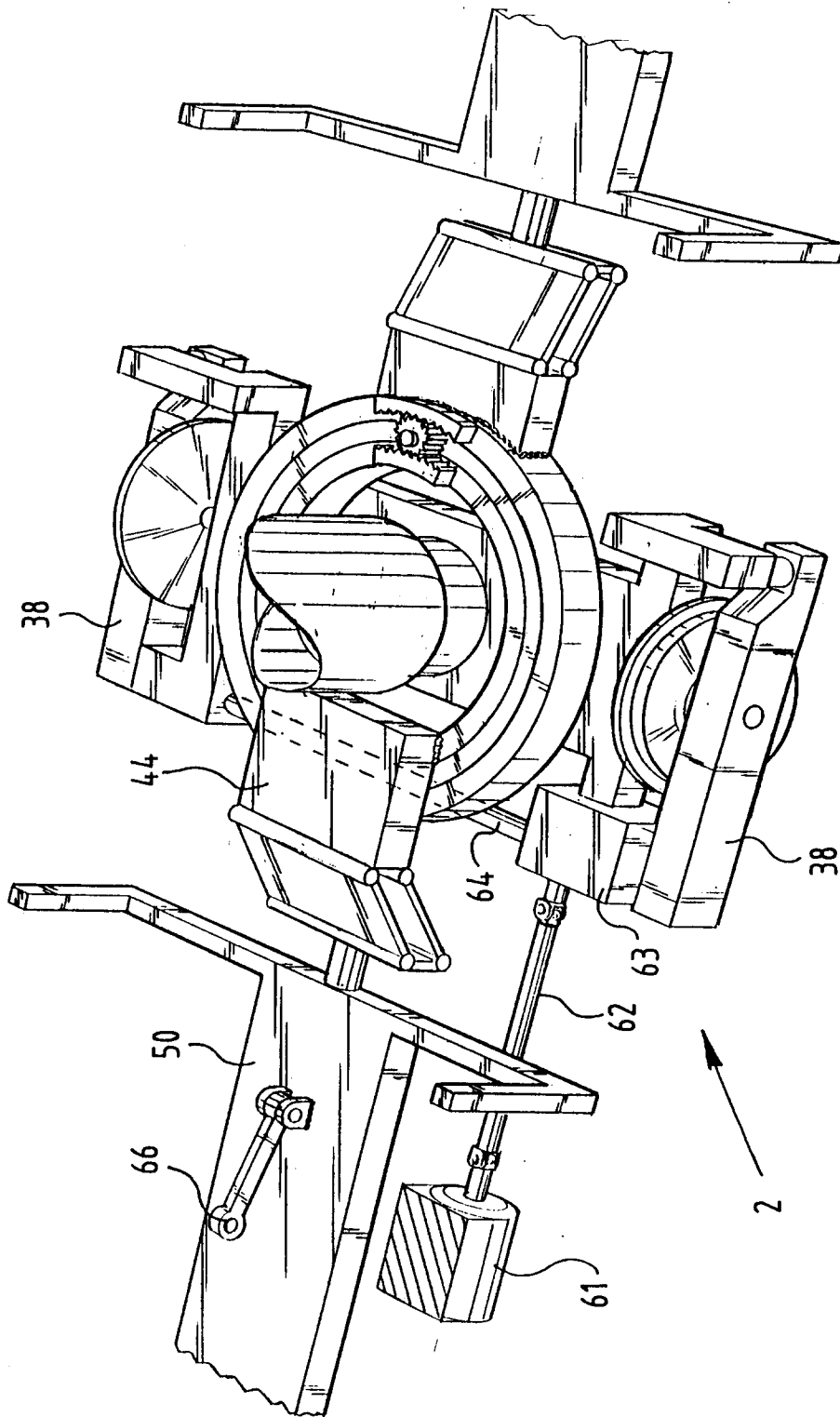


FIG. 5

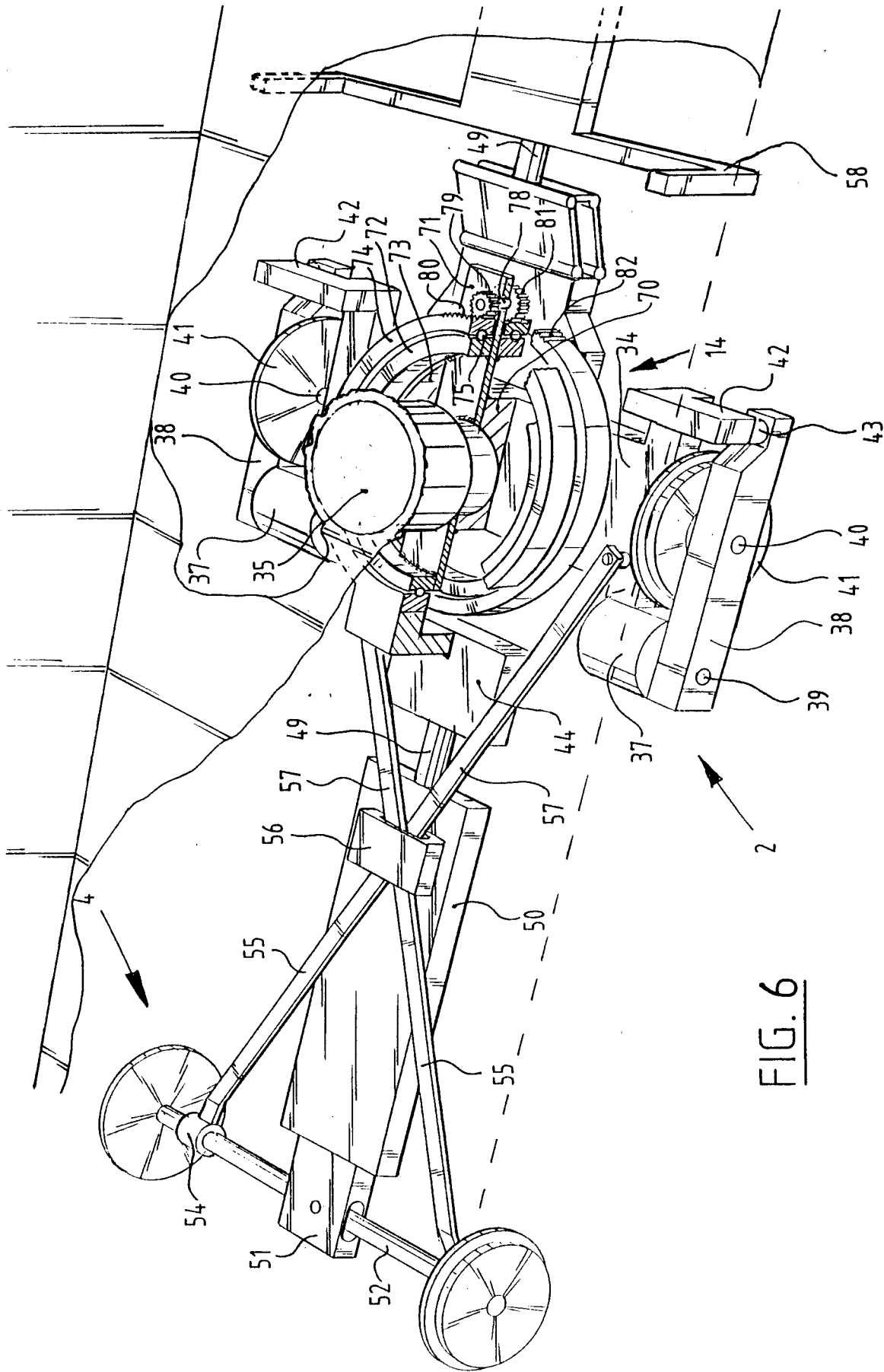


FIG. 6